MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
JUNE 2017

STAFF REPORT

Biological and water chemistry surveys of selected stations in the upper Grand River and Red Cedar River watersheds in Eaton, Ingham, Jackson, and Livingston Counties, Michigan, July-September 2016.

1. Introduction

Biological and physical habitat conditions of selected water bodies in the upper Grand River and Red Cedar River watersheds in Eaton, Ingham, Jackson, and Livingston Counties were assessed by staff of the Michigan Department of Environmental Quality (MDEQ), Surface Water Assessment Section (SWAS), from July-September of 2016. 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) Address monitoring requests submitted by internal and external customers.
3) Identify nonpoint sources (NPS) of water quality impairment.
4) Evaluate biological community temporal trends.
5) Evaluate effectiveness of best management practices at Carrier Creek.
6) Determine if toxins in the sediment are contributing to impairments at Indian Mill Creek in the lower Grand River watershed.

2. Watershed Information

Watersheds are defined as the area of land (and water) that flows into a river, lake, or wetland. Watersheds are often separated by a line of higher elevation land, such as a ridge or hills. Hydrologic Unit Codes (HUC), are numeric identifiers that were developed by the United States Geological Survey in order to standardize nomenclature across the nation. Larger watersheds are identified by HUCs with fewer digits in their identifier. As smaller watersheds are nested within larger watersheds, more digits are added. For example, the Dietz Creek subwatershed (HUC 040500040409) is nested within the Eastern Red Cedar River (HUC 0405000404), which is within the upper Grand River watershed (HUC 04050004).

Land cover can have a significant impact on the quality and condition of surface waters. The 2011-era land cover and other characteristics for sampled Grand River – Red Cedar River subwatersheds are shown in Table 1, by 12-digit HUC.

Table 1. 2011-era land cover estimates (NOAA, 2011) and information on selected indicators of human development by subwatershed, including: wetlands lost since settlement (Fizzell, 2015), population density (U.S. Census Bureau, 2010 and 2012), and impervious surfaces. The length of the bar in each cell represents the impact in the subwatershed from that development indicator, relative to the others HUCs.

Station	HUC-12	Subwatershed Name	Developed Land	Agricultural Land	Impervious Surfaces	Lost Wetlands	Population Density	Natural Riparian Buffers	Total Natural Landcover (Wetlands and Forest)
			Percent of Subwatershed (HUC-12)			Percent of Presettlement Area	People per square mile (2010)	Percent of riparian area in natural land cover (30-meter buffer)	Percent of Subwatershed (HUC-12)
1	040500040704	Carrier Creek-Grand River	77	10	34	30	1988	25	11
2	040500040305	Otter Creek-Spring Brook	5	57	1	9	45	70	37
3	040500040210	Perry Creek-Grand River	5	62	1	12	85	65	33
4	040500040106	Hurd Narvin Drain-Grand River	65	7	28	21	1662	59	26
5	040500040702	Skinner Extension Drain-Grand River	14	57	3	41	261	48	28
6	040500040304	N Onondaga Drain (Willow Creek)	6	68	1	29	83	55	26
7	040500040702	Skinner Extension Drain-Grand River	14	57	3	41	261	48	28
8	040500040704	Carrier Creek-Grand River	77	10	34	30	1988	25	11
9	040500040704	Carrier Creek-Grand River	77	10	34	30	1988	25	11
10	040500040704	Carrier Creek-Grand River	77	10	34	30	1988	25	11
11	040500040704	Carrier Creek-Grand River	77	10	34	30	1988	25	11
12	040500040208	Huntoon Creek	12	66	3	42	167	43	22
13	040500040209	Western Creek-Grand River	13	44	3	18	288	74	42
14	040500040205	Batteese Creek	7	43	1	18	74	72	48
15	040500040505	Mud Creek	6	66	1	32	88	45	27
16	040500040408	Hayhoe Drain-Doan Creek	6	68	1	40	53	34	24
17	040500040506	Headwaters Sycamore Creek	24	61	7	43	358	36	15
18	040500040506	Headwaters Sycamore Creek	24	61	7	43	358	36	15
19	040500040502	Sloan Creek	9	72	2	27	82	38	19
20	040500040502	Sloan Creek	9	72	2	27	82	38	19
21	040500040401	Handy Howell Drain-Red Cedar River	18	45	4	16	204	51	34
22	040500040503	Coon Creek-Red Cedar River	14	58	3	15	212	67	27
23	040500040411	Squaw Creek-Red Cedar River	12	70	3	20	173	50	18
24	040500040503	Coon Creek-Red Cedar River	14	58	3	15	212	67	27
25	040500040503	Coon Creek-Red Cedar River	14	58	3	15	212	67	27
26	040500040504	Pine Lake Outlet	41	18	13	14	981	54	36
27	040500040504	Pine Lake Outlet	41	18	13	14	981	54	36
28	040500040406	Kalamink Creek	12	69	3	57	105	44	19
29	040500040506	Headwaters Sycamore Creek	24	61	7	43	358	36	15
30	040500040503	Coon Creek-Red Cedar River	14	58	3	15	212	67	27
31	040500040504	Pine Lake Outlet	41	18	13	14	981	54	36

Both the upper Grand River and Red Cedar River watersheds are contained within the Southern Michigan Northern Indiana Drift Plains (SMNIDP) ecoregion (Omernik and Gallant, 1988). The Grand River is the longest river in Michigan and has the second largest watershed (about 5,572 square miles in area) in Michigan. The focus of this report is the upper Grand River and Red Cedar River portions of the watershed within HUC 04050004 (Figure 1). For the purposes of the MDEQ's biosurvey monitoring, the "upper Grand River watershed" is considered to be from the river's headwaters in Hillsdale County, to its confluence with the Maple River near the towns of Muir and Lyons in Ionia County. Major tributaries to the upper Grand River include the Maple and Looking Glass Rivers; however, those watersheds are monitored separately and are not included here. The main stem of the upper Grand River from its headwaters to the Maple River confluence is 136 miles long and the upper Grand River portion of this study area is 1,092 square miles. There is only one tributary designated as protected for a coldwater fishery (Table 2) in the upper Grand River watershed and there are no coldwater streams in the Red Cedar River watershed. The main stem Red Cedar River is 51 miles long from its origin in Cedar Lake, Livingston County, to its confluence with the Grand River in Lansing, Ingham County. The Red Cedar River watershed has an area of approximately 472 square miles.

The majority of the upper Grand River and Red Cedar River watershed lies within the Lansing subsubsection (VI.4.1) of the regional Landscape Ecosystem Classification of Michigan (Albert, 1995), and likewise, the majority of sampling stations are in this subsubsection (all except 2, 4, 14, and 21). This area is composed of broad, gently sloping ground moraine, with end-moraine ridges. Hills are a maximum of 100 feet high, and slopes are less than 6 percent, leading to low gradient stream channels even prior to European settlement. Bedrock underlying the area is rarely exposed because it is buried deeply under a thick layer of glacial deposits. A notable rock outcropping though, is located in the city of Grand Ledge along the Grand River. The soils in the ground moraines are approximately 30 percent poorly drained. The undulating topography of the moraines has resulted in alternating, well-drained ridges and poorly-drained linear depressions. The nearly linear north-south oriented drainages in the eastern portions of the Red Cedar River watershed (e.g., Doan and Kalamink Creeks; Figure 1), are an example of this. Lakes are uncommon in the Lansing subsubsection of the study area. Presettlement vegetation on uplands was largely beech-maple forests, with pockets of oak-hickory, which have been converted to crop production. Lowlands were formerly wet prairies or red maple swamps which contained the red cedars that gave the watershed its name.

Four stations (2, 4, 14, and 21) were located within the Jackson Interlobate subsubsection VI.1.3. (Albert, 1995). Landforms are composed of outwash sand and gravelly end moraines with steeper slopes than the Lansing subsubsection (as high as 25 to 40 percent). Lakes and wetlands are much more common than in the Lansing subsubsection, due to depressions left in the glacial outwash by melting glacial ice blocks. The soils and vegetation are extremely variable based on the landform present. Moraines and sandy portions of the outwash tend to be well drained soils and thus are dominated by oak (black, white, and burr oaks) and hickory forests, although presettlement, oak savannahs were more common in these areas. The poorly drained portions of outwash areas were hardwood swamps (often with some tamarack), marshes, fens, or bogs. The extensive wetlands are now largely degraded by agricultural and residential development in the uplands, but still form the headwaters of the upper Grand River and Red Cedar Rivers.

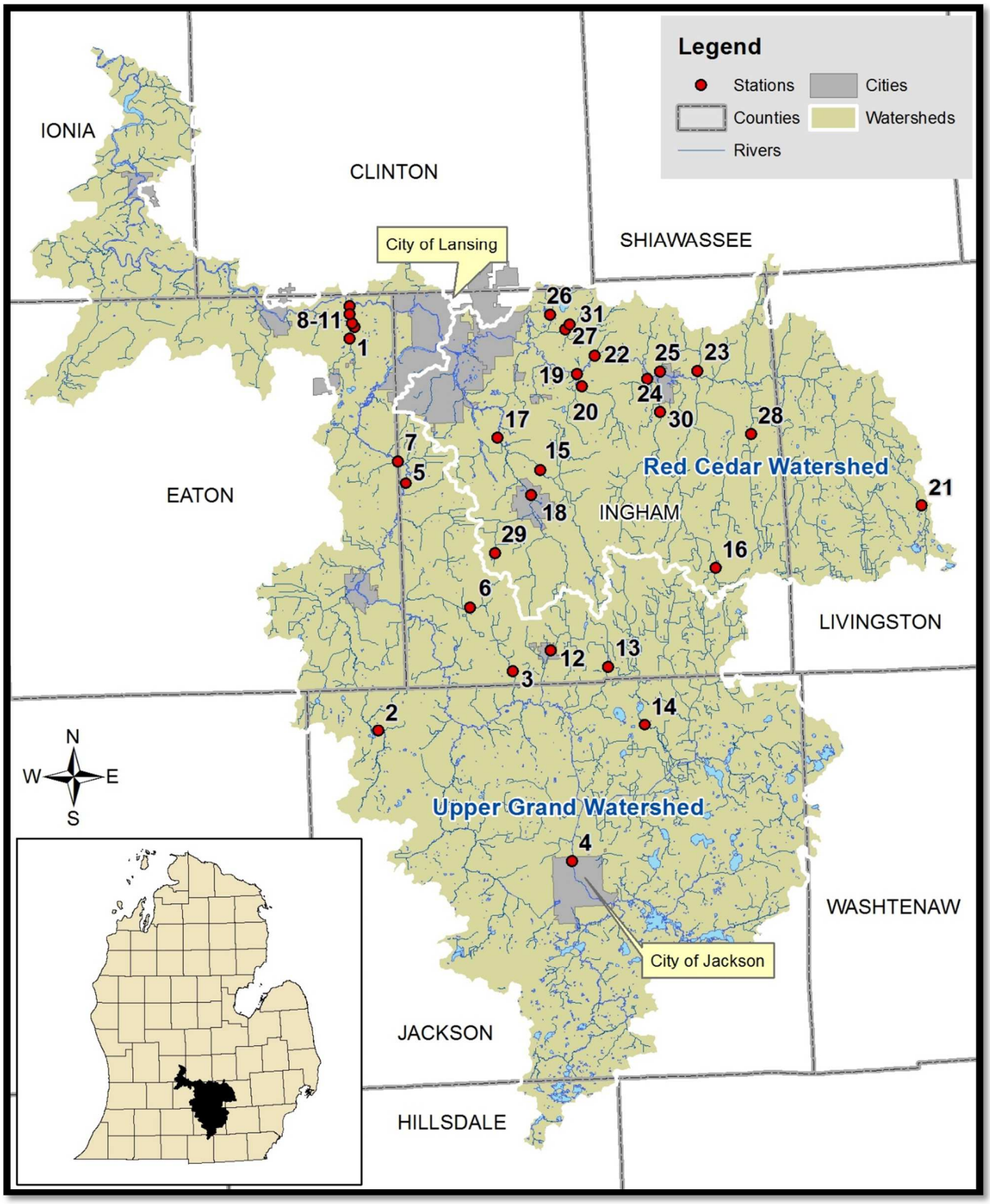

Figure 1. Upper Grand and Red Cedar River watersheds. Dots represent 2016 aquatic macroinvertebrate community survey stations.

Table 2. Coldwater designated streams in the upper Grand River watershed (adapted [MDNR, 1997]).

Stream	Township, Range, Section	County
Mackey Brook	T2S, R2W, S16	Jackson

Upper Grand River

The Grand River has a long history of manipulation and pollution. The main stem river was historically used for disposal of raw sewage by the city of Jackson. As early as 1890, residents began complaining about the river pollution and associated odors (Ennis, 2011). Between 1914 and 1920 the city of Jackson channelized the Grand River in an effort to increase the flow of the river and flush raw sewage away from the city faster (Price, 2013). However, channelizing the river did not ameliorate the pollution problem. Starting in 1936, the city of Jackson again reconfigured the Grand River by constructing a concrete river bottom and concrete vertical walls for the river banks in an attempt to speed up flow. Additionally, a 2,580-foot long concrete "cap" was placed over top of the river in an attempt to eliminate odors originating from it (Price, 2013). By the 1990s, the cap, along with safeguards put in place to prevent people from going near the entrance to it, began to deteriorate. As a result, several children drowned after being swept under it. Eventually, the concrete cap was removed in 2000 both for safety and aesthetic reasons (Price, 2013; Figure 2).

Despite improvements from historic perturbations, the main stem Grand River and many of its tributaries are not supporting the following designated uses: other indigenous aquatic life and wildlife (OIALW) (reason: total suspended solids), warmwater fishery (reasons: low dissolved oxygen and total suspended solids), and total and partial body contact (reason: *E. coli* exceedances). These nonattainments extend from the city of Jackson to Thompkins Road (Thompkins Township) located just south of the Jackson-Ingham County border. From the Moores Park Dam in the city of Lansing, to its confluence with Carrier Creek in Delta Township, the main stem Grand River is not supporting its warmwater fishery designated use because of low dissolved oxygen (Goodwin et al., 2014).

Downstream of Jackson, the Grand River flows through a mixture of natural land, agriculture (Figure 3), and light residential land uses before it flows through heavily urbanized sections of the city of Lansing (Figure 4). Downstream of Lansing, the Grand River flows through a natural area (Portland State Game Area) and through urbanized portions of the cities of Grand Ledge and Portland.

Because the soils are poorly drained in this area, drainage ditches are extensive in agricultural areas (second only to the Maumee and Saginaw Lake-Plain subsections) and are what typically make up the headwaters of small tributaries to the Grand River. Many of the agricultural fields in this section are tiled to facilitate field drainage (Albert, 1995).

Figure 2. Concrete cap being removed from over top of the Grand River in downtown Jackson in 2000 (photo by K. Price, https://rodmalloy.com/tag/kenny-price/).

Red Cedar River

The city of East Lansing, portions of the city of Lansing, Meridian Township, and Lansing Township are the major population centers of the Red Cedar River watershed. The Red Cedar River is a large tributary that confluences with the Grand River within the city of Lansing.

In the Red Cedar River, most wetlands have been converted to pastureland or drained for agriculture. Hydrology has been altered by historic and current efforts to quickly drain water from agricultural production areas via ditches. All wet prairies in the region have been destroyed or degraded and few large tracts of beech-maple forest exist due to conversion to agricultural land. Some subwatersheds (such as Dietz Creek, in the Red Cedar River) have as much as 80 percent of their land area in agricultural use, and have lost as much as 59 percent of their original wetland area (NOAA, 2011). Throughout the upper Grand River and Red Cedar River study area, on the 10-digit HUC scale, the eastern Red Cedar River (0405000404) has the most agricultural land cover (Figure 3), and the western Red Cedar River (0405000405) has the most developed land.

NPS of pollution, particularly nutrients, pathogens, and sediment are likely to be affecting the water quality, as well as the macroinvertebrate and fish communities in the upper Grand River

and Red Cedar River watershed. Urbanization and agricultural land use and accompanying artificial drainage are issues in this watershed. Wetlands, which act as natural storm water retention areas and provide pollutant filtration, were once prevalent. Much of the wetland area has been drained and the functions the wetlands performed have been lost. Efforts to decrease NPS pollution in the Red Cedar River watershed include the recent development of a Clean Water Act Section 319 watershed management plan for the Red Cedar River (Rippke, 2012).

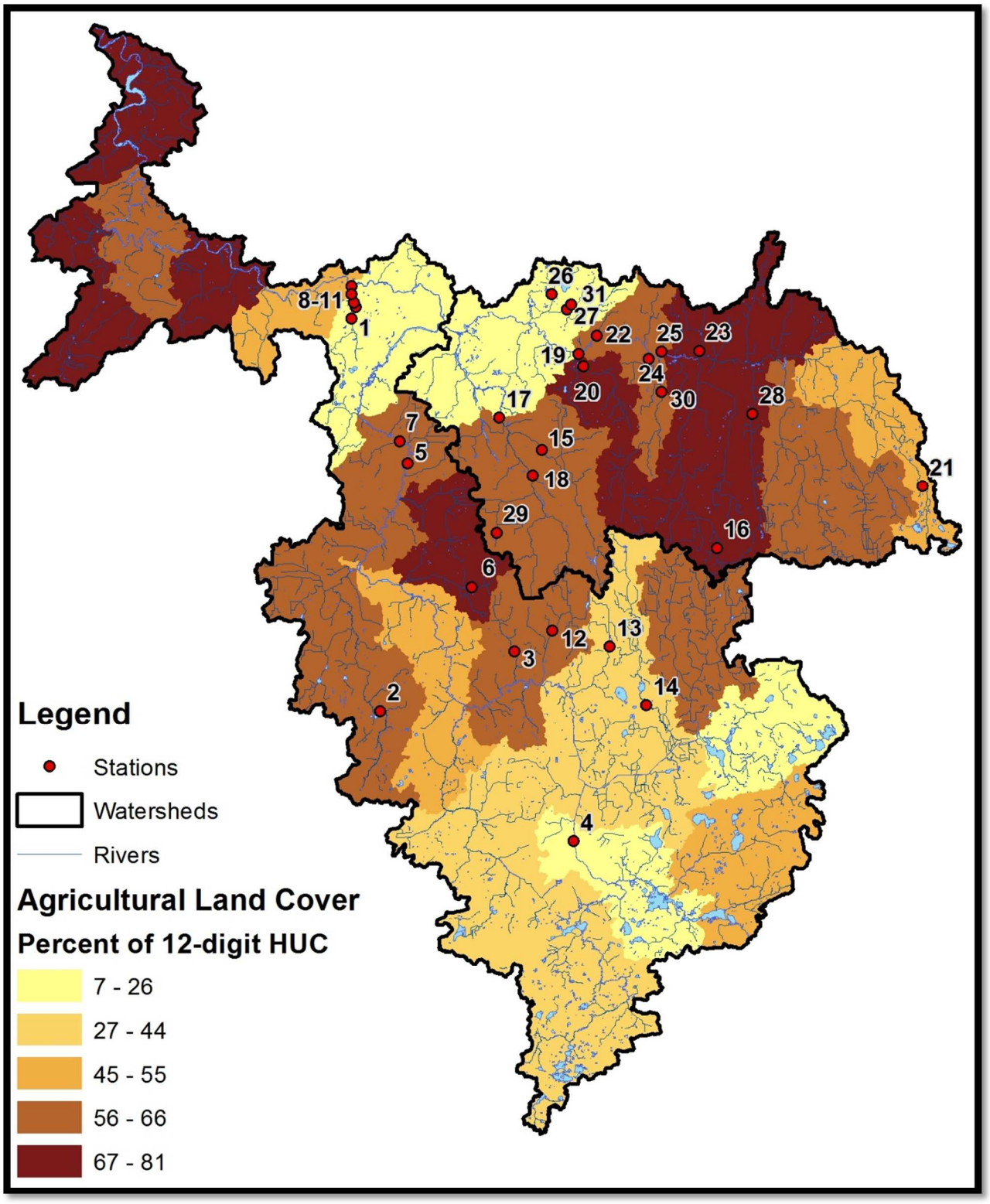

Figure 3. 2011-era agricultural land cover (cultivated and pasture/hay) by 12-digit HUC in the upper Grand River and Red Cedar River watershed. Dots represent 2016 aquatic macroinvertebrate community survey stations.

