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

BIOLOGICAL AND SEDIMENT CHEMISTRY SURVEYS OF SELECTED LOWER GRAND RIVER WATERSHED STREAMS IONIA, KENT, MONTCALM, MUSKEGON, AND OTTAWA COUNTIES, MICHIGAN AUGUST-SEPTEMBER 2019

Introduction

The biological integrity and physical habitat conditions of the lower Grand River (Hydrologic Unit Code (HUC) 04050006) and selected tributaries were surveyed during August and September 2019 by the Surface Water Assessment Section and Permits Section of the Michigan Department of Environment, Great Lakes, and Energy's (EGLE) Water Resources Division (WRD). The objectives of this study were to:

1. Evaluate the attainment status of the Other Indigenous Aquatic Life and Wildlife (OIALW) designated use.

2. Identify and investigate effects of nonpoint sources of pollution.

3. Satisfy monitoring requests submitted by internal and external customers.

4. Support Water Quality-Based Effluent Limit development for National Pollutant Discharge Elimination System (NPDES) permits.

Methods: The macroinvertebrate communities were assessed and scored with metrics that rate the communities on a scale from excellent to poor. Possible scores can range from 9 to -9. Stations with a score greater than or equal to +5 are considered excellent. Stations with a score less than or equal to -5 are classified as poor. Stations with a score of -4 through +4 are classified as acceptable (minimally to moderately impaired). Habitat evaluations are based on 10 metrics, with a possible maximum total score of 200. Stations are classified as excellent with a habitat score >154, good with a score between 105 and 154, marginal with a score between 56 and 104, and poor with a score <56.

Two site-selection methods were used to assess lower Grand River watershed streams in 2019: (1) stratified random; and (2) targeted. A probabilistic monitoring approach, using stratified random site selection to address statewide and regional questions about water quality, was used to select 7 sites within the lower Grand River watersheds. The sites were chosen randomly from a combined pool of streams that included this sampling area. Twenty-four sites were sampled to satisfy targeted monitoring requests that were submitted (described below). Four sites were sampled as part of the statewide trend program.

Summary Results of Monitoring Objectives

1. Evaluate the attainment status of the OIALW designated use.

Thirty-five different stations (status/trend and targeted combined) were sampled throughout the lower Grand River watershed. Of those 35 stations, 5 had poor macroinvertebrate community scores and 4 had poor fish community scores. The other stations ranged from low acceptable to excellent. Mill Creek had 4 stations that received poor fish and/or macroinvertebrate scores. Mill Creek has elevated nutrient concentrations and flashy flow conditions that likely impact the fish and macroinvertebrate communities. The macroinvertebrate community in Sand Creek at Luce Street scored poor. Further investigations into sediment contamination at that site were investigated in 2021 and are described below. Bass Creek at Pierce Street scored poor. Bass Creek is maintained as a county drain. Mill Creek is not attaining its OIALW or coldwater fishery designated uses.

Stations that received either poor or low acceptable scores often times had macroinvertebrate communities that were dominated by Amphipoda taxa. Amphipoda are facultative, meaning that they can occur in environments ranging from pristine to those containing moderate levels of pollution/disturbance. However, Amphipoda tend to dominate in systems exhibiting more disturbance (Voshell, 2002). Amphipoda also tend to be habitat generalists (Voshell, 2002) and were often found to be the most abundant taxa at stations that were lacking a wide variety of habitat types.

2. Identify and investigate effects of nonpoint sources of pollution.

During 2019 western Michigan received precipitation that was classified as “much above average” by the National Oceanic and Atmospheric Administration (NOAA) (ncdc.noaa.gov/temp-and-precip/us-maps). As a result, most of the streams that were visited by EGLE staff in the lower Grand River watershed displayed evidence of extremely high flows during storm events such as scoured banks, active erosion, and debris entangled in tree branches several feet above baseflow. Several subwatersheds in the lower Grand River are highly developed (Tables 1 and 2) and already experienced flashy storm flow patterns during normal precipitation years (Parker, 2016). Thus, the increased precipitation in 2019 likely exacerbated erosion and sedimentation in streams draining developed and agricultural areas.

During the spring of 2018 while investigating a nuisance algal growth complaint in Mill Creek, piles of manure were observed 50-100 feet away from the stream on an agricultural field. WRD staff filed a Right-to-Farm complaint with the Michigan Department of Agriculture and Rural Development (MDARD) and requested that the farmstead be investigated to determine whether the producers were conforming with generally accepted agricultural and management practices. The farmstead was visited by MDARD personnel, after which, the manure was incorporated into the field and the areas with the piled manure were re-seeded.

Nutrient concentrations in Mill Creek were elevated and were highest in the upstream reaches. The headwaters of Mill Creek begin as a network of linear drains in agricultural areas with minimal riparian vegetation.

Several other sites were sampled prior to proposed restoration activities and are described below.

3. Satisfy monitoring requests submitted by internal and external customers.

Rush, Plaster, Mill, Indian Mill, and Sand Creeks were all monitored either because best management practice (BMP) implementation is planned, or has been proposed, in each watershed. Almost all of the sites sampled in the abovementioned streams were characterized by evidence of flashy stream conditions, with banks heavily scoured and actively eroding. These conditions were also exacerbated in 2019 by record precipitation in western Michigan, most of which occurred in several heavy rain events. Macroinvertebrate community scores in those streams ranged from poor to acceptable (-6 to +1), fish community scores ranged from poor to acceptable (-8 to -2), and habitat scores ranged from marginal to excellent (65 to 157).

An unnamed tributary to Lloyds Bayou and Willow Hill Creek were sampled upstream and downstream of road crossings where culvert failures and subsequent sedimentation events had occurred. The macroinvertebrate scores at the unnamed tributary to Lloyds Bayou and Willow Hill Creek were acceptable and ranged from -4 to +1 and habitat ranged from good to excellent (121-161).

Attempts will be made to reassess sites in Rush, Plaster, Indian Mill, Mill, and Sand Creeks during the next cycle year if BMPs are implemented. Attempts will also be made to assess the unnamed tributary to Lloyds Bayou and Willow Hill Creek to assess any improvements over time following the sedimentation events.

Sediment samples were collected from Plaster Creek, an unnamed tributary to Plaster Creek, Egypt Creek, and Sand Creek. Plaster Creek samples were collected to inform future BMPs and whether sediment contamination would hamper future restoration efforts. Sand Creek was sampled after reports of unpermitted oil brine applications to nearby roads, and Egypt Creek was sampled to assess potential impacts of an abandoned landfill next to it. Most of the sites had non-detections (ND) for contaminants. The unnamed tributary to Plaster Creek had detectable concentrations of poly-aromatic hydrocarbons (PAH), but they are not expected to affect benthic invertebrates because of low amounts of organic carbon for the contaminants to bind to.