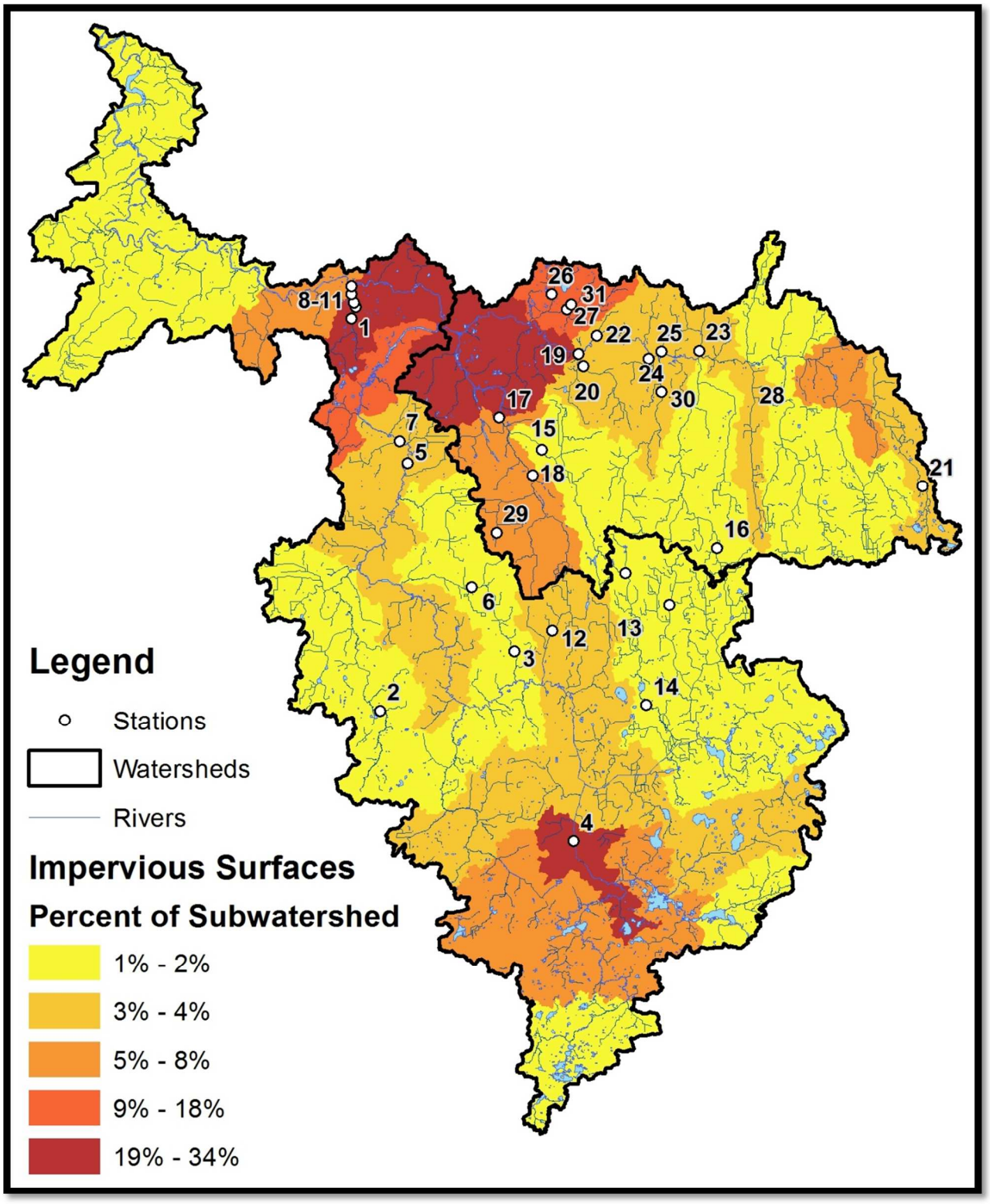

Figure 4. 2011-era estimates of percent impervious surfaces by 12-digit HUC in the upper Grand River and Red Cedar River watershed. Dots represent 2016 aquatic macroinvertebrate community survey stations.

3. Historical Sampling Efforts and Information

The Grand River upstream of Jackson has historically had good water quality with biological communities that would be characteristic of minimally impacted water bodies (Sylvester and Grant, 1977; Goodwin 2000; Rockafellow 2003(a) and 2003(b); and Holden, 2007). Downstream of Jackson, wadeable portions of the main stem of the Grand River have received high acceptable and excellent macroinvertebrate community scores. The smaller tributaries typically score acceptable, with some scoring poor in channelized, agricultural drains (Holden, 2012).

In the Red Cedar River portion of this study area, the macroinvertebrate and fish communities tend to be borderline between the poor and acceptable range (particularly in the Sycamore Creek subwatershed), which results in waffling between the poor and low acceptable ratings among sampling years. In a 1996 survey of the Sycamore Creek subwatershed, macroinvertebrate communities scored poor at two stations on Willow Creek, and one station on Sycamore Creek, downstream of the Mason Wastewater Treatment Plant (WWTP) (Thelen, 1999). In 2006 the macroinvertebrate community at these stations continued to score poor, while the Sycamore Creek station scored acceptable in both 2001 and 2006 (Rockafellow, 2003c; Rippke, 2008). Macroinvertebrate communities in Doan Creek at Holt Road also scored poor in 1996. However, Doan Creek was sampled in four locations in the 2006 survey and macroinvertebrate communities scored acceptable at all stations. Fish were determined to be poor during the 1996 survey of Doan Creek, due to less than 50 fish being captured, and the station has not been resampled. During the 2001 survey of the Red Cedar watershed, Kalamink Creek at Holt Road and the Middle Branch of the Red Cedar at Sargent Road scored poor for macroinvertebrates (Rockafellow, 2003c). The exact stations were not resampled, but nearby stations on Kalamink Creek and the Middle Branch of the Red Cedar River found acceptable scores during the 2006 survey. Also in 2006, a poor warmwater fish community was found on Talmadge Creek. In 2011, the macroinvertebrate community at three stations (Sycamore Creek, Middle Branch Red Cedar River, and Pine Lake Outlet) scored poor.

4. Methods

The macroinvertebrate community and physical habitat were qualitatively assessed at 31 stations (Table 3; Figure 1) using the SWAS Procedure 51 (Creal et al., 1996; MDEQ, 1990) for wadeable streams. If a station is at a road crossing, it is sampled upstream unless otherwise noted. The macroinvertebrate communities were assessed and scored with metrics that rate water bodies from excellent (+5 to +9) to poor (-5 to -9). Scores from +4 to -4 are rated acceptable. Negative 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. Habitat evaluations are based on 10 metrics, with a maximum total score of 200. A station habitat score of >154 is characterized as having excellent habitat, 105-154 is good, 56-104 is marginal, and <56 is poor. Where available, macroinvertebrate community scores are used to determine attainment of the OIALW designated use and fish community scores are used to assess attainment of the relevant fish designated use. Habitat scores and individual metrics are used to help better understand the biological community scores. Appendices 1 and 2 contain the macroinvertebrate community and habitat assessment results.

5. Station Selection

Two station-selection methods were used to assess the upper Grand River and Red Cedar River watersheds in 2016: (1) stratified random; and (2) targeted. Sixteen randomly selected

stations were assigned to support the SWAS Status (6 stations) and Trend (9 stations) Program. These stations will be used to estimate the watershed attainment status for the 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, as amended, and will be used as baseline data to facilitate a measurement of biological community temporal trends (MDEQ, 2015).

Sixteen stations within the upper Grand River and Red Cedar River watersheds were selected for targeted monitoring to support and answer concerns of stakeholders or staff (Figure 1). Three stations in the lower Grand River watershed were targeted for sediment sampling and are reported here. Specifically, three sediment samples were taken from Indian Mill Creek in the city of Grand Rapids. The sediment was collected using a PONAR grab sampler, placed in a metal bowl, and homogenized using a metal spoon. A subsample of the sediment was then placed in an 8 oz. glass jar and stored on ice until it was delivered to the MDEQ Environmental Laboratory. At the laboratory, the sediment was analyzed for polyaromatic hydrocarbons (PAH), oil range organics (ORO), diesel range organics (DRO), Michigan-10 metals, and total organic carbon.

Table 3. Summary of the aquatic habitat and macroinvertebrate community evaluations for selected stations in the upper Grand River and Red Cedar River watersheds, July-September 2016.

Station	Watershed	Stream Name	Road Crossing	STORET	County	TRS	Latitude	Longitude	County Drain	Date	Habitat Rating	Habitat Score	Bug Rating	Bug Score	Station Type	AUID
1	Upper Grand	Carrier Creek	Williamsburg ST	230233	Eaton	04N03WS15	42.73104	-84.65596	X	7/29/2016	Good	115	Acceptable	-4	Tr	040500040704-02
2	Upper Grand	Spring Brook	Robbins RD	380456	Jackson	01S03WS14	42.38468	-84.63487		7/27/2016	Good	146	Acceptable	1	Tr	040500040305-01
3	Upper Grand	Perry Creek	D/S Olds RD	330419	Ingham	01N01WS31	42.43391	-84.4735	X	7/27/2016	Good	108	Acceptable	-2	Tr	040500040210-03
4	Upper Grand	Grand River	W. Monroe ST	380085	Jackson	02S01WS27	42.26525	-84.40987		7/27/2016	Marginal	86	Acceptable	1	Tr	040500040106-01
5	Upper Grand	Grand River	Off Waverly RD (RiverBend Natural Area)	330433	Ingham	03N02WS31	42.6023	-84.59364		7/28/2016	Good	124	Excellent	5	Tr	040500040702-01
6	Upper Grand	North Onondaga Drain	Aurelius RD	330418	Ingham	01N02WS11	42.4911	-84.52165	X	7/28/2016	Good	117	Acceptable	-2	Tr	040500040304-01
7	Upper Grand	Grand River	Waverly RD	330467	Ingham	03N02WS30	42.62208	-84.60276		7/28/2016	Good	145	Excellent	8	S	040500040702-01
8	Upper Grand	Carrier Creek	Saginaw HWY	230200	Eaton	04N03WS10	42.74105	-84.64998	X	7/29/2016	Good	118	Poor	-7	S	040500040704-02
9	Upper Grand	Carrier Creek	Old River Trail	230136	Eaton	04N03WS03	42.759582	-84.65472	X	7/29/2016	Good	152	Acceptable	-1	T	040500040704-02
10	Upper Grand	Carrier Creek	North Ridge CT	230247	Eaton	04N03WS10	42.74477	-84.65244	X	7/29/2016	Good	149	Poor	-5	T	040500040704-02
11	Upper Grand	Carrier Creek	Willow Woods LN	230199	Eaton	04N03WS10	42.75237	-84.65516	X	8/1/2016	Good	129	Acceptable	-4	T	040500040704-02
12	Upper Grand	Huntoon Creek	Bellevue ST	330468	Ingham	01N01WS28	42.4511	-84.42742	X	8/2/2016	Good	112	Acceptable	-1	S	040500040208-01
13	Upper Grand	Shaw Branch	Olds RD	330469	Ingham	01N01ES31	42.43553	-84.35967	X	8/2/2016	Marginal	89	Acceptable	-3	S	040500040209-01
14	Upper Grand	Bateese Creek	Kennedy RD	380401	Jackson	01S01ES16	42.38299	-84.31876		8/2/2016	Good	139	Acceptable	-3	S	040500040205-01
15	Red Cedar	Mud Creek	Okemos RD	330417	Ingham	03N01WS16	42.6106	-84.433	X	8/1/2016	Marginal	68	Acceptable	-4	Tr	040500040505-01
16	Red Cedar	Doan Creek	Swan RD	330432	Ingham	02N02ES32	42.5191	-84.2287	X	8/1/2016	Marginal	85	Acceptable	-2	Tr	040500040408-01
17	Red Cedar	Sycamore Creek	Holt RD	330018	Ingham	03N01WS18	42.64026	-84.48287		9/7/2016	Marginal	84	Acceptable	0	Tr	040500040507-01
18	Red Cedar	Sycamore Creek	D/S outfall at cemetary	330154	Ingham	02N01WS05	42.58862	-84.44528		8/1/2016	Marginal	97	Acceptable	-1	T	040500040506-01
19	Red Cedar	Sloan Creek	Legg Park off Van Atta RD	330473	Ingham	04N01WS35	42.69416	-84.38645	X	9/12/2016	Good	128	Acceptable	0	S	040500040502-02
20	Red Cedar	Sloan Creek	Jolly RD	330253	Ingham	04N01WS36	42.68333	-84.38056	X	9/7/2016	Marginal	86	Acceptable	-3	T	040500040502-02
21	Red Cedar	Red Cedar River	Jewell RD	470665	Livingston	02N04ES09	42.5677	-83.9811		9/9/2016	Good	107	Acceptable	3	T	040500040401-01
22	Red Cedar	Red Cedar River	Grand River AVE	330247	Ingham	04N01WS25	42.7096	-84.364		9/12/2016	Marginal	102	Acceptable	0	T	040500040503-03
23	Red Cedar	Squaw Creek	Rowley RD	330474	Ingham	04N02ES32	42.6936	-84.2422	X	9/9/2016	Marginal	88	Acceptable	-3	T	040500040411-03
24	Red Cedar	Unnamed tributary to Red Cedar River	Rowley RD	330475	Ingham	04N01ES35	42.6937	-84.2868		9/9/2016	Good	115	Poor	-5	T	040500040503-01
25	Red Cedar	Atzinger Drain	Corwin RD	330476	Ingham	04N01ES35	42.68767	-84.30234	X	9/9/2016	Marginal	89	Acceptable	-4	T	040500040503-03
26	Red Cedar	Pine Lake Outlet	Haslett RD	330477	Ingham	04N01WS10	42.7472	-84.4157	X	9/15/2016	Marginal	78	Poor	-6	T	040500040504-01
27	Red Cedar	Foster Drain	Tihart RD	330478	Ingham	04N01WS14	42.7337	-84.3983	X	9/15/2016	Good	112	Acceptable	1	T	040500040504-01
28	Red Cedar	Kalamink Creek	Van Orden RD	330431	Ingham	02N02ES23	42.63639	-84.18104	X	9/2/2016	Marginal	104	Acceptable	-1	T	040500040406-01
29	Red Cedar	Willow Creek	Toles RD	330319	Ingham	02N02WS25	42.53854	-84.49035	X	9/7/2016	Good	124	Acceptable	-3	T	040500040506-03
30	Red Cedar	Deer Creek	Noble RD	330387	Ingham	03N01ES14	42.6587	-84.2885	X	9/9/2016	Marginal	79	Acceptable	-1	T	040500040503-02
31	Red Cedar	Jeffries Drain	Cornell RD	330479	Ingham	04N01WS14	42.7376	-84.3929	X	9/15/2016	Good	135	Acceptable	-3	T	040500040504-01

Station type: S/T/Tr = status, targeted, trend station

Habitat Scoring Wadeable Stations
Poor < 56 Marginal 56-104 Good 105-154 Excellent >154

Macroinvertebrate Scoring Wadeable Stations
Poor < -4 Acceptable -4 to +4 Excellent > +4

6. Summary of Findings by Monitoring Objective

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

In 2016, 6 randomly selected stations within the upper Grand River and Red Cedar River watersheds were sampled to support the attainment status calculation. Based on the probabilistic monitoring aspect of this watershed group survey, 83.3 +/- 38.8 percent of the randomly selected stations supported the OIALW designated use using biological monitoring procedures. Percent attainment was calculated by dividing the number of random stations that met WQS by the total number of random locations ((5 / 6)100 = 83.3 percent). This value is coupled with a 95 percent confidence interval to provide our estimation of certainty, meaning there is 95 percent certainty that the true proportion of attainment in the upper Grand River watershed is between 44.6 and 100 percent (MDEQ, 2015).

In the Red Cedar River portion of this study, stations 24 (unnamed tributary to the Red Cedar River at Rowley Road), and 26 (Pine Lake Outlet at Haslett Road) had poor macroinvertebrate community ratings. In the upper Grand River portion of this study, the macroinvertebrate community at stations 8 and 10 (Carrier Creek at Saginaw Highway and North Ridge Court) scored poor. No stations in the Red Cedar River portion of this study were found to have an excellent macroinvertebrate community; however, in the upper Grand River portion, two stations had excellent macroinvertebrate communities (Grand River at Waverly Road and at Riverbend Natural Area). These results will be considered in determining if the OIALW designated use is being met in the 2018 Sections 303(d), 305(b), and 314 Integrated Report.

The macroinvertebrate community and habitat assessment results are located in Appendix 1 and Appendix 2, respectively. Detailed station descriptions and findings are located in Section 8 of this report.

Objective 2: Satisfy monitoring requests submitted by internal and external customers.

Targeted monitoring requests generated by internal customers were approved for 14 stations in the upper Grand River and Red Cedar River watersheds and 3 stations in the lower Grand River watershed. Detailed station descriptions and findings are provided under Objective 5 (Carrier Creek), Objective 6 (Indian Mill Creek), and in Section 8 of this report. The results of the sediment samples in Indian Mill Creek have been shared with all interested stakeholders. Three stations in Carrier Creek were targeted to assess the biological communities after extensive restoration work. The results from the latest sampling showed that macroinvertebrate communities have not improved since the restoration work was completed. Three stations in the Red Cedar River watershed were targeted because of past poor, or low acceptable, scores: Pine Lake Outlet, Sycamore Creek downstream of the Mason WWTP, and Willow Creek. Sycamore Creek showed a slight improvement in macroinvertebrate scores (-4 in 2006, -1 in 2016), Pine Lake outlet was essentially unchanged (-5 in 2011, -6 in 2016), and Willow Creek went from poor to low acceptable (-5 in 2006, -3 in 2016).

All of the other stations were targeted either because they had never been sampled before or had been sampled and scored using older methodologies. These newly sampled stations had macroinvertebrate scores ranging from high acceptable (3; Red Cedar River – Jewell Road) to poor (-5; unnamed tributary to Red Cedar River – Rowley Road).

Objective 3: Identify NPS of water quality impairment.

The landscape of the upper Grand River and Red Cedar River watershed is gently sloping and has poorly drained soils. Agriculture tends to be the dominant land use in both watersheds. To facilitate drainage of the agricultural fields in this landscape, most of the tributaries to the Grand River and Red Cedar River have been channelized and converted to county drains. Because the soils are poorly drained, many of the agricultural fields in the upper Grand River and Red Cedar River watershed use artificial tile drainage. The artificially drained fields and channelized streams are designed to convey high volumes of water at a fast velocity, which scours the stream banks and fills in stream bottoms with sediment. With few exceptions, a common observation at most of the stations in the upper Grand River and Red Cedar River watershed was eroding banks, evidence of stream flashiness (fast accumulation of storm water in the stream from its associated basin, resulting in a peak discharge soon after a precipitation event), and sedimentation.

More specific NPS issues observed in the upper Grand River and Red Cedar River watersheds were:

- At several areas along Station 5 (Grand River at Riverbend Natural Area) park visitors had accessed the river by walking down steep banks of bare soil, which has accelerated erosion. This is a trend station and will be revisited in 2021.
- Station 12, Huntoon Creek at Bellevue Street in the village of Leslie, may have received metal contamination after a fire burned down a plating factory upstream of the station in 2014. During the next watershed cycle in 2021, sediment and water samples should be taken at that station to assess potential metal contamination.
- Throughout Carrier Creek, flashy conditions following precipitation events appeared to be having the greatest impacts on the stream.
- At Atzinger Drain (Station 25), portions of the bank are slumping into the stream (Figure 10). This is a grassy, park-like area surrounded by residential apartments and may benefit from planting more substantial riparian vegetation (trees and shrubs) to stabilize the banks.

Objective 4: Evaluate biological community temporal trends.

Most of the trend stations in the upper Grand River and Red Cedar River watersheds received macroinvertebrate community scores that were similar to past results (Table 4). However, the macroinvertebrate scores for Spring Brook at Robbins Road have declined since 2006 from excellent to mid-range acceptable. During past surveys at Spring Brook, Holden (2007; 2012) noted that gravel and undercut banks were present. In the most recent survey, no gravel was observed and undercut banks were sparse. The immediate area that was sampled at Spring Brook did not show obvious signs of bank erosion or other sources of sedimentation. This station may be receiving sediment that is originating from further upstream. The macroinvertebrate community in Sycamore Creek at Holt Road scored poor (-5) in 2011. In this latest biosurvey, the macroinvertebrate community for that station scored mid-range acceptable (0). Rippke (2013) noted that a large flood event had occurred at this station early in 2011. This may have altered habitat and disturbed the macroinvertebrate community, which was reflected in the poor macroinvertebrate score. This latest biosurvey result may be more reflective of macroinvertebrate communities under normal flow condition years.

Table 4. Trend station macroinvertebrate scores for upper Grand River and Red Cedar River watersheds in 2006, 2011, and 2016.

Grand River Watershed		2006	2011	2016
Waterbody	location	Holden (2007)	Holden (2012)	This report
Carrier Creek	Williamsburg ST	-4	-1	-4
Spring Brook	Robbins RD	6	3	1
Perry Creek	D/S Olds RD	1	0	-2
Grand River	W. Monroe ST	3	2	1
Grand River	Off Waverly RD (RiverBend Natural Area)	6	6	5
N. Onondaga Drain	Aurelius RD	-3	-1	-2
Red Cedar River Watershed		Rippke (2008)	(Rippke 2013)	This report
Mud Creek	Okemos RD	-4	-2	-4
Doan Creek	Swan RD	-1	-1	-2
Sycamore Creek	Holt RD	-2	-5	0

Objective 5. Evaluate effectiveness of best management practices at Carrier Creek.

Carrier Creek is a small, second-order, warmwater tributary to the Grand River located entirely in Delta Charter Township, in northeast Eaton County (Figure 5). Carrier Creek has a long history of sedimentation impacts and flashy flow conditions that were first documented in 1989 (Goble and Masterson, 1990). Carrier Creek drains a heavily-populated area (population density of 1,988 people per square mile; Table 1) with a high percentage of impervious surfaces (34%; Table 1). Carrier Creek, which was historically dredged and straightened to accommodate agricultural land use and wetland drainage, is still managed as a county drain. Goble and Masterson (1990) documented sedimentation impacts to Carrier Creek at the Interstate 496 crossing, which was attributed to recent road work. In 1996, Hanshue (1999) noted that the upper reaches had been impacted by historic drainage and relocation. Hanshue (1999) also documented severe sedimentation starting upstream of Saginaw Highway. In the mid-1990s, a large tract of land on Saginaw Highway that is adjacent to Carrier Creek, was cleared and no storm water control measures were implemented. As a result, severe erosion occurred in that area, resulting in large amounts of sediment entering Carrier Creek and burying epifaunal substrate. As a result of Hanshue's (1999) observations, Carrier Creek was placed on the U.S. Environmental Protection Agency's (USEPA) Section 303(d) list as a "threatened" water body in 1998.

Starting in 2000, restoration activities began on Carrier Creek and a biota total maximum daily load to address sedimentation issues was approved in 2002 (Cooper, 2002). Improvements that were implemented throughout multiple sections of Carrier Creek included wetland restoration in the headwaters, floodplain restoration, stream bank stabilization, stream pattern restoration (meandering), and installation of in-stream structures meant to both stabilize banks and provide habitat for fish and invertebrates. In 2016, biosurveys were performed at five different stations in Carrier Creek. The stations sampled included one trend station, one status station, and three targeted monitoring stations.

Carrier Creek is currently listed as not attaining the OIALW designated use. Two of the stations sampled in Carrier Creek had macroinvertebrate communities that scored poor and two of them scored low acceptable. Despite major restoration activities in Carrier Creek that were

implemented in the 2000s, some of the stations received worse macroinvertebrate scores in 2016 than they had in past years. In some areas where erosion control netting had been installed, the banks were eroding behind the netting and, in some places, the netting had slumped into the stream. Based on staff observations of bank scour and from speaking with a riparian resident, stream flashiness is still a major problem for Carrier Creek.

Table 5. Macroinvertebrate community scores from 2001-2016 at five different stations in Carrier Creek.

	2001	2006	2009	2011	2016
Location	Wuycheck (2002)	Holden (2007)	Holden (2011)	Holden (2012)	This report
Williamsburg ST		-4	-2	-1	-4
Saginaw Hwy	-4				-7
North Ridge CT			-2	-3	-5
Willow Woods LN	-2	-3	1	0	-4
Old River Trail				-1	-1

Table 6. Habitat scores from 2006-2016 at five different stations in Carrier Creek.

	2006	2009	2011	2016
Location	Holden (2007)	Holden (2011)	Holden (2012)	This report
Williamsburg ST	77	83	80	115
Saginaw Hwy				118
North Ridge CT		110	123	149
Willow Woods DR	154	138	136	129
Old River Trail			126	152

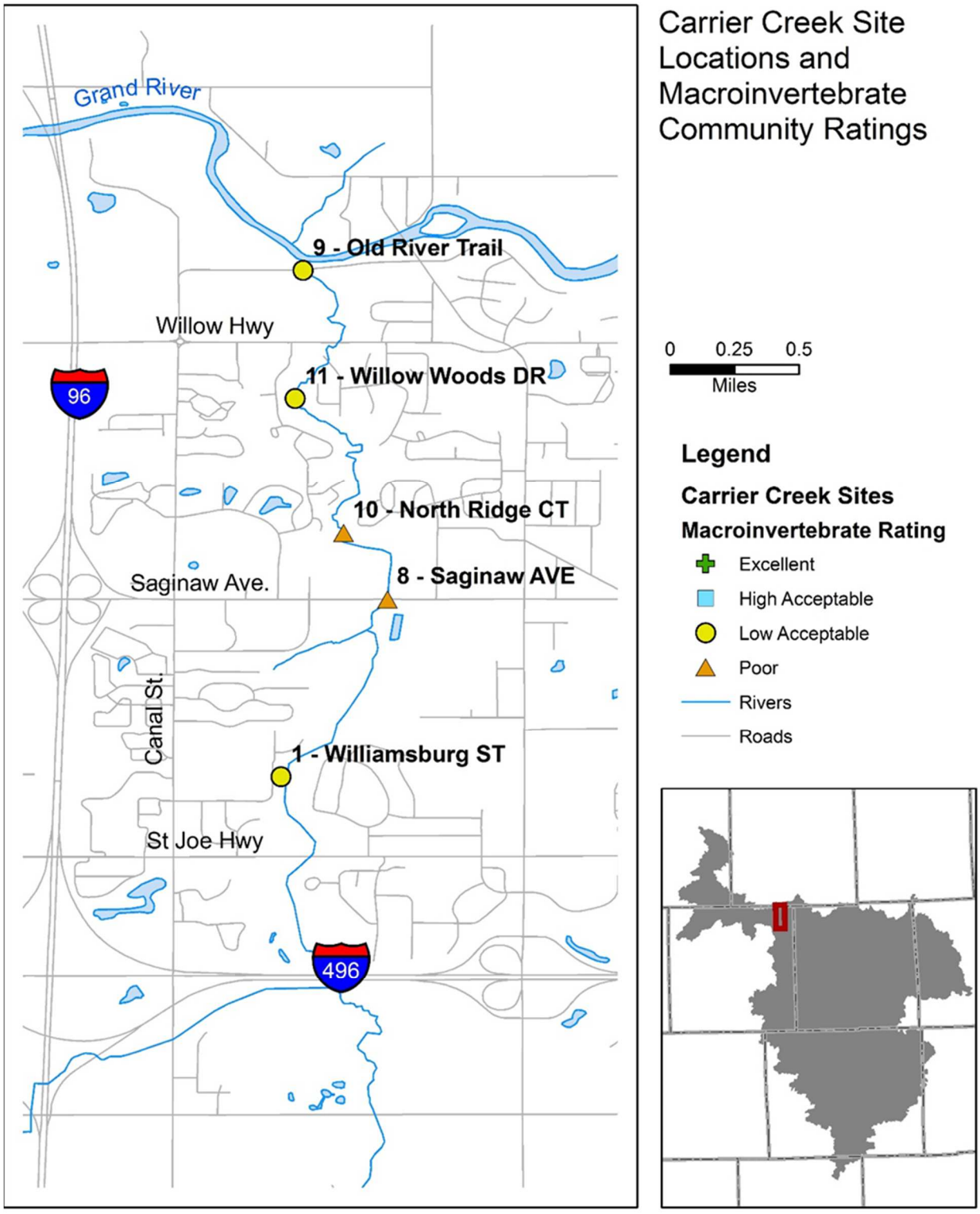

Figure 5. Stations sampled in Carrier Creek in 2016.

Station 1, near Williamsburg Street, is a trend station that has been sampled in 2006, 2009, and 2011 and was the furthest upstream station sampled in 2016 (Figure 5). The macroinvertebrate

community scored low acceptable (-4) and habitat scored low good (115). The macroinvertebrate score was the same as Holden (2007) reported. The 2016 low acceptable score comes after slight improvements were reported in 2009 and 2011 (Table 5). The habitat score was higher than had previously been reported (Table 6). Eighteen different macroinvertebrate taxa were collected. Only two Trichoptera taxa were collected indicating poor water and habitat quality. One Unionidae mussel, the slippershell (*Alasmidonta viridis*) was found at the station and returned to the stream. The slippershell is a state threatened species and the individual that was sampled was a juvenile, indicating that some recruitment is occurring (Joseph Rathbun, Pers. Comm.). Corixidae was the most abundant taxa collected, which are very tolerant to stressors (Voshell, 2002). This station had meanders restored and erosion control netting installed along the banks. The substrate was mostly hard pan clay (60% visual estimate) and sand (29% visual estimate). Clay substrate is largely considered to provide poor habitat for macroinvertebrates, which tend to prefer irregular substrate and interstices that they can burrow into, as opposed to smooth, hard surfaces (Allan, 1995). Small amounts of gravel were present, but were embedded in fine sediment. Habitat such as large woody debris and undercut banks was sparse throughout the station. The stream appeared to be flashy and the banks were eroded greater than 20 inches above the water surface. A riparian resident that we spoke with at the station described flashy stream flow conditions during rain events. In several areas along the bank, water had scoured out the soil behind erosion control netting that had been installed on the banks in the 2000s and in some areas, the netting was slumping into the stream (Figure 6). The left bank had patchy sections of intact forest alongside the stream punctuated by residential lawns. The right bank had mostly intact forest. Large trees are on both sides of the stream, which provide good canopy cover.

Figure 6. Exposed erosion control netting along banks at Station 1.

Station 8 was upstream of Saginaw Highway (Figure 5). The macroinvertebrate community scored poor (-7) and habitat scored low good (118). Twenty-three different taxa were collected, of which only one Ephemeroptera and one Trichoptera taxa were collected (in low numbers) indicating poor water and habitat quality. Coenagrionidae dominated the macroinvertebrate community, which are somewhat, to very, tolerant of stressors (Voshell, 2002). This station had been heavily impacted by sedimentation two decades earlier after the adjacent land was cleared and no storm water controls were implemented (Hanshue, 1999). The sediment observed in the latest survey was mostly soft silt (70% visual estimate) and sand (28% visual estimate). Thick beds of the invasive plant *Myriophyllum spicatum* (Eurasian milfoil) was covering some sections of the stream bottom. Other than the milfoil beds, the only other moderately available habitat was overhanging vegetation. The stream channel was straight and some evidence of flashiness was present, with banks scoured 9-18 inches above the water surface. The riparian area resembled a wet meadow, with low vegetation. Very few large trees are near Carrier Creek at this station to provide canopy cover. The greater surrounding area contains some forested land, but is mostly residential and dense urban land use along Saginaw Highway. The poor macroinvertebrate score at this station was likely because the majority of the sediment was silt, which is generally detrimental to macroinvertebrates (Allan, 2005). Siltation has direct effects on macroinvertebrates such as physical abrasion, gill clogging, and burial. Indirect effects include loss of habitat as interstices between larger particles become filled, loss of substrate for food resources, such as periphyton, to grow on, and unstable substrate for crawling, bottom-dwelling invertebrates (Wood and Armitage, 1997; Allan, 2005; and Jones et al., 2011).

Station 10 was sampled near North Ridge Court (Figure 5). The macroinvertebrate community scored poor (-5) and habitat scored good (149). Eighteen different taxa were collected, of which no EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa were collected, indicating poor water quality. Amphipoda and Isopoda dominated the taxa collected (Amphipoda 42.4%, Isopoda 20%). The macroinvertebrate community score was lower than past scores at this station (Table 5). The high habitat score is due to the extensive restoration work that had been implemented at this station. This station is about 0.4 river miles downstream from Saginaw Highway (Station 8 in this report), which was impacted by the large sedimentation event two decades ago. This station was impacted by the upstream sedimentation, which is why restoration took place. Several rock structures and artificial riffles had been placed in the stream. Because of the structures and added riffles, the substrate was largely composed of cobble and gravel. Where the artificial substrate is absent, the native sediment appeared to be hard pan clay. Moderate amounts of large woody debris, undercut banks, and Eurasian milfoil were present. Flashiness was evident at this station, as banks were scoured over 20 inches above the water surface. The water temperature (84º F) at the time of sampling was 12º F higher than at nearby Station 8, which was sampled on the same date. The upstream portion of this station had wet meadow habitat, which lacked large trees in the riparian area. The lower half contained intact forest, which provides good canopy cover.

Station 11 was sampled near Willow Woods Lane (Figure 5). The macroinvertebrate community scored low acceptable (-4) and habitat scored good (129). Twenty-two different taxa were collected, of which two were Ephemeroptera and one was Trichoptera, indicating low water and habitat quality. Amphipoda, Isopoda, and Hydropsychidae were the dominant taxa collected. Amphipoda and Hydropsychidae have a tendency to dominate in degraded to moderately degraded habitats, and Isopoda are somewhat tolerant to organic pollution (Voshell, 2002). The macroinvertebrate community scores had increased at this station in 2009 and 2011, but this latest score is the lowest that has been recorded for that station (Table 5). This station is in a section of Carrier Creek where artificial meanders were constructed as part of the restoration effort. Artificial riffles and rock substrate were also installed at this station. The rocks and gravel

were embedded by fine sediment and the majority of the stream substrate was hard pan clay and silt. Besides the rocks, other habitat types such as large woody debris, undercut banks, and macrophytes were sparse. The station showed signs of flashiness with bank scour occurring greater than 20 inches above the water surface. On some of the banks where erosion control netting had been installed to stabilize the banks, erosion was occurring behind the netting and the nets were slumping into the stream (Figure 7). The immediate riparian area contained some forest and meadow, as well as some residential lawns. Large trees to provide canopy cover are lacking because the restoration activities, which occurred less than two decades ago, required clearing land along the stream.

Figure 7. Exposed erosion control netting at Station 11.

Station 9, was sampled at Old River Trail, just upstream of Carrier Creek's confluence with the Grand River (Figure 5). The macroinvertebrate community scored acceptable (-1) and habitat scored good (152). The macroinvertebrate score at this station was the highest score in Carrier Creek and was the same as the score that was reported in 2011 (Table 5). Sixteen different taxa were collected, of which two were Ephemeroptera and one was Trichoptera, indicating poor-intermediate water and habitat quality. The macroinvertebrate community was dominated by Amphipoda and Hydropsychidae. The stream bottom is mostly covered with cobble that was artificially placed in the stream and several riffles composed of large boulders are present (Figure 8). Other than the rocks, habitat types such as large woody debris, undercut banks, and overhanging vegetation were either sparse or absent. The banks did show signs of flashiness with scoured banks 9-18 inches above the water surface. Also noteworthy is that the

water temperature at the time of sampling was 86º F (air temperature was 68º F). A rain event had occurred the night before we sampled so the high water temperature may have been a result of warm runoff water entering the stream (Marsalek et al., 2008). Along the right bank the riparian area had intact forest. Along the left bank was a residential lot. Both sides had large mature trees, which provide good canopy cover. The greater surrounding area contains a mix of land use including a large park, residential areas, and a WWTP (which discharges to the Grand River).

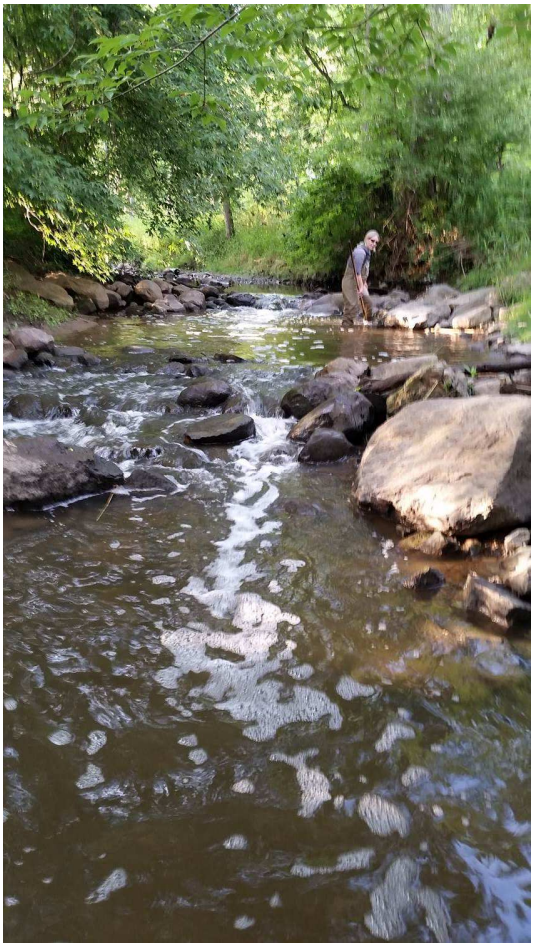

Figure 8. Carrier Creek upstream of Old River Trail.

Objective 6. Indian Mill Creek (lower Grand River watershed) Sediment Sampling

Indian Mill Creek is a tributary to the lower Grand River that flows through Alpine Township, the city of Walker, and the city of Grand Rapids. The lower section of Indian Mill Creek is not attaining its coldwater fishery designated use (Rippke, 2011). The lower section of Indian Mill Creek flows through a heavily urbanized section of Grand Rapids. Adjacent to Indian Mill Creek are large auto salvage yards and metal processing facilities. Because of concerns about contamination from these facilities and elsewhere throughout the watershed, sediment samples were taken from three stations within the city of Grand Rapids: Richmond Dam, Tamarack Avenue NW, and Turner Avenue NW.

The sediment results for organics and metals are presented in Table 7. The sediment chemistry results were analyzed three different ways using three different lines of evidence: Equilibrium Partitioning Sediment Benchmark Toxicity Units (ESBTU), Probable Effects Concentration Quotient (PEC-Q), and the Sediment Toxicity of Petroleum Hydrocarbon Fractions using the DRO and ORO data. All of these lines of evidence were normalized based on the total organic carbon content in the sediments, which were 1.1% for Richmond Dam and Tamarack Avenue NW, and 1.0% for Turner Avenue NW.

ESBTU

ESBTU for the 17 PAHs at the Richmond Dam, Tamarack Avenue NW, and Turner Avenue NW stations were 0.85, 0.48, and 0.97, respectively. Typically, a PAH ESBTU less than, or equal to, 1 indicates that benthic organisms are not expected to be harmed by contamination present in the sediments (USEPA, 2003). However, because the total scan of 34 PAHs was not carried out, a correction factor to determine the 95% confidence level was applied to the summation of the 17 hydrocarbons. Therefore the ESBTUs after the correction factor are: 7.29, 4.17, and 8.35 for the Richmond Dam, Tamarack Avenue NW, and Turner Avenue NW stations, respectively. This would suggest that the current concentrations of PAHs may be having detrimental effects on the benthic communities.

PEC-Q

The PEC-Q calculation results in a risk to benthic fauna if the value is greater than 0.5, which is equivalent to 64% to 94% of the organisms not showing a toxic effect. Because the PEC_{PAH} values for the Richmond Dam, Tamarack Avenue NW, and Turner Avenue NW stations were 0.25, 0.14, and 0.29, respectively, we do not expect a detrimental effect on the benthic community. Also, when the metals were analyzed using the PEC-Q analysis, the Richmond Dam, Tamarack Avenue NW, and Turner Avenue NW stations were found to have results of 0.05, 0.06, and 0.06, respectively. Again suggesting no detrimental benthic community effects from metals.

Sediment Toxicity of Petroleum Hydrocarbon Fractions

When analyzing the DRO/ORO data, a Sample Specific Risk Screening Level (SSRSL) was developed based on the MADEP (2007) sediment benchmark recommendations. The DRO SSRSL was exceeded at both the Richmond Dam and Turner Avenue NW stations while the ORO SSRSL was exceeded at all three stations, suggesting a potential risk to the benthic communities.

When analyzing the three lines of evidence for the organic contaminants, two out of the three suggested that there could be detrimental effects on benthic invertebrates, given the low amount of total organic carbon to bind the contaminants. Many of the metals were either not detected or were below the Threshold Effects Concentration (TEC). The TEC is the concentration below which adverse effects are not expected to occur in benthic (bottom-dwelling) biological communities (MacDonald et al., 2000).

Table 7. Sediment chemistry results for Indian Mill Creek. ND = not detected.

Site Type	Targeted	Targeted	Targeted
Waterbody Name	Indian Mill Creek	Indian Mill Creek	Indian Mill Creek
Location	Richmond Dam	Richmond Park	Turner ST
STORET	410818	410674	410119
Total Organic Carbon (%)	1.1	1.1	1.0
Organics-DRO/ORO (µg/kg)			
Diesel Range Org(C10-C20)	55000	31000	52000
Oil Range Organics (C20-C34)	310000	120000	400000
Organics-Semivolatiles (µg/kg)			
2-Methylnaphthalene	ND	ND	ND
Acenaphthene	ND	ND	ND
Acenaphthylene	ND	ND	ND
Anthracene	ND	ND	ND
Benz[a]anthracene	320	ND	360
Benzo[a]pyrene	ND	ND	ND
Benzo[b]fluoranthene	750	ND	820
Benzo[g,h,i]perylene	ND	ND	ND
Benzo[k]fluoranthene	ND	ND	ND
Chrysene	510	290	550
Dibenz[a,h]anthracene	ND	ND	ND
Fluoranthene	1200	480	1300
Fluorene	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	ND
Naphthalene	ND	ND	ND
Phenanthrene	420	ND	460
Pyrene	810	350	980
Inorganics-Metals (mg/kg)			
% Total solids	63	80.4	67.1
Arsenic	2.0	2.5	2.3
Barium	32.0	24.0	30.0
Cadmium	ND	ND	ND
Chromium	6.7	5.4	9.2
Copper	6.7	4.3	9.5
Lead	8.4	22.0	13.0
Mercury	ND	ND	ND
Selenium	ND	ND	0.3
Silver	ND	ND	ND
Zinc	39.0	32.0	49.0

7. Future Monitoring Recommendations

SWAS staff recommend the following sampling be conducted in 2021:

- Six upper Grand River and three Red Cedar River trend stations.
- The macroinvertebrate communities of the five Carrier Creek stations sampled in this study (Table 3).
- Sediment and water analysis for metal content in Huntoon Creek at Bellevue Street to ensure that metal contamination from an upstream plating factory fire did not contaminate the stream.
- As a follow-up to poor fish community found in 1996, Doan Creek in the vicinity of Holt Road should be resampled for fish in the future.
- Indian Mill Creek sediment will be resampled at the same three sites in 2017. Sediment toxicity tests will be performed on the sediment and the sediment will be analyzed for 34 PAHs.

8. Detailed Descriptions of Survey Results

Upper Grand River – Station Descriptions

Skinner Extension Drain-Grand River

The Skinner Extension Drain-Grand River subwatershed has lost a significant amount of wetlands (41%) and is highly agricultural in land cover (57%). This subwatershed was sampled at two stations on the main stem Grand River; Riverbend Natural Area (Station 5), and at Waverly Road (Delhi Charter Township; Station 7). No smaller tributaries were sampled.

Station 5, the Grand River at Riverbend Natural Area, is geographically close to Waverly Road, and in past reports (Holden, 2007 and 2012) is described as “Grand River off Waverly Rd.” The macroinvertebrate community scored excellent (5) and habitat scored good (124). The macroinvertebrate score is similar to scores reported in 2006 (6; Holden, 2007) and 2011 (6; Holden, 2012). In 2006, habitat scored excellent (155; Holden, 2007) and in 2011 the habitat scored the same as the results in the latest biosurvey (124; Holden, 2012). Thirty-one different taxa were collected at Station 5, including four Ephemeroptera and four Trichoptera taxa, indicating good water and habitat quality. Gomphidae was the dominant taxa collected, although it only comprised 16.6% of the community. According to Voshell (2002), Gomphidae are generally sensitive to stressors. In the thalweg of the river, the bottom substrate is largely cobble. Along the margins of the river is mostly sand and silt, with some gravel. Station 5 is located at a large bend in the Grand River near a popular nature trail with a canoe landing and a lookout deck on the erosional bank. Given the lack of large rocks along the bank and on the surrounding landscape, the rocks that we observed were likely artificially placed in the river at some point, possibly to protect the canoe landing and deck structures. A couple of log jams were present, but other habitat types such as undercut banks and macrophytes were absent. The banks are high at Station 5 and actively eroding. In some spots, foot traffic from park visitors, off of designated trails, is exacerbating bank erosion. The immediate riparian area consists of mostly intact forest. The greater surrounding area contains a mix of forest, agriculture, and low-density residential land use.

The main stem Grand River was also sampled at Waverly Road in Delhi Charter Township (Station 7). The macroinvertebrate community scored excellent (8) and habitat scored good

(145). These results were similar to past findings at this station. Goodwin (2000) reported excellent fish and macroinvertebrate communities in 1996 and Rockafellow (2003a) reported an excellent macroinvertebrate community in 2001. Both of the previous biosurveys had used a different scoring methodology than this most recent one. In this latest survey, 30 different taxa were collected, of which 15 were EPT taxa, indicating good water quality. Hydropsychidae dominated the macroinvertebrate community. Hydropsychidae are facultative (occur in wide-ranging environments), but tend to dominate in rivers with moderate amounts of nutrients and/or organic matter (Voshell, 2002). The Grand River is approximately 170-feet wide at this station, but was only about a foot deep at the time of sampling. The river was also warm (82º F). The bottom substrate was mostly cobble (75% visual estimate) with some sand and gravel interspersed. Scattered throughout the station were also numerous large boulders (Figure 9). Other habitat types such as large woody debris, undercut banks, and rootwads were sparse, although macrophytes were dense in the river (Figure 9). Large trees were present along the immediate riparian land, although residential lots made up all of the land use on both sides of the river. The greater surrounding area is a mix of residential and agricultural land use, with some forested areas near the river.

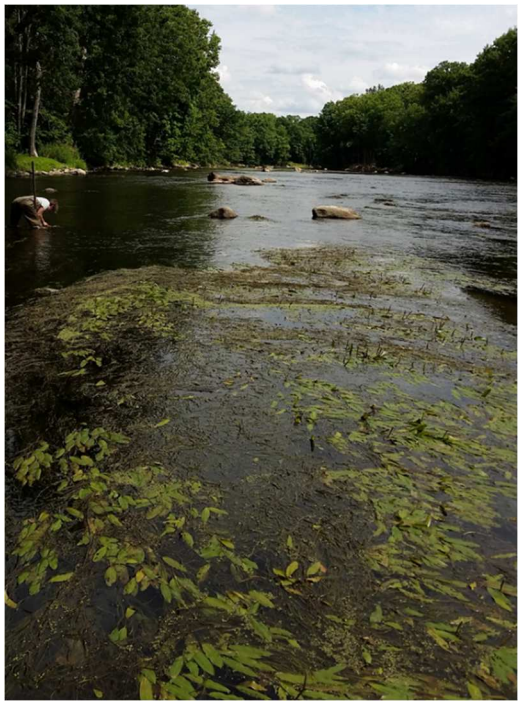

Figure 9. Grand River upstream of Waverly Road in Delhi Charter Township (Station 7).

Huntoon Creek

The Huntoon Creek subwatershed is highly agricultural (66%) and has lost a high amount of its presettlement wetland area (42%) in order to expand agriculture, resulting in the common use of field tiles as artificial drainage. Huntoon Creek was sampled at Bellevue Street in the village of Leslie (Station 12). The macroinvertebrate community scored acceptable (-1) and habitat scored good (112). Twenty different taxa were collected, of which two were Ephemeroptera and four were Trichoptera, indicating intermediate water quality. These results were similar to those reported by Rippke (2009; macroinvertebrates: -2 and habitat: 93). Amphipoda dominated the macroinvertebrate community (60%). Amphipoda are highly pollution and disturbance tolerant and typically if they are the dominant taxa, that is an indication of disturbance. The bottom

substrate was mostly sand with some gravel. Some cobble and a few boulders were also present. Large woody debris was moderately available, but other habitat types such as undercut banks and overhanging vegetation were either sparse or absent. All of the headwater tributaries, and Huntoon Creek itself, are channelized and managed as county drains for their entire lengths in Ingham County. As such, the stream channel at Station 12 was channelized. The stream banks showed signs of flashiness with stream banks eroded more than two feet above the water surface. Large trees are along the immediate stream bank, which provide good canopy cover; however, riparian vegetation is diminished by a residential lot on the left bank and a commercial lot on the right bank. The greater surrounding area consists of urbanized land use in the village of Leslie and beyond the village is a mix of agricultural and low-density residential land use.

This station is located just downstream of a former plating company. The company, which had been in operation since 1973, had been a source of total and hexavalent chromium groundwater contamination because of improper disposal practices. In July 2014 the facility was destroyed by a fire and may have released chemicals into the ground. Starting in the spring of 2017, the station will have groundwater samples collected and the contaminated soil will be removed from the station and replaced with clean fill. Rippke (2009) performed biosurveys and collected water and sediment samples below the facility in 2008. No exceedances of WQS or sediment consensus-based TECs were detected by Rippke (2009). The macroinvertebrate communities scored low acceptable in 2008, which Rippke (2009) attributed to poor habitat conditions rather than venting of contaminated groundwater to Huntoon Creek. This station was one of the random status stations sampled in the watershed and was not targeted because of the plating facility and potential contamination from it after the 2014 fire. The low acceptable score in 2016 may have been a result of the flashiness of the stream rather than from chemical contamination.

Western Creek-Grand River

The dominant land covers in the Western Creek-Grand River subwatershed are natural cover types (42%). Natural land cover types include forest, wetland, and grass/shrub land. Despite this, 18% of presettlement wetland area has been lost. Seventy-two percent of the rivers in this watershed have natural riparian vegetated buffers, providing protection from pollutants in runoff and erosion. This subwatershed was sampled at Shaw Branch at Olds Road in Bunker Hill Township (Station 13). The Shaw Branch is an Intercounty Drain and is referred to as the Freeman-Marsh Intercounty Drain by the Ingham and Jackson County Drain Commissions. Despite being channelized, with laminar flow, the Shaw Branch did not appear to be too flashy (the bank was only scoured 4-8 inches above the water surface). This could be because of the natural land cover and riparian buffers that are prevalent in this subwatershed. The macroinvertebrate community scored low acceptable (-3) and the habitat scored marginal (89). Twenty-five different taxa were collected. Other than 2 individuals (a Hydropsychidae and a Limnephilidae larvae), no other EPT taxa were collected, indicating poor water and habitat quality. Dytisidae larvae and adults dominated the macroinvertebrate community and surface air breathing taxa made up 61% of the fauna collected. Dytisidae beetles are adapted to live in stagnant conditions and are somewhat tolerant to stressors (Voshell, 2002). The drain was shallow (average depth < 1 foot) and slow moving at the time of sampling (0.1 feet per second). The substrate was all soft silt and the drain was devoid of macrophytes, undercut banks, and rootwads. Large woody debris was sparsely available, otherwise the only stable habitat was moderate amounts of overhanging vegetation on the left bank. Along the left bank is an intact forest-marsh complex, but other than some small trees, riparian vegetation is absent along the right bank. Forty feet away from the drain, on the right bank, is a horse pasture on a farm lot.

Bateese Creek

The Bateese Creek subwatershed has more natural cover (48%), than any other subwatershed in this study. Like Shaw Branch, the Bateese Creek station did not exhibit signs of flow flashiness or excess sedimentation. Bateese Creek was sampled at Kennedy Road in Henrietta Township (Station 14). The macroinvertebrate community scored low acceptable (-3) and the habitat scored good (139). Twenty-five different taxa were collected, of which only 2 Ephemeroptera and 1 Trichoptera families were collected, indicating marginal water and habitat quality. Amphipoda and Isopoda dominated the macroinvertebrate communities at 38.8% and 37.5% of the total collected individuals, respectively. Bateese Creek serves as the outlet to Bateese Lake to the north of Station 14. Along the margins of Bateese Creek at Station 14 were areas of stagnant water with moderate amounts of organic matter and dense stands of lily pads. The sediment along the margins consisted of mostly silt and organic matter, and had an anaerobic odor. The area of main flow was mostly sand. A nuisance bloom of the filamentous algae *Cladophora* occupied about 80% (visual estimate) of the flowing water. Nuisance *Cladophora* blooms in lotic systems are typically indicative of high nutrient concentrations (e.g., Dodds et al., 1997). Other than the heavy amounts of macrophytes and *Cladophora* strands, other habitat types such as large woody debris and overhanging vegetation were sparse. Few trees were present due to the wetland nature of the riparian area immediately along both sides of Station 14. The greater surrounding area consists of a mix of forest, agriculture, low-density residential areas, and a large golf course.

Otter Creek-Spring Brook

The Otter Creek-Spring Brook subwatershed has high agricultural land cover (57%) with very little developed land (5%) and the lowest human population density (45 people per square mile) in this study. Despite the prevalence of agricultural land cover, most of the streams (70%) have a natural land cover riparian buffer. This is the case at Station 2, Spring Brook at Robbins Road in Springport Township, where the immediate riparian area consists of forest-wetland complex. The macroinvertebrate community scored acceptable (1) and the habitat scored good (146). This station is a trend site, and the macroinvertebrate community scores have been noticeably decreasing. For 2006, Holden (2007) reported a macroinvertebrate community score of 6 (excellent) and a habitat score of 174 (excellent). For 2011, Holden (2012) reported a macroinvertebrate community score of 3 (acceptable) and a habitat score of 137 (good). In 2016, 28 different taxa were collected, of which only 5 were Ephemeroptera or Trichoptera, indicating intermediate water quality. This is a notable decline from past surveys in 2006 and 2011 in which 12 and 7 Ephemeroptera and Trichoptera taxa were collected, respectively. In 2016 Amphipoda comprised 70% of the taxa that were collected. The percentage of Amphipoda has increased from previous biosurveys (4.4-9.5%). The bottom substrate was mostly sand and silt, with some cobble present. In 2016, no gravel was observed and undercut banks were sparse, while in previous surveys (2007 and 2012) some gravel had been observed. Large woody debris, rootwads, and overhanging vegetation were also heavy to moderate in the past and most recent biosurveys. The banks at Station 2 appeared to be stable, with little erosion occurring. There also did not appear to be any obvious signs of flashiness at this station. Based on the observed loss of gravel substrate and undercut banks, it appears that this station may be slowly receiving soft sediment from upstream that is filling in the station and reducing habitat complexity.

Perry Creek-Grand River

Outside of the Red Cedar River watershed, the Perry Creek-Grand River subwatershed has the highest agricultural land cover (66%). Only one-third of the streams in this subwatershed have

natural land cover in the immediate riparian zone, mainly due to row crop farming. Perry Creek was sampled downstream of Olds Road in Leslie Township (Station 3), where it is a county drain and is recognized as East Onondaga Drain by the Ingham County Drain Commissions. The macroinvertebrate community scored acceptable (-2) and habitat scored low good (108) at this trend site. The macroinvertebrate community scores were slightly lower than those reported in previous years: 1 (acceptable) in 2006 (Holden, 2007) and 0 (acceptable) in 2011 (Holden, 2012). Nineteen total taxa were collected, of which only 1 Ephemeroptera and 2 Trichoptera taxa were collected, indicating low water and habitat quality. Amphipoda made up the majority of the taxa (59.4%). The bottom substrate consisted of roughly equal parts sand and silt with very little gravel present. Overhanging vegetation was heavy at this station, and was some of the only habitat available for epifaunal colonization. There were a lot of downed trees that were resting over top of the stream. However, because the water depth was so low at the time of sampling (average depth = 0.6 feet), and the banks were high, the water did not reach many of the downed trees. Because it is a county drain, Station 3 did not exhibit much sinuosity. The past channelization is likely why the stream banks were artificially high and steep, which prevented trees from falling into the water. The immediate riparian area consists of forest, which provides good canopy cover.

Hurd Narvin Drain-Grand River

The main stem Grand River was sampled at West Monroe Street in the city of Jackson (Station 4). This subwatershed is 63% developed land cover, with only 7% agricultural cover. Twenty-eight percent of the subwatershed is impervious surface, making it the subwatershed with the second-most amount of impervious surfaces in this study. Flow flashiness, and the associated influx of pollutants from storm water, is an issue in this subwatershed. The river at this station was straightened from past channelization, the flow was laminar, and the banks were steep. The macroinvertebrate community scored acceptable (1) and habitat scored marginal (86). The macroinvertebrate scores were slightly lower than previous scores in 2006 (3; Holden, 2007) and 2011 (2; Holden, 2012). The habitat score was lower than those reported in 2006 (102; Holden, 2007) and 2011 (97; Holden, 2012). Twenty-three different taxa were collected, of which 3 were Ephemeroptera and 4 were Trichoptera, indicating intermediate water quality. Chironomidae larvae dominated the number of taxa collected, but only at 19% of the total individual macroinvertebrates collected. The second most abundant taxa were invasive *Corbicula* clams (16%). The percent of *Corbicula* collected is an increase from past surveys at that station: 2% in 2006 (Holden, 2007) and 0% in 2011 (Holden, 2012). Sousa et al. (2008) noted that *Corbicula* are found in a wide variety of habitats ranging from pristine to highly degraded, indicating that they may not be a useful indicator of stream condition. Sousa et al. (2008), in their review, found that *Corbicula* can reach high densities under certain conditions, which may displace native species and compete for resources. The bottom substrate was mostly sand with small amounts of gravel, cobble, and boulders. Other than the little gravel, habitat types such as large woody debris and macrophytes were sparse. No undercut banks or rootwads were observed. Field personnel also observed a slight sewage odor at the station. Along the left bank is a bicycle path with scattered, tall trees, providing some canopy cover, and a factory complex beyond that. Along the right bank are some residential lots.

North Onondaga Drain (Willow Creek)

The North Onondaga Drain subwatershed, also known as Willow Creek, is highly agricultural (68%) and about half of the riparian buffers are in natural land cover. This subwatershed is sparsely populated and has little development. North Onondaga Drain was sampled at Aurelius Road in Onondaga Township (Station 6). The macroinvertebrate community scored

acceptable (-2) and habitat scored good (117). The habitat score was slightly better than past scores in 2006 (85; Holden, 2007) and 2011 (78; Holden, 2012). The latest macroinvertebrate score is similar to past scores reported by Holden (2007; 2012) for 2006 (-3) and 2011 (-1). Twenty-five different taxa were collected. Of the macroinvertebrates collected, over half were Isopoda, snails, Hirudinea (leech), or air breathing taxa, indicating poor water quality. The drain is straightened from historic channelization and dredging. The bottom substrate was mostly sand and silt with very little gravel. About 25% (visual estimate) of Station 6 had thick stands of *Sparganium* (Bur-reed) macrophytes growing in the drain. Nuisance amounts of the filamentous algae *Cladophora* were present and covered any rocks and large woody debris that was present. Nuisance *Cladophora* blooms in lotic systems are typically indicative of high nutrient concentrations (e.g. Dodds et al., 1997). The immediate riparian area on both sides of the drain appeared to be marshy habitat. There are no large trees along the drain to provide any canopy cover.

Red Cedar River – Station Descriptions

Mud Creek

Mud Creek was sampled at Okemos Road in Alaiedon Township (Station 15) for the statewide trend analysis. The macroinvertebrate community scored low acceptable (-4) and habitat scored marginal (68). Corixidae and Belostomatidae were the most abundant taxa collected (52% and 29% of taxa collected, respectively), which are both very tolerant to stressors (Voshell, 2002). Two Ephemeroptera taxa were collected in low numbers, further indicating poor water and habitat quality. The macroinvertebrate community and habitat scores were similar to what Rippke (2008; 2013) reported for 2006 and 2011. The substrate at Station 15 was largely silt (90% visual estimate) and habitat types such as large woody debris, overhanging vegetation, and undercut banks were sparse. Mud Creek is managed as a county drain and has been historically channelized. Moderate amounts of bank erosion was occurring and bank scour was evident greater than 20 inches above the water surface, indicating flashy conditions. At this station, less than 10 feet of riparian vegetation exists on either bank, and that vegetation lacks large trees. Overall, this subwatershed lacks natural vegetated buffers on 55% of its river miles. The Mud Creek subwatershed is 66% percent agricultural land with very little development (6%).

Doan Creek

Doan Creek is a highly agricultural watershed, with 68% agricultural land cover and only 34% of its river miles have a naturally vegetated riparian buffer. Doan Creek was sampled at Swan Road in White Oak Township (Station 16). The macroinvertebrate community scored acceptable (-2) and habitat scored marginal (85). Twenty-five different taxa were collected, of which 2 were Ephemeroptera and 2 were Trichoptera, indicating marginal water and habitat quality. Amphipoda dominated the taxa collected, but only at 20% of the community sampled. Isopoda and 2 snail taxa, Physidae and Planorbidae, which all tend to be tolerant to stressors, made up 28% of the community. The macroinvertebrate community and habitat scores were similar to what Rippke (2008; 2013) reported for 2006 and 2011. The substrate was composed of all sand (70% visual estimate) and silt (30% visual estimate). Overhanging vegetation was heavy and aquatic macrophytes were moderately available as habitat. Doan Creek is channelized and is managed as a county drain. The creek at this station is shallow with no pool variability.

Sycamore Creek

The headwaters of the Sycamore Creek subwatershed were sampled at Stations 17, 18, and 29. This subwatershed is 24% developed land, 61% agricultural land, with very little natural land cover (15%; Table 1). This area also suffers from a very high loss of its presettlement wetlands area (43% loss). This combination of high stressors (agriculture, development, and wetland loss) makes this a particularly impacted subwatershed, especially since wetlands converted to agriculture are generally drained artificially by field tiles, increasing the flow flashiness as evidenced by bank scour seen at Stations 17 and 18. Bank erosion is a significant issue on the main stem of Sycamore Creek.

At Station 17 (Sycamore Creek at Holt Road), the macroinvertebrate community scored acceptable (0) and habitat scored marginal (84). Oligochaeta was the most abundant taxa collected and comprised 23% of the community. Oligochaeta are a diverse group of organisms with a wide range of tolerances, for the most part, though they tend to dominate in disturbed systems (Voshell, 2002). This most recent macroinvertebrate community score is an improvement from the scores reported at this station in 2006 (-2; Rippke, 2008) and 2011 (-5; Rippke, 2013). The bottom substrate was almost all silt (90% visual estimate). Large woody debris was moderately available, but all other habitat types such as undercut banks and overhanging vegetation was absent. Station 17 had heavy amounts of sedimentation and exhibited signs of flashiness with banks scoured greater than 20 inches above the water surface. Over half of the length of stream bank observed was devoid of vegetation and was actively eroding. The immediate riparian area is forested with large trees that provide good canopy cover.

Table 6. Macroinvertebrate results and scores at Sycamore Creek downstream of the Mason WWTP from 1973 to 2016.

	1973	1996	2001	2006	2016
Location	Mikula (1974)	Thelen (1999)	Rockafellow (2003 c)	Rippke (2008)	This report
Downstream of Mason WWTP	Only high densities of Chironomidae found	-5	0	-4	-1

Station 18, Sycamore Creek downstream of the Mason WWTP, has been sampled several times since Mikula (1974) first documented adverse impacts to the biological communities of Sycamore Creek below the Mason WWTP (Table 6). Mikula (1974) noted that, starting from the WWTP outfall, the stream bottom was covered with a black, anaerobic sludge that emitted a septic odor. This sludge covered the stream bottom as far downstream as the Harper Road crossing (2.5 miles downstream). Mikula (1974) also documented increases in various heavy metals below the WWTP, especially arsenic and nickel. Although macroinvertebrate community scores were not calculated at that time, Mikula (1974) only found high densities of Chironomidae larvae below the WWTP and no other macroinvertebrates. Clark (1990) sampled Sycamore Creek in 1989, but did not sample the station below the WWTP. However, Clark (1990) did sample at Harper Road and noted that there was no anaerobic sludge present at the time, which was likely a result of improvement upgrades at the WWTP. In 1996, Thelen (1999) sampled below the outfall and the macroinvertebrate community scored poor (-5), which was attributed to the WWTP, although no sludge deposits were reported. Macroinvertebrate scores at this station have since fluctuated from minimally acceptable to mid-range acceptable (Table 6).

At station 18, the macroinvertebrate community sampled in 2016 scored acceptable (-1) and habitat scored marginal (97). Twenty-two different taxa were collected at Station 18 including 1 Ephemeroptera and 3 Trichoptera taxa, indicating intermediate water and habitat quality. Hydropsychidae and Simulidae larvae dominated the macroinvertebrate community. This is the most Simulidae larvae (23% of the sample) observed at any station in this study. Some species of Simulidae will become abundant in areas with moderate inputs of nutrients or organic materials (although, no organic deposits or sewage odors were noted). The substrate at Station 18 was mostly sand (90% visual estimate) with very little gravel. Large woody debris and aquatic macrophytes were moderately available, but other habitat types were sparse. Over half the length of the banks that were observed lacked vegetative protection and were actively eroding with the banks scoured greater than 20 inches above the water surface. The macroinvertebrate and habitat scores found at this station were similar to others throughout the upper Grand River and Red Cedar River watershed (Table 1). The biggest issues at Station 18 now appear to be related to flashy flow conditions and sedimentation.

Willow Creek is managed as a county drain and has been historically channelized. Unlike Stations 17 and 18, the stream banks appeared to be stable and bank scour was minimal. The riparian area at this station is well vegetated with a tree and shrub canopy due to a restoration and preservation effort funded by Clean Water Act Section 319 funding. The macroinvertebrate community at Willow Creek at Toles Road (Station 29) scored low acceptable (-3) and habitat scored good (124). In this most recent biosurvey, 25 different taxa were collected, which only included 1 Ephemeroptera and 2 Trichoptera taxa, indicating poor water and habitat quality. Isopoda dominated the macroinvertebrate community (62%). Isopoda are somewhat tolerant to organic pollution (Voshell, 2002). The substrate was mostly sand, though small gravel patches were present. The stream was categorized as a riffle/run stream although the riffles were infrequent. Overhanging vegetation and aquatic macrophytes were moderately available; however, other habitat types such as undercut banks and large woody debris were sparse. This station has been previously sampled in 2006 and 2011 (Rippke, 2008 and 2013). The macroinvertebrate community scored poor (-6) in 2006 and acceptable (-1) in 2011.

Sloan Creek

Sloan Creek was sampled in two locations: at Legg Park off of Van Atta Road (Station 19) and Jolly Road in Meridian Township (Station 20). The Sloan Creek subwatershed is the most highly agricultural in this study (72%), with only 19% natural land covers (Table 1). It is a sparsely inhabited watershed with only 82 people per square mile, 9% developed land cover, and impervious surfaces are very low (2%). Sloan Creek is managed as a county drain and has been historically channelized. These stations showed signs of flashiness with the banks scoured 9-18 inches above the water surface and large sediment deposits were present. The bottom substrate at Stations 19 and 20 was mostly sand (80% visual estimate) and silt.

At Legg Park in Meridian Township (Station 19), the macroinvertebrate community in Sloan Creek scored acceptable (0) and habitat scored good (128). Amphipoda dominated the macroinvertebrate community (57%). Two Ephemeroptera and 3 Trichoptera taxa were collected indicating intermediate water and habitat quality. Rootwads were extensive throughout the station; however, other habitat types such as large woody debris and undercut banks were sparse. The immediate riparian area contains intact forest with large trees that provide dense canopy cover.

At Station 20, the macroinvertebrate community scored acceptable (-3) and habitat scored marginal (86). Eighteen different taxa were collected at Station 20, which only included

3 Trichoptera taxa, and Amphipoda dominated the community (38.6%), indicating poor to intermediate water and habitat quality.

Handy Howell Drain-Red Cedar River

The Handy Howell Drain-Red Cedar River headwaters subwatershed was sampled at Jewell Road in Marion Township (Station 21). This subwatershed is less agricultural that many of the rural subwatersheds in the Red Cedar River, with 43% in that land cover category, and 18% in developed land. This section of the Red Cedar River is managed as a county drain and is referred to as the "East Cedar River Drain" by the Livingston County Drain Commission. Despite being managed as a drain, there was some channel sinuosity at Station 21. Heavy sedimentation was noted and stream flashiness was evidenced by bank scour 9-18 inches above the water surface. The macroinvertebrate community scored high acceptable (3) and habitat scored low good (107). Twenty-seven different taxa were collected, of which 6 were Trichoptera and 1 was an Ephemeroptera, indicating intermediate water and habitat quality. Hydropsychidae dominated the macroinvertebrate community (35.5%). The substrate was mostly sand (80% visual estimate) and the rest was silt. Large woody debris was moderately available, but other habitat types such as undercut banks and overhanging vegetation were either sparse or absent.

Coon Creek – Red Cedar River

The Coon Creek – Red Cedar River subwatershed was sampled at 4 stations; 22 (Red Cedar River), 24 and 25 (unnamed tributaries), and 30 (Deer Creek). This subwatershed is characterized as 15% developed land and 58% agriculture. In general, many of the streams have naturally vegetated riparian buffers (67%). The substrates at these stations were mainly sand, with some silt.

The macroinvertebrate community at Station 22 (Red Cedar River at Grand River Avenue) scored acceptable (0) and habitat scored marginal (102). Twenty-one different taxa were collected including 7 EPT taxa, indicating intermediate water and habitat quality. However, Amphipoda made up the vast majority of the community, accounting for 85% of the macroinvertebrates collected. Rootwads were moderately available, but all other habitat types such as undercut banks and large woody debris were either sparse or absent. Despite the river being wide at the station (average width ~55 feet), the average depth was only 1.5 feet and the station lacked a variety of pool types. Areas of sedimentation were present and some evidence of flashiness was apparent with banks scoured 9-18 inches above the water surface.

An unnamed tributary to the Red Cedar River was sampled at Rowley Road in Williamston Township (Station 24). The macroinvertebrate community scored poor (-5) and habitat scored low good (115). Only seventeen different taxa were collected, which included 1 individual Ephemeroptera specimen and 1 individual Trichoptera specimen, indicating poor water and habitat quality. Amphipoda made up 82.8% of the community. The amount of large woody debris present was heavy. The stream was shallow (average depth 0.5 feet) and there was no pool variability. Although this stream is not currently managed as a drain, it appears to have been historically channelized, especially downstream of Rowley Road where it flows through a golf course. Along the right bank at Station 24 is a large, 175-foot channel that appears to have been artificially created; possibly to facilitate drainage of adjacent wetlands. The stream flows parallel to Rowley Road along its left bank for ~125 feet. Large trees are alongside the stream, which provide good canopy cover.

Atzinger Drain was sampled near the intersection of Corwin Road and East Grand River Avenue in the city of Williamston (Station 25). Erosion was a serious problem at this station, with portions of the bank slumping into the stream (Figure 10), and the banks are entirely mowed lawn (grass). The macroinvertebrate community scored low acceptable (-4) and habitat scored marginal (89). Twenty-one different taxa were collected, of which only 1 individual Ephemeroptera specimen was collected, indicating poor water and habitat quality. Oligochaeta and Coenagrionidae were the most abundant taxa collected. Oligochaeta are a diverse group of organisms with a wide range of tolerances, for the most part, though their dominance indicates a disturbed system (Voshell, 2002). Coenagrionidae are somewhat, to very, tolerant to stressors (Voshell, 2002). Although Atzinger Drain is a designated county drain, the watercourse at this station was sinuous and did not appear to have been dredged in recent years. The average depth of the drain was less than 1 foot with little pool variability.

Figure 10. Atzinger Drain near Corwin Road and East Grand River Avenue (Station 25).

Deer Creek is managed as a county drain and has been historically channelized. At Noble Road (Station 30), the macroinvertebrates scored acceptable (-1) and habitat scored marginal (79). This station had a low number of individual macroinvertebrates that were collected (75 individuals) after a regular sampling effort. Twenty-one different taxa were collected, of which only 2 were Ephemeroptera and 1 was a Trichoptera, indicating poor water and habitat quality. Large woody debris was moderately available, but other habitat types such as undercut banks and overhanging vegetation were sparse. Heavy sedimentation was present and flashiness was evident by the banks being scoured >20 inches above the water surface. Over half the length of

the banks observed at this station lacked vegetative protection and were actively eroding. Along the left bank is a residential lot that has diminished the riparian vegetation.

Squaw Creek

The Squaw Creek subwatershed is characterized as highly agricultural (70%) and moderately developed (12%) compared with the rest of the study area. Squaw Creek was sampled at Rowley Road in Locke Township (Station 23). The macroinvertebrate community scored low acceptable (-3) and habitat scored marginal (88). Twenty-two different taxa were collected, of which only 2 were Trichoptera indicating poor water and habitat quality. Amphipoda and Oligochaeta dominated the macroinvertebrate community. Oligochaeta are a diverse group of organisms with a wide range of tolerances, but for the most part, they tend to dominate in disturbed systems (Voshell, 2002). The bottom substrate was composed of mostly sand (80% visual estimate) and silt. Overhanging vegetation was moderately available; however, other habitat types such as large woody debris and undercut banks were sparse. Squaw Creek is managed as a county drain and was channelized at Station 23. The average stream depth was only a little over half a foot and there was no variability in pool depth. There was evidence of flashiness, with bank scour 9-18 inches above the water surface.

Pine Lake Outlet

Pine Lake Outlet subwatershed was sampled at Stations 26, 27, and 31. This subwatershed, relative to the rest of the study area, has very high developed land (41%) as well as high amounts of impervious surfaces (13%) resulting from the development. Having more developed land means that this watershed is impacted by extreme flashiness from storm drains from the roads and residential developments. The human population is among the highest in the upper Grand River and Red Cedar River study area, at 981 people per square mile.

Pine Lake Outlet (Station 26) was sampled at Haslett Road in Meridian Township. The macroinvertebrate community scored poor (-6) and habitat scored marginal (78). Only 14 different taxa were collected, which did not include any EPT, indicating poor water and habitat quality. Oligochaeta dominated the macroinvertebrate community (42%), followed by Turbellaria (21%). Oligochaeta may dominate in disturbed systems, and a high proportion of Turbellaria at a station is typically indicative of organic or nutrient pollution (Voshell, 2002). The substrate was mostly silt (90% visual estimate) and the remaining substrate was sand. All habitat types such as undercut banks and large woody debris were either sparse or absent. This water body is maintained as a county drain and was highly channelized. The average stream depth was less than a half-foot and there was no pool variability. Flashiness was evident with bank scour 9-18 inches above the water surface. Large trees are present along the banks, which provide good canopy cover. Along the left bank is a residential area, but along the right bank is some forested land. The greater surrounding area contains a mix of forest and residential land use.

Foster Drain was sampled at Tihart Road in Meridian Township (Station 27). The macroinvertebrate community scored acceptable (1) and habitat scored good (112). Twenty different macroinvertebrate taxa were collected, including 1 Ephemeroptera and 2 Trichoptera taxa. Amphipoda and Hydropsychidae dominated the macroinvertebrate community. The substrate was largely composed of sand (50% visual estimate) and silt (40% visual estimate). Overhanging vegetation was moderately available as habitat, but other habitat types such as undercut banks and large woody debris were either sparse or absent. Some sedimentation was present and flashiness was evident with the banks scoured 9-18 inches above the water surface. Foster Drain is maintained as a county drain; however, it did not appear to have been

dredged in the last couple decades. The riparian area was forested with large trees that provide good canopy cover. The greater surrounding area is a mix of forest and residential land use. A review of aerial photos over the last decade revealed increasing areas of subdivision development near Foster Drain, which are likely to increase the peak discharges in the water body.

Jeffries Drain was sampled at Cornell Road in Meridian Township (Station 31). Although this water body is a county drain, this station exhibited some sinuosity. Sedimentation was present, although this particular station did not show signs of flashiness. The riparian area is natural but the vegetation is mostly tall grass with large trees lacking. The macroinvertebrate community scored low acceptable (-3) and habitat scored good (135). Only 13 different taxa were collected, of which 1 individual Trichoptera specimen was found, indicating poor water and habitat quality. Amphipoda comprised 91% of the taxa collected. Overhanging vegetation was heavy and aquatic macrophytes (*Elodea* and *Ludwigia*) were moderately available. The substrate was composed of sand (90% visual estimate) and silt (10% visual estimate).

Kalamink Creek

The Kalamink Creek subwatershed (sampled at Van Orden Road - Station 28) has lost more of its presettlement wetland area than any other subwatershed in this study (57%). These wetlands were drained and are currently in agricultural land cover (69% of the subwatershed). The macroinvertebrate community scored acceptable (-1) and habitat scored marginal (104). These scores were very similar to those reported by Rippke (2008) for this station (macroinvertebrate community; 0, habitat 104). Twenty-six different taxa were collected, of which, 1 was an Ephemeroptera and 3 were Trichoptera. Amphipoda and Hydropsychidae were the most abundant taxa collected, which tend to dominate in moderately disturbed systems (Voshell, 2002). The substrate at this station was mostly gravel (35% visual estimate) and cobble (35% visual estimate), which is rare for Red Cedar River tributaries. A moderate amount of rootwads were available as macroinvertebrate habitat; however, other habitat types such as undercut banks and large woody debris were sparse. Kalamink Creek is managed as a county drain and has been historically channelized. Some evidence of flashiness was present with banks scoured 9-18 inches above the water surface. In several localized areas, drain pipes were protruding from the stream banks and had created large erosional gullies leading to the creek. The riparian vegetation is less than 10-feet wide on both banks with residential lots on both sides. Large trees are on both banks, which provide good canopy cover.

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Appendix 1. Qualitative macroinvertebrate results, by station, from 2016 study.

TAXA	Carrier Creek Off Williamsburg Rd 7/29/2016 STATION 1	Spring Brook Robbins Rd 7/27/2016 STATION 2	Perry Creek D/S Olds Rd 7/27/2016 STATION 3	Grand River W Monroe Ave 7/27/2016 STATION 4
PORIFERA (sponges)		1		
PLATYHELMINTHES (flatworms)				
Turbellaria	15			
ANNELIDA (segmented worms)				
Oligochaeta (worms)	1	1		30
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	36	209	165	32
Decapoda (crayfish)	4	1	1	3
Isopoda (sowbugs)	14			2
Arachnoidea				
Hydracarina				10
Insecta				
Ephemeroptera (mayflies)				
Baetidae		9	1	2
Heptageniidae		3		4
Tricorythidae				4
Odonata				
Anisoptera (dragonflies)				
Aeshnidae			3	
Gomphidae				1
Zygoptera (damselflies)				
Calopterygidae	5	22	5	1
Coenagrionidae				2
Hemiptera (true bugs)				
Corixidae	67	1	10	
Gerridae	2	1	1	
Mesoveliidae		4	1	
Notonectidae	1		1	
Megaloptera				
Corydalidae (dobson flies)		3		
Sialidae (alder flies)		1	2	
Trichoptera (caddisflies)				
Brachycentridae		1	2	9
Hydropsychidae	20	4	32	8
Leptoceridae	2	7		8
Polycentropodidae				5
Coleoptera (beetles)				
Dytiscidae (total)	6	1		1
Gyrinidae (adults)		2		
Hydrophilidae (total)		1	2	
Dryopidae				10
Elmidae	19	8	5	3
Scirtidae (larvae)		1		
Diptera (flies)				
Chironomidae	41	5	32	48
Dixidae		3		
Simuliidae			11	12
Stratiomyidae			1	
Tabanidae		1		
Tipulidae	2	4	1	
MOLLUSCA				
Gastropoda (snails)				
Lymnaeidae		1		
Physidae		1	2	3
Planorbidae		1		
Viviparidae				12
Pelecypoda (bivalves)				
Corbiculidae	6			41
Dreissenidae		1		
Sphaeriidae (clams)	17			
Unionidae (mussel)	1			
TOTAL INDIVIDUALS	259	298	278	251

Appendix 1.

METRIC	Carrier Creek Off Williamsburg Rd 7/29/2016 STATION 1 Value	Score	Spring Brook Robbins Rd 7/27/2016 STATION 2 Value	Score	Perry Creek D/S Olds Rd 7/27/2016 STATION 3 Value	Score	Grand River W Monroe Ave 7/27/2016 STATION 4 Value	Score
TOTAL NUMBER OF TAXA	18	0	28	1	19	0	23	0
NUMBER OF MAYFLY TAXA	0	-1	2	0	1	-1	3	0
NUMBER OF CADDISFLY TAXA	2	0	3	0	2	0	4	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	0.00	-1	4.03	0	0.36	-1	3.98	0
PERCENT CADDISFLY COMP.	8.53	0	4.03	0	12.23	0	11.95	0
PERCENT DOMINANT TAXON	25.97	0	70.13	-1	59.35	-1	19.12	1
PERCENT ISOPOD, SNAIL, LEECH	5.43	0	1.01	1	0.72	1	6.77	0
PERCENT SURF. AIR BREATHERS	29.46	-1	3.36	1	5.76	1	0.40	1
TOTAL SCORE		-4		1		-2		1
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Appendix 1.

TAXA	Grand River Off Waverly Rd (RiverBend Natural Area) 7/28/2016 STATION 5	North Onondaga Drain Aurelius Rd 7/28/2016 STATION 6	Grand River Waverly Rd 7/28/2016 STATION 7	Carrier Creek Saginaw Hwy 7/29/2016 STATION 8
PLATYHELMINTHES (flatworms)				
Turbellaria				1
ANNELIDA (segmented worms)				
Hirudinea (leeches)	1	4		
Oligochaeta (worms)	9	8	1	27
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	32	32	52	32
Decapoda (crayfish)	2		1	
Isopoda (sowbugs)	1	37		29
Arachnoidea				
Hydracarina		3	1	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	3	6	14	1
Caenidae	20		1	
Ephemeridae	1		3	
Heptageniidae	28		15	
Isonychiidae			7	
Tricorythidae			14	
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	3		1
Gomphidae	43	2		
Libellulidae				1
Zygoptera (damselflies)				
Calopterygidae	4	1		
Coenagrionidae		31		111
Plecoptera (stoneflies)				
Perlidae			1	
Hemiptera (true bugs)				
Belostomatidae		1		1
Corixidae	4	5		18
Gerridae	1			
Mesoveliidae	3		1	2
Nepidae		1		1
Pleidae				1
Megaloptera				
Sialidae (alder flies)	19	6		
Trichoptera (caddisflies)				
Brachycentridae	3		10	
Helicopsychidae			3	
Hydropsychidae	3		98	2
Hydroptilidae		1	3	
Leptoceridae	5	6	3	
Limnephilidae		1	2	
Molannidae	1			
Polycentropodidae			4	
Uenoidae			12	
Coleoptera (beetles)				
Dytiscidae (total)		1		1
Gyrinidae (adults)			1	1
Haliplidae (adults)		10		3
Psephenidae (adults)			3	
Scirtidae (adults)	1		1	
Dryopidae	1		2	
Elmidae	12	5	5	1
Haliplidae (larvae)		2		
Diptera (flies)				
Athericidae	2			4
Ceratopogonidae	2	2		
Chironomidae	33	20	3	14
Dixidae		1		
Simuliidae			4	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	2			1
Physidae	2	45		20
Planorbidae		38		
Pleuroceridae	1		6	
Pelecypoda (bivalves)				
Corbiculidae	14		1	
Sphaeriidae (clams)	5		1	1
TOTAL INDIVIDUALS	259	272	273	274

Appendix 1.

	Grand River Off Waverly Rd (RiverBend Natural Area) 7/28/2016 STATION 5		North Onondaga Drain Aurelius Rd 7/28/2016 STATION 6		Grand River Waverly Rd 7/28/2016 STATION 7		Carrier Creek Saginaw Ave 7/29/2016 STATION 8	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	31	1	25	1	30	1	23	0
NUMBER OF MAYFLY TAXA	4	1	1	-1	6	1	1	-1
NUMBER OF CADDISFLY TAXA	4	0	3	0	8	1	1	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	1	1	0	-1
PERCENT MAYFLY COMP.	20.08	1	2.21	-1	19.78	1	0.36	-1
PERCENT CADDISFLY COMP.	4.63	0	2.94	-1	49.45	1	0.73	-1
PERCENT DOMINANT TAXON	16.60	1	16.54	1	35.90	0	40.51	-1
PERCENT ISOPOD, SNAIL, LEECH	2.70	1	45.59	-1	2.20	1	18.25	-1
PERCENT SURF. AIR BREATHERS	3.47	1	6.62	1	2.20	1	10.22	0
TOTAL SCORE		5		-2		8		-7
MACROINV. COMMUNITY RATING		EXCELLENT		ACCEPT.		EXCELLENT		POOR

Appendix 1.

TAXA	Carrier Creek u/s Old River Tr 7/29/2016 STATION 9	Carrier Creek off North Ridge Crt 7/29/2016 STATION 10	Carrier Creek Willow Woods LN 8/1/2016 STATION 11	Huntoon Creek Bellevue St 8/2/2016 STATION 12
PLATYHELMINTHES (flatworms)				
Turbellaria	1	3	11	
ANNELIDA (segmented worms)				
Hirudinea (leeches)		2		2
Oligochaeta (worms)			1	
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	119	108	147	157
Decapoda (crayfish)	1	6	4	9
Isopoda (sowbugs)	24	51	52	18
Arachnoidea				
Hydracarina	1		1	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	7		2	4
Heptageniidae	3		1	16
Odonata				
Anisoptera (dragonflies)				
Aeshnidae		1	1	1
Zygoptera (damselflies)				
Calopterygidae		1		4
Coenagrionidae		34	2	
Hemiptera (true bugs)				
Belostomatidae		1	1	
Corixidae		12		1
Gerridae	1		1	4
Mesoveliidae			1	1
Notonectidae	1		1	
Pleidae		1		
Trichoptera (caddisflies)				
Hydropsychidae	120		53	17
Hydroptilidae				1
Limnephilidae				1
Uenoidae				6
Coleoptera (beetles)				
Dytiscidae (total)	2	2		
Elmidae	5	3	13	7
Psephenidae (larvae)			2	
Diptera (flies)				
Athericidae	39		1	1
Chironomidae	28	15	24	11
Simuliidae	2			1
Tipulidae	1			
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		3		
Physidae		2	1	
Planorbidae				1
Pelecypoda (bivalves)				
Corbiculidae		2	1	
Sphaeriidae (clams)		8	2	
TOTAL INDIVIDUALS	355	255	323	263

Appendix 1.

METRIC	Carrier Creek u/s Old River Tr 7/29/2016 STATION 9 Value	Score	Carrier Creek off North Ridge Crt 7/29/2016 STATION 10 Value	Score	Carrier Creek Willow Woods LN 8/1/2016 STATION 11 Value	Score	Huntoon Creek Bellevue St 8/2/2016 STATION 12 Value	Score
TOTAL NUMBER OF TAXA	16	0	18	1	22	0	20	0
NUMBER OF MAYFLY TAXA	2	0	0	-1	2	0	2	0
NUMBER OF CADDISFLY TAXA	1	-1	0	-1	1	-1	4	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	2.82	-1	0.00	-1	0.93	-1	7.60	0
PERCENT CADDISFLY COMP.	33.80	1	0.00	-1	16.41	0	9.51	0
PERCENT DOMINANT TAXON	33.80	0	42.35	-1	45.51	-1	59.70	-1
PERCENT ISOPOD, SNAIL, LEECH	6.76	0	22.75	-1	16.41	-1	7.98	0
PERCENT SURF. AIR BREATHERS	1.13	1	6.27	1	1.24	1	2.28	1
TOTAL SCORE		-1		-5		-4		-1
MACROINV. COMMUNITY RATING		ACCEPT.		POOR		ACCEPT.		ACCEPT.

Appendix 1.

TAXA	Shaw Branch Olds Rd 8/2/2016 STATION 13	Batteese Creek Kennedy Rd 8/2/2016 STATION 14
PORIFERA (sponges)		1
PLATYHELMINTHES (flatworms)		
Turbellaria		2
ANNELIDA (segmented worms)		
Hirudinea (leeches)		19
Oligochaeta (worms)		1
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	57	257
Decapoda (crayfish)	2	
Isopoda (sowbugs)		248
Insecta		
Ephemeroptera (mayflies)		
Baetidae		12
Caenidae		16
Odonata		
Anisoptera (dragonflies)		
Aeshnidae	2	
Libellulidae	13	5
Zygoptera (damselflies)		
Calopterygidae	3	
Coenagrionidae		64
Hemiptera (true bugs)		
Belostomatidae	4	2
Corixidae	20	14
Gerridae	1	1
Mesoveliidae	3	3
Naucoridae		1
Nepidae	3	1
Notonectidae	2	2
Veliidae	1	
Trichoptera (caddisflies)		
Hydropsychidae	1	1
Limnephilidae	1	
Coleoptera (beetles)		
Dytiscidae (total)	97	1
Gyrinidae (adults)	5	
Haliplidae (adults)	10	1
Hydrophilidae (total)	8	1
Noteridae (adults)	4	
Gyrinidae (larvae)	1	
Diptera (flies)		
Ceratopogonidae		3
Chironomidae	18	3
Culicidae	1	
Syrphidae	1	
MOLLUSCA		
Gastropoda (snails)		
Lymnaeidae	1	
Physidae	4	
Planorbidae		1
Valvatidae	1	
Pelecypoda (bivalves)		
Sphaeriidae (clams)		1
TOTAL INDIVIDUALS	264	661

Appendix 1.

METRIC	Shaw Branch Olds Rd 8/2/2016 STATION 13 Value	Score	Batteese Creek Kennedy Rd 8/2/2016 STATION 14 Value	Score
TOTAL NUMBER OF TAXA	25	1	25	1
NUMBER OF MAYFLY TAXA	0	-1	2	0
NUMBER OF CADDISFLY TAXA	2	0	1	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMP.	0.00	-1	4.24	0
PERCENT CADDISFLY COMP.	0.76	-1	0.15	-1
PERCENT DOMINANT TAXON	36.74	0	38.88	-1
PERCENT ISOPOD, SNAIL, LEECH	2.27	1	40.54	-1
PERCENT SURF. AIR BREATHERS	60.61	-1	4.08	1
TOTAL SCORE		-3		-3
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.

Appendix 1.

TAXA	Mud Creek Okemos Road 8/1/2016 STATION 15	Doan Creek Swan Road 8/1/2016 STATION 16	Sycamore Creek Holt Road 9/7/2016 STATION 17	Sycamore Creek d/s Outfall @ Cemetary 8/1/2016 STATION 18
PORIFERA (sponges)				1
ANNELIDA (segmented worms)				
Hirudinea (leeches)				10
Oligochaeta (worms)	1	1	49	23
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	5	60	14	9
Decapoda (crayfish)	3	5		
Isopoda (sowbugs)		21	5	4
Insecta				
Ephemeroptera (mayflies)				
Baetidae	2	3	13	
Caenidae		7		
Heptageniidae	8		14	1
Odonata				
Anisoptera (dragonflies)				
Aeshnidae		1		1
Libellulidae				1
Zygoptera (damselflies)				
Calopterygidae	8	5	22	10
Coenagrionidae	6	9	6	3
Hemiptera (true bugs)				
Belostomatidae	93	1		
Corixidae	167	17	9	3
Gerridae			3	4
Mesoveliidae	2		2	1
Notonectidae	1			
Pleidae	3			
Megaloptera				
Sialidae (alder flies)	2	1		
Trichoptera (caddisflies)				
Brachycentridae			8	
Hydropsychidae		4	12	71
Leptoceridae		1		1
Polycentropodidae				5
Coleoptera (beetles)				
Dytiscidae (total)	2	4	1	
Haliplidae (adults)		7		
Hydrophilidae (total)		2		
Dryopidae			27	3
Elmidae	2	22	17	4
Scirtidae (larvae)		1		
Diptera (flies)				
Chironomidae	3	13	4	32
Culicidae		1		
Simuliidae		1	3	58
Stratiomyidae	2		2	
Tipulidae	6			
MOLLUSCA				
Gastropoda (snails)				
Physidae	3	40	1	1
Planorbidae		22		
Pelecypoda (bivalves)				
Sphaeriidae (clams)		46		2
TOTAL INDIVIDUALS	319	295	212	248

Appendix 1.

METRIC	Mud Creek Okemos Road 8/1/2016 STATION 15 Value	Score	Doan Creek Swan Road 8/1/2016 STATION 16 Value	Score	Sycamore Creek Holt Road 9/7/2016 STATION 17 Value	Score	Sycamore Creek d/s Outfall @ Cemetary 8/1/2016 STATION 18 Value	Score
TOTAL NUMBER OF TAXA	19	0	25	1	19	0	22	0
NUMBER OF MAYFLY TAXA	2	0	2	0	2	0	1	-1
NUMBER OF CADDISFLY TAXA	0	-1	2	0	2	0	3	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	3.13	0	3.39	0	12.74	0	0.40	-1
PERCENT CADDISFLY COMP.	0.00	-1	1.69	-1	9.43	0	31.05	1
PERCENT DOMINANT TAXON	52.35	-1	20.34	0	23.11	0	28.63	0
PERCENT ISOPOD, SNAIL, LEECH	0.94	1	28.14	-1	2.83	1	6.05	0
PERCENT SURF. AIR BREATHERS	84.64	-1	10.85	0	8.02	0	3.23	1
TOTAL SCORE		-4		-2		0		-1
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Appendix 1.

TAXA	Sloan Creek Legg Park off Van Atta Road 9/12/2016 STATION 19	Sloan Creek Jolly Rd 9/7/2016 STATION 20	Red Cedar River Jewell Road 9/9/2016 STATION 21	Red Cedar River Grand River Avenue 9/12/2016 STATION 22
ANNELIDA (segmented worms)				
Oligochaeta (worms)	8	8	4	2
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	142	71	18	243
Decapoda (crayfish)	9	4	1	1
Isopoda (sowbugs)	1	12		5
Arachnoidea				
Hydracarina			1	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	6		6	3
Heptageniidae	4			4
Isonychiidae				1
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	2	3	2	
Gomphidae	1		2	1
Zygoptera (damselflies)				
Calopterygidae	26	48	25	5
Coenagrionidae	4	2		
Plecoptera (stoneflies)				
Perlidae				1
Hemiptera (true bugs)				
Belostomatidae	1			1
Gerridae	1	4	1	1
Mesoveliidae		1	4	
Nepidae	1			
Veliidae	1			1
Megaloptera				
Corydalidae (dobson flies)	1			
Sialidae (alder flies)			1	
Trichoptera (caddisflies)				
Brachycentridae			1	
Hydropsychidae	23	13	88	3
Leptoceridae	1			
Limnephilidae		1	1	
Molannidae			2	
Philopotamidae	1		4	1
Phryganeidae		3	1	1
Coleoptera (beetles)				
Dryopidae			24	2
Elmidae	2	6	5	8
Diptera (flies)				
Chironomidae	6	1	23	1
Dixidae		1		
Simuliidae	5		5	
Stratiomyidae			1	
Tabanidae	3	3	5	
Tipulidae			2	1
MOLLUSCA				
Gastropoda (snails)				
Physidae			1	
Planorbidae		1		
Viviparidae			2	
Pelecypoda (bivalves)				
Sphaeriidae (clams)		2	18	1
TOTAL INDIVIDUALS	249	184	248	287

Appendix 1.

	Sloan Creek Legg Park off Van Atta Road 9/12/2016 STATION 19		Sloan Creek Jolly Rd 9/7/2016 STATION 20		Red Cedar River Jewell Road 9/9/2016 STATION 21		Red Cedar River Grand River Avenue 9/12/2016 STATION 22	
METRIC	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	22	0	18	0	27	1	21	0
NUMBER OF MAYFLY TAXA	2	0	0	-1	1	0	3	0
NUMBER OF CADDISFLY TAXA	3	0	3	0	6	1	3	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	1	1
PERCENT MAYFLY COMP.	4.02	0	0.00	-1	2.42	-1	2.79	-1
PERCENT CADDISFLY COMP.	10.04	0	9.24	0	39.11	1	1.74	-1
PERCENT DOMINANT TAXON	57.03	-1	38.59	-1	35.48	0	84.67	-1
PERCENT ISOPOD, SNAIL, LEECH	0.40	1	7.07	0	1.21	1	1.74	1
PERCENT SURF. AIR BREATHERS	1.61	1	2.72	1	2.42	1	1.05	1
TOTAL SCORE		0		-3		3		0
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Appendix 1.

TAXA	Squaw Creek Rowley Road 9/9/2016 STATION 23	Unnamed Trib to Red Cedar River Rowley Road 9/9/2016 STATION 24	Atzinger Drain upstream of Corwin Road 9/9/2016 STATION 25	Pine Lake Outlet Haslett Road 9/15/2016 STATION 26
PLATYHELMINTHES (flatworms)				
Turbellaria		2		55
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1		20
Oligochaeta (worms)	64	6	63	109
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	94	212	22	21
Decapoda (crayfish)	3		48	
Isopoda (sowbugs)	2	15	2	
Arachnoidea				
Hydracarina			4	
Insecta				
Ephemeroptera (mayflies)				
Baetidae		1	1	
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	2			1
Zygoptera (damselflies)				
Calopterygidae	10		19	1
Coenagrionidae	3		60	
Hemiptera (true bugs)				
Belostomatidae	1			
Corixidae	5	1		
Gerridae		1		
Mesoveliidae	3	2	5	
Notonectidae	4	1	1	1
Pleidae	1		1	1
Megaloptera				
Sialidae (alder flies)	1			
Trichoptera (caddisflies)				
Hydropsychidae		1		
Limnephilidae	1			
Phryganeidae	3			
Coleoptera (beetles)				
Dytiscidae (total)	1	2	12	
Haliplidae (adults)			2	
Hydrophilidae (total)			1	
Dryopidae			1	
Elmidae		1		
Diptera (flies)				
Ceratopogonidae	4		5	2
Chironomidae	36	7	25	10
Culicidae			1	
Dixidae	1			
Tabanidae	1			
MOLLUSCA				
Gastropoda (snails)				
Hydrobiidae			2	10
Physidae	6	1	9	
Planorbidae		1		4
Viviparidae				1
Pelecypoda (bivalves)				
Sphaeriidae (clams)	2	1	4	25
TOTAL INDIVIDUALS	248	256	288	261

Appendix 1.

METRIC	Squaw Creek Rowley Road 9/9/2016 STATION 23 Value	Score	Unnamed Trib to Red Cedar River Rowley Road 9/9/2016 STATION 24 Value	Score	Atzinger Drain upstream of Corwin Road 9/9/2016 STATION 25 Value	Score	Pine Lake Outlet Haslett Road 9/15/2016 STATION 26 Value	Score
TOTAL NUMBER OF TAXA	22	0	17	0	21	0	14	0
NUMBER OF MAYFLY TAXA	0	-1	1	-1	1	0	0	-1
NUMBER OF CADDISFLY TAXA	2	0	1	-1	0	-1	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	0.00	-1	0.39	-1	0.35	-1	0.00	-1
PERCENT CADDISFLY COMP.	1.61	-1	0.39	-1	0.00	-1	0.00	-1
PERCENT DOMINANT TAXON	37.90	-1	82.81	-1	21.88	0	41.76	-1
PERCENT ISOPOD, SNAIL, LEECH	3.23	1	7.03	0	4.51	0	13.41	-1
PERCENT SURF. AIR BREATHERS	6.05	1	2.73	1	7.99	0	0.77	1
TOTAL SCORE		-3		-5		-4		-6
MACROINV. COMMUNITY RATING		ACCEPT.		POOR		ACCEPT.		POOR

Appendix 1.

TAXA	Foster Drain Tihart Road 9/15/2016 STATION 27	Kalamink Creek Van Orden Road 9/2/2016 STATION 28	Willow Creek Toles Road 9/7/2016 STATION 29	Deer Creek Noble Road 9/9/2016 STATION 30
PLATYHELMINTHES (flatworms)				
Turbellaria		1	5	
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1	1	
Oligochaeta (worms)	3	1	11	2
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	118	117	62	
Decapoda (crayfish)	1	1	1	4
Isopoda (sowbugs)	1	9	214	1
Arachnoidea				
Hydracarina			1	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	1	7	1	1
Heptageniidae				1
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	5	3	5	3
Zygoptera (damselflies)				
Calopterygidae	25	12	11	10
Coenagrionidae		1		1
Hemiptera (true bugs)				
Belostomatidae			1	
Corixidae		2		2
Gerridae	2		1	
Mesoveliidae	3			2
Nepidae				1
Veliidae		1	1	
Megaloptera				
Sialidae (alder flies)		1	1	
Trichoptera (caddisflies)				
Hydropsychidae	71	94	3	10
Leptoceridae		1		
Phryganeidae	5		1	
Polycentropodidae		1		
Coleoptera (beetles)				
Dytiscidae (total)			1	
Gyrinidae (adults)	2			
Hydrophilidae (total)		1		
Dryopidae		1	1	4
Elmidae	3	7	5	11
Diptera (flies)				
Athericidae		1		
Ceratopogonidae	1		1	
Chironomidae	14	1	10	11
Culicidae			1	
Simuliidae				1
Tabanidae	1		1	1
Tipulidae	1	9	1	2
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		1		2
Hydrobiidae	1			
Physidae	1	1	2	
Planorbidae		1		
Viviparidae				1
Pelecypoda (bivalves)				
Sphaeriidae (clams)	1	3		4
TOTAL INDIVIDUALS	260	279	343	75

Appendix 1.

METRIC	Foster Drain Tihart Road 9/15/2016 STATION 27 Value	Score	Kalamink Creek Van Orden Road 9/2/2016 STATION 28 Value	Score	Willow Creek Toles Road 9/7/2016 STATION 29 Value	Score	Deer Creek Noble Road 9/9/2016 STATION 30 Value	Score
TOTAL NUMBER OF TAXA	20	1	26	1	25	1	21	0
NUMBER OF MAYFLY TAXA	1	0	1	-1	1	0	2	0
NUMBER OF CADDISFLY TAXA	2	0	3	0	2	0	1	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	0.38	-1	2.51	-1	0.29	-1	2.67	-1
PERCENT CADDISFLY COMP.	29.23	1	34.41	1	1.17	-1	13.33	0
PERCENT DOMINANT TAXON	45.38	-1	41.94	-1	62.39	-1	14.67	1
PERCENT ISOPOD, SNAIL, LEECH	1.15	1	4.66	0	63.27	-1	5.33	0
PERCENT SURF. AIR BREATHERS	2.69	1	1.43	1	1.46	1	6.67	1
TOTAL SCORE		1		-1		-3		-1
MACROINV. COMMUNITY RATING		ACCEPT.		ACCEPT.		ACCEPT.		ACCEPT.

Appendix 1.

TAXA	Jeffries Drain Cornell Road 9/15/2016 STATION 31
PLATYHELMINTHES (flatworms)	
Turbellaria	6
ANNELIDA (segmented worms)	
Hirudinea (leeches)	1
ARTHROPODA	
Crustacea	
Amphipoda (scuds)	282
Arachnoidea	
Hydracarina	1
Insecta	
Odonata	
Anisoptera (dragonflies)	
Libellulidae	1
Zygoptera (damselflies)	
Calopterygidae	5
Coenagrionidae	8
Hemiptera (true bugs)	
Belostomatidae	1
Gerridae	1
Notonectidae	1
Trichoptera (caddisflies)	
Phryganeidae	1
Diptera (flies)	
Simuliidae	1
MOLLUSCA	
Pelecypoda (bivalves)	
Sphaeriidae (clams)	1
TOTAL INDIVIDUALS	310

METRIC	Jeffries Drain Cornell Road 9/15/2016 STATION 31 Value	Score
TOTAL NUMBER OF TAXA	13	0
NUMBER OF MAYFLY TAXA	0	-1
NUMBER OF CADDISFLY TAXA	1	0
NUMBER OF STONEFLY TAXA	0	-1
PERCENT MAYFLY COMP.	0.00	-1
PERCENT CADDISFLY COMP.	0.32	-1
PERCENT DOMINANT TAXON	90.97	-1
PERCENT ISOPOD, SNAIL, LEECH	0.32	1
PERCENT SURF. AIR BREATHERS	0.97	1
TOTAL SCORE		-3
MACROINV. COMMUNITY RATING		ACCEPT.

Appendix 2. Habitat evaluation for selected stations in the upper Grand and Red Cedar River watersheds, Eaton, Ingham, Jackson, and Livingston Counties, July-September, 2016.

	Carrier Creek		Spring Brook		Perry Creek		Grand River		Grand River	
	Off Williamsburg Rd		Robbins Rd		D/S Olds Rd		W Monroe Ave		Off Waverly Rd (RiverBend Natural Area)	
	GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL	
	STATION 1		STATION 2		STATION 3		STATION 4		STATION 5	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	6		11		8		7		11	
Embeddedness (20)*										
Velocity/Depth Regime (20)*										
Pool Substrate Characterization (20)**	11		10		11		13		11	
Pool Variability (20)**	8		12		3		3		10	
Channel Morphology										
Sediment Deposition (20)	10		13		13		8		13	
Flow Status - Maint. Flow Volume (10)	9		9		9		9		9	
Flow Status - Flashiness (10)	1		9		5		1		2	
Channel Alteration (20)	19		19		14		13		19	
Frequency of Riffles/Bends (20)*										
Channel Sinuosity (20)**	19		5		3		2		18	
Riparian and Bank Structure										
Bank Stability (L) (10)	5		9		5		3		5	
Bank Stability (R) (10)	5		9		5		7		3	
Vegetative Protection (L) (10)	5		10		7		5		5	
Vegetative Protection (R) (10)	2		10		7		5		5	
Riparian Veg. Zone Width (L) (10)	5		10		9		5		10	
Riparian Veg. Zone Width (R) (10)	10		10		9		5		3	
TOTAL SCORE (200):	115		146		108		86		124	
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		MARGINAL (MODERATELY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)	
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).										
Date:	7/29/2016		7/27/2016		7/27/2016		7/27/2016		7/28/2016	
Weather:	Sunny		Sunny				Sunny		Sunny	
Air Temperature:		Deg. F.		Deg. F.		Deg. F.		Deg. F.		Deg. F.
Water Temperature:	78	Deg. F.	80	Deg. F.	72	Deg. F.	76	Deg. F.		Deg. F.
Ave. Stream Width:	5.7	Feet	19.7	Feet	12.0	Feet	28.0	Feet	100	Feet
Ave. Stream Depth:	0.3	Feet	1.2	Feet	0.6	Feet	1.5	Feet	6	Feet
Surface Velocity:	1.5	Ft./Sec.	0.6	Ft./Sec.	0.8	Ft./Sec.	0.8	Ft./Sec.		Ft./Sec.
Estimated Flow:	2.3	CFS	13.3	CFS	5.8	CFS	35.1	CFS		CFS
Stream Modifications:	Relocated		None				None		Bank Stabilization	
Nuisance Plants (Y/N):	N		N		N		N		N	
Report Number:										
STORET No.:	230233		380456		330419		380085		330433	
Stream Name:	Carrier Creek		Spring Brook		Perry Creek		Grand River		Grand River	
Road Crossing/Location:	Off Williamsburg Rd		Robbins Rd		Olds Rd		W Monroe Ave		Off Waverly Rd (Birchfield Park)	
County Code:	23		38		33		38		33	
TRS:	04N03W15		01S03WS14		01N01W31		02S01W27		03N02W31	
Latitude (dd):	42.7310422		42.38468		42.43391		42.26525		42.6023	
Longitude (dd):	-84.6559573		-84.63487		-84.4735		-84.40987		-84.59364	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Warmwater		Warmwater		Warmwater		Warmwater		Warmwater	
USGS Basin Code:	4050004		4050004		4050004		4050004		4050004	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										
COMMENTS:										

Appendix 2.

	North Onondaga Drain		Grand River		Carrier Creek		Carrier Creek		Carrier Creek	
	Aurelius Rd		Waverly Rd		Saginaw HWY		u/s Old River Tr		off North Ridge Crt	
	GLIDE/POOL		RIFFLE/RUN		GLIDE/POOL		RIFFLE/RUN		GLIDE/POOL	
	STATION 6		STATION 7		STATION 8		STATION 9		STATION 10	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	11		15		8		15		15	
Embeddedness (20)*			19				19			
Velocity/Depth Regime (20)*			10				15			
Pool Substrate Characterization (20)**	13				11				11	
Pool Variability (20)**	2				7				10	
Channel Morphology										
Sediment Deposition (20)	17		15		13		15		16	
Flow Status - Maint. Flow Volume (10)	9		9		9		9		9	
Flow Status - Flashiness (10)	9		8		4		5		1	
Channel Alteration (20)	6		19		13		19		19	
Frequency of Riffles/Bends (20)*			10				19			
Channel Sinuosity (20)**	1				7				19	
Riparian and Bank Structure										
Bank Stability (L) (10)	9		9		7		5		8	
Bank Stability (R) (10)	9		9		7		5		8	
Vegetative Protection (L) (10)	7		6		7		4		8	
Vegetative Protection (R) (10)	7		6		7		8		8	
Riparian Veg. Zone Width (L) (10)	7		5		9		4		7	
Riparian Veg. Zone Width (R) (10)	10		5		9		10		10	
TOTAL SCORE (200):	117		145		118		152		149	
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)	
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).										
Date:	7/28/2016		7/28/2016		7/29/2016		7/29/2016		7/29/2016	
Weather:			Sunny		Rainy		Partly Cloudy		Partly Cloudy	
Air Temperature:		Deg. F.		Deg. F.		Deg. F.		Deg. F.		Deg. F.
Water Temperature:	62	Deg. F.	82	Deg. F.	72	Deg. F.	86	Deg. F.	84	Deg. F.
Ave. Stream Width:	11.0	Feet	170.0	Feet	14.3	Feet	13.0	Feet	8.7	Feet
Ave. Stream Depth:	0.7	Feet	1.0	Feet	1.2	Feet	1.1	Feet	1.0	Feet
Surface Velocity:	0.4	Ft./Sec.		Ft./Sec.	0.4	Ft./Sec.	1.3	Ft./Sec.	0.3	Ft./Sec.
Estimated Flow:	3.1	CFS		CFS	7.3	CFS	18.4	CFS	3.0	CFS
Stream Modifications:	None				None		Bank Stabilization		Relocated	
Nuisance Plants (Y/N):	Y		N		N		N		N	
Report Number:										
STORET No.:	330418		330467		230200		230136		230247	
Stream Name:	North Onondaga Drain		Grand River		Carrier Creek		Carrier Creek		Carrier Creek	
Road Crossing/Location:	Aurelius Rd		Waverly Rd		Saginaw HWY		u/s Old River Tr		off North Ridge Crt	
County Code:	33		33		23		23		23	
TRS:	01N02W11		03N02W30		04N03W10		04N03W03		04N03W10	
Latitude (dd):	42.4911		42.62208		42.74111		42.75955		42.74477	
Longitude (dd):	-84.52165		-84.60276		-84.64999		-84.65486		-84.652437	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Warmwater				Warmwater		Warmwater		Warmwater	
USGS Basin Code:	4050004		4050004		4050004		4050004		4050005	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										
COMMENTS:										

Appendix 2.

	Carrier Creek		Huntoon Creek		Shaw Branch		Batteese Creek	
	Willow Creek Dr		Bellevue St		Olds Rd		Kennedy Rd	
	RIFFLE/RUN		RIFFLE/RUN		GLIDE/POOL		GLIDE/POOL	
	STATION 11		STATION 12		STATION 13		STATION 14	
HABITAT METRIC								
Substrate and Instream Cover								
Epifaunal Substrate/ Avail Cover (20)	10		13		5		9	
Embeddedness (20)*	10		16					
Velocity/Depth Regime (20)*	15		14					
Pool Substrate Characterization (20)**					6		13	
Pool Variability (20)**					3		5	
Channel Morphology								
Sediment Deposition (20)	15		16		15		16	
Flow Status - Maint. Flow Volume (10)	9		9		9		9	
Flow Status - Flashiness (10)	1		1		6		9	
Channel Alteration (20)	18		6		11		15	
Frequency of Riffles/Bends (20)*	15		13					
Channel Sinuosity (20)**					1		13	
Riparian and Bank Structure								
Bank Stability (L) (10)	5		4		8		9	
Bank Stability (R) (10)	5		4		8		9	
Vegetative Protection (L) (10)	7		5		5		7	
Vegetative Protection (R) (10)	7		5		5		7	
Riparian Veg. Zone Width (L) (10)	9		5		5		9	
Riparian Veg. Zone Width (R) (10)	3		1		2		9	
TOTAL SCORE (200):	129		112		89		139	
HABITAT RATING:	GOOD (SLIGHTLY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		MARGINAL (MODERATELY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)	
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).								
Date:	8/1/2016		8/2/2016		8/2/2016		8/2/2016	
Weather:			Partly Cloudy		Partly Cloudy		Sunny	
Air Temperature:		Deg. F.		Deg. F.		Deg. F.		Deg. F.
Water Temperature:	86	Deg. F.	68	Deg. F.	80	Deg. F.	71	Deg. F.
Ave. Stream Width:	11.3	Feet	14.8	Feet	7.8	Feet	10.3	Feet
Ave. Stream Depth:	1.0	Feet	0.7	Feet	0.8	Feet	1.2	Feet
Surface Velocity:	0.2	Ft./Sec.	0.3	Ft./Sec.	0.1	Ft./Sec.	0.5	Ft./Sec.
Estimated Flow:	2.6	CFS	3.0	CFS	0.9	CFS	6.2	CFS
Stream Modifications:			Bank Stabilization		Canopy Removal		None	
Nuisance Plants (Y/N):	N		N		N		Y	
Report Number:								
STORET No.:	230199		330468		330469		380401	
Stream Name:	Carrier Creek		Huntoon Creek		Shaw Branch		Batteese Creek	
Road Crossing/Location:	Willow Creek Dr		Bellevue St		Olds Rd		Kennedy Rd	
County Code:	23		33		33		38	
TRS:	04N03W10		01N01W28		01N01E31		01S01E16	
Latitude (dd):	42.75237		42.4511		42.43553		42.38297	
Longitude (dd):	-84.65516		-84.42742		-84.35967		-84.31918	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Warmwater						Warmwater	
USGS Basin Code:	4050004		4050004		4050004		4050004	
* Applies only to Riffle/Run stream Surveys								
** Applies only to Glide/Pool stream Surveys								
COMMENTS:								

Appendix 2.

	Mud Creek		Doan Creek		Sycamore Creek		Sycamore Creek		Sloan Creek	
	Okemos Road		Swan Road		Holt Road		d/s Outfall @ Cemetary		Legg Park off Van Atta Road	
	GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		RIFFLE/RUN	
	STATION 15		STATION 16		STATION 17		STATION 18		STATION 19	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	3		6		7		11		10	
Embeddedness (20)*									10	
Velocity/Depth Regime (20)*									10	
Pool Substrate Characterization (20)**	6		13		6		6			
Pool Variability (20)**	3		3		3		8			
Channel Morphology										
Sediment Deposition (20)	6		13		4		8		5	
Flow Status - Maint. Flow Volume (10)	9		10		9		8		8	
Flow Status - Flashiness (10)	2		8		2		2		5	
Channel Alteration (20)	8		5		11		16		18	
Frequency of Riffles/Bends (20)*									18	
Channel Sinuosity (20)**	3		3		4		16			
Riparian and Bank Structure										
Bank Stability (L) (10)	5		8		8		2		6	
Bank Stability (R) (10)	5		8		8		2		6	
Vegetative Protection (L) (10)	7		3		2		5		7	
Vegetative Protection (R) (10)	7		3		2		5		7	
Riparian Veg. Zone Width (L) (10)	2		1		9		3		10	
Riparian Veg. Zone Width (R) (10)	2		1		9		5		8	
TOTAL SCORE (200):	68		85		84		97		128	
HABITAT RATING:	MARGINAL (MODERATELY IMPAIRED)		MARGINAL (MODERATELY IMPAIRED)		MARGINAL (MODERATELY IMPAIRED)		MARGINAL (MODERATELY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)	
	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).									
Date:	8/1/2016		8/1/2016		9/7/2016		8/1/2016		9/12/2016	
Weather:	Sunny		Sunny		Sunny		Sunny			
Air Temperature:		Deg. F.	70	Deg. F.		Deg. F.		Deg. F.		Deg. F.
Water Temperature:	73	Deg. F.	64	Deg. F.	74	Deg. F.	70	Deg. F.	60	Deg. F.
Ave. Stream Width:	15.3	Feet	7.0	Feet	36.7	Feet	15.7	Feet	18.0	Feet
Ave. Stream Depth:	1.2	Feet	0.6	Feet	1.6	Feet	0.6	Feet	0.6	Feet
Surface Velocity:	0.2	Ft./Sec.	1.4	Ft./Sec.	0.7	Ft./Sec.	1.1	Ft./Sec.	0.9	Ft./Sec.
Estimated Flow:	4.5	CFS	5.9	CFS	43.6	CFS	10.8	CFS	10.0	CFS
Stream Modifications:					Dredged					
Nuisance Plants (Y/N):	N		N		N		N		N	
Report Number:										
STORET No.:	330417		330432		330018		330154		330473	
Stream Name:	Mud Creek		Doan Creek		Sycamore Creek		Sycamore Creek		Sloan Creek	
Road Crossing/Location:	Okemos Road		Swan Road		Holt Road		d/s Outfall @ Cemetary		Legg Park off Van Atta Road	
County Code:	33		33		33		33		33	
TRS:	03N01WS33		02N02E32		03N01W19		02N01W05		04N01W35	
Latitude (dd):	42.6106		42.5191		42.6401		42.5872		42.69416	
Longitude (dd):	-84.433		-84.2287		-84.4827		-84.44513		-84.386448	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Warmwater		Warmwater		Warmwater		Warmwater			
USGS Basin Code:	4050004		4050004		4050004		4050004		4050004	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										
COMMENTS:										

Appendix 2.

	Sloan Creek		Red Cedar River		Red Cedar River		Squaw Creek		Unnamed Trib to Red Cedar River	
	Jolly Rd		Jewell Road		Grand River Avenue		Rowley Road		Rowley Road	
	GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL		GLIDE/POOL	
	STATION 20		STATION 21		STATION 22		STATION 23		STATION 24	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	5		6		8		5		6	
Embeddedness (20)*										
Velocity/Depth Regime (20)*										
Pool Substrate Characterization (20)**	6		6		6		8		6	
Pool Variability (20)**	5		8		5		3		5	
Channel Morphology										
Sediment Deposition (20)	10		5		8		6		7	
Flow Status - Maint. Flow Volume (10)	9		9		9		9		9	
Flow Status - Flashiness (10)	3		5		5		4		8	
Channel Alteration (20)	11		16		15		13		11	
Frequency of Riffles/Bends (20)*										
Channel Sinuosity (20)**	5		17		10		6		11	
Riparian and Bank Structure										
Bank Stability (L) (10)	8		8		8		7		10	
Bank Stability (R) (10)	8		7		5		7		10	
Vegetative Protection (L) (10)	5		7		6		6		9	
Vegetative Protection (R) (10)	5		7		6		6		9	
Riparian Veg. Zone Width (L) (10)	2		4		8		4		8	
Riparian Veg. Zone Width (R) (10)	4		2		3		4		6	
TOTAL SCORE (200):	86		107		102		88		115	
HABITAT RATING:	MARGINAL		GOOD		MARGINAL		MARGINAL		GOOD	
	(MODERATELY		(SLIGHTLY		(MODERATELY		(MODERATELY		(SLIGHTLY	
	IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)		IMPAIRED)	
	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).									
Date:	9/7/2016		9/9/2016		9/12/2016		9/9/2016		9/9/2016	
Weather:	Rainy		Cloudy		Sunny		Cloudy		Partly Cloudy	
Air Temperature:		Deg. F.	70	Deg. F.		Deg. F.		Deg. F.		Deg. F.
Water Temperature:	70	Deg. F.	69	Deg. F.	68	Deg. F.	70	Deg. F.	67	Deg. F.
Ave. Stream Width:	9.0	Feet	7.4	Feet	54.7	Feet	9.3	Feet	11.7	Feet
Ave. Stream Depth:	0.5	Feet	0.4	Feet	1.5	Feet	0.7	Feet	0.5	Feet
Surface Velocity:	0.6	Ft./Sec.	0.6	Ft./Sec.	2.0	Ft./Sec.	0.2	Ft./Sec.	0.3	Ft./Sec.
Estimated Flow:	2.3	CFS	1.8	CFS	163.5	CFS	1.1	CFS	2.0	CFS
Stream Modifications:	Dredged				None		None			
Nuisance Plants (Y/N):	N		N		N		N		N	
Report Number:										
STORET No.:	330253		470665		330247		330474		330475	
Stream Name:	Sloan Creek		Red Cedar River		Red Cedar River		Squaw Creek		Unnamed Trib to Red Cedar River	
Road Crossing/Location:	Jolly Rd		Jewell Road		Grand River Avenue		Rowley Road		Rowley Road	
County Code:	33		47		33		33		33	
TRS:	03N01W01		02N04E09		04N01W25		04N02E32		04N01E35	
Latitude (dd):	42.68304		42.5677		42.7096		42.6936		42.6937	
Longitude (dd):	-84.38081		-83.9811		-84.364		-84.2422		-84.2868	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:	Warmwater									
USGS Basin Code:	4050004		4050004		4050004		4050004		4050004	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										
COMMENTS:										

Appendix 2.

	Atzinger Drain		Pine Lake Outlet		Foster Drain		Kalamink Creek		Willow Creek	
	upstream of Corwin Road		Haslett Road		Tihart Road		Van Orden Road		Toles Road	
	GLIDE/POOL		GLIDE/POOL		RIFFLE/RUN		RIFFLE/RUN		RIFFLE/RUN	
	STATION 25		STATION 26		STATION 27		STATION 28		STATION 29	
HABITAT METRIC										
Substrate and Instream Cover										
Epifaunal Substrate/ Avail Cover (20)	3		3		6		10		13	
Embeddedness (20)*					7		11		10	
Velocity/Depth Regime (20)*					13		10		7	
Pool Substrate Characterization (20)**	6		6							
Pool Variability (20)**	7		1							
Channel Morphology										
Sediment Deposition (20)	13		5		6		15		9	
Flow Status - Maint. Flow Volume (10)	9		7		9		9		10	
Flow Status - Flashiness (10)	9		3		4		3		7	
Channel Alteration (20)	16		11		13		13		10	
Frequency of Riffles/Bends (20)*					6		8		6	
Channel Sinuosity (20)**	12		3							
Riparian and Bank Structure										
Bank Stability (L) (10)	3		8		6		5		10	
Bank Stability (R) (10)	3		8		8		5		10	
Vegetative Protection (L) (10)	2		7		6		7		8	
Vegetative Protection (R) (10)	2		7		8		5		8	
Riparian Veg. Zone Width (L) (10)	2		2		10		2		7	
Riparian Veg. Zone Width (R) (10)	2		7		10		1		9	
TOTAL SCORE (200):	89		78		112		104		124	
HABITAT RATING:	MARGINAL (MODERATELY IMPAIRED)		MARGINAL (MODERATELY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)		MARGINAL (MODERATELY IMPAIRED)		GOOD (SLIGHTLY IMPAIRED)	
	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).									
Date:	9/9/2016		9/15/2016		9/15/2016		9/2/2016		9/7/2016	
Weather:	Partly Cloudy				Sunny		Partly Cloudy		Sunny	
Air Temperature:		Deg. F.		Deg. F.		Deg. F.		Deg. F.	75	Deg. F.
Water Temperature:	70	Deg. F.		Deg. F.	62	Deg. F.	65	Deg. F.	65	Deg. F.
Ave. Stream Width:	7.0	Feet	8.0	Feet	5.3	Feet	11.3	Feet	7.7	Feet
Ave. Stream Depth:	0.9	Feet	0.4	Feet	0.4	Feet	0.5	Feet	0.6	Feet
Surface Velocity:	0.3	Ft./Sec.	0.2	Ft./Sec.	0.7	Ft./Sec.	1.3	Ft./Sec.	1.0	Ft./Sec.
Estimated Flow:	1.8	CFS	0.5	CFS	1.6	CFS	6.6	CFS	4.5	CFS
Stream Modifications:	Canopy Removal				Dredged		Dredged		None	
Nuisance Plants (Y/N):	N		N		N		N		N	
Report Number:										
STORET No.:	330476		330477		330478		330431		330319	
Stream Name:	Atzinger Drain		Pine Lake Outlet		Foster Drain		Kalamink Creek		Willow Creek	
Road Crossing/Location:	upstream of Corwin Road		Haslett Road		Tihart Road		Van Orden Road		Toles Road	
County Code:	33		33		33		33		33	
TRS:	04N01E35		04N01W10		04N01W14		03N02E23		02N02W24	
Latitude (dd):	42.68767		42.7472		42.7337		42.6365		42.53854	
Longitude (dd):	-84.30234		-84.4157		-84.3983		-84.1842		-84.49035	
Ecoregion:	SMNITP		SMNITP		SMNITP		SMNITP		SMNITP	
Stream Type:							Warmwater		Warmwater	
USGS Basin Code:	4050004		4050004		4050004		4050004		4050004	
* Applies only to Riffle/Run stream Surveys										
** Applies only to Glide/Pool stream Surveys										
COMMENTS:										

Appendix 2.

	Deer Creek		Jeffries Drain				
	Noble Road		Cornell Road				
	GLIDE/POOL		GLIDE/POOL				
	STATION 30		STATION 31				
HABITAT METRIC							
Substrate and Instream Cover							
Epifaunal Substrate/ Avail Cover (20)	8		10				
Embeddedness (20)*							
Velocity/Depth Regime (20)*							
Pool Substrate Characterization (20)**	6		11				
Pool Variability (20)**	5		5				
Channel Morphology							
Sediment Deposition (20)	6		6				
Flow Status - Maint. Flow Volume (10)	9		10				
Flow Status - Flashiness (10)	2		10				
Channel Alteration (20)	13		11				
Frequency of Riffles/Bends (20)*							
Channel Sinuosity (20)**	3		16				
Riparian and Bank Structure							
Bank Stability (L) (10)	4		10				
Bank Stability (R) (10)	4		10				
Vegetative Protection (L) (10)	4		8				
Vegetative Protection (R) (10)	4		8				
Riparian Veg. Zone Width (L) (10)	3		10				
Riparian Veg. Zone Width (R) (10)	8		10				
TOTAL SCORE (200):	79		135				
HABITAT RATING:	MARGINAL		GOOD				
	(MODERATELY		(SLIGHTLY				
	IMPAIRED)		IMPAIRED)				
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).							
Date:	9/9/2016		9/15/2016				
Weather:			Cloudy				
Air Temperature:		Deg. F.	70	Deg. F.			
Water Temperature:		Deg. F.	58	Deg. F.			
Ave. Stream Width:	22.1	Feet	4.3	Feet			
Ave. Stream Depth:	1.4	Feet	0.5	Feet			
Surface Velocity:	0.8	Ft./Sec.	1.3	Ft./Sec.			
Estimated Flow:	25.1	CFS	2.9	CFS			
Stream Modifications:							
Nuisance Plants (Y/N):	N		N				
Report Number:							
STORET No.:	330387		330479				
Stream Name:	Deer Creek		Jeffries Drain				
Road Crossing/Location:	Noble Road		Cornell Road				
County Code:	33		33				
TRS:	03N01E14		04N01W14				
Latitude (dd):	42.65889		42.7376				
Longitude (dd):	-84.28856		-84.3929				
Ecoregion:	SMNITP		SMNITP				
Stream Type:	Warmwater						
USGS Basin Code:	4050004		4050004				
* Applies only to Riffle/Run stream Surveys							
** Applies only to Glide/Pool stream Surveys							
COMMENTS:							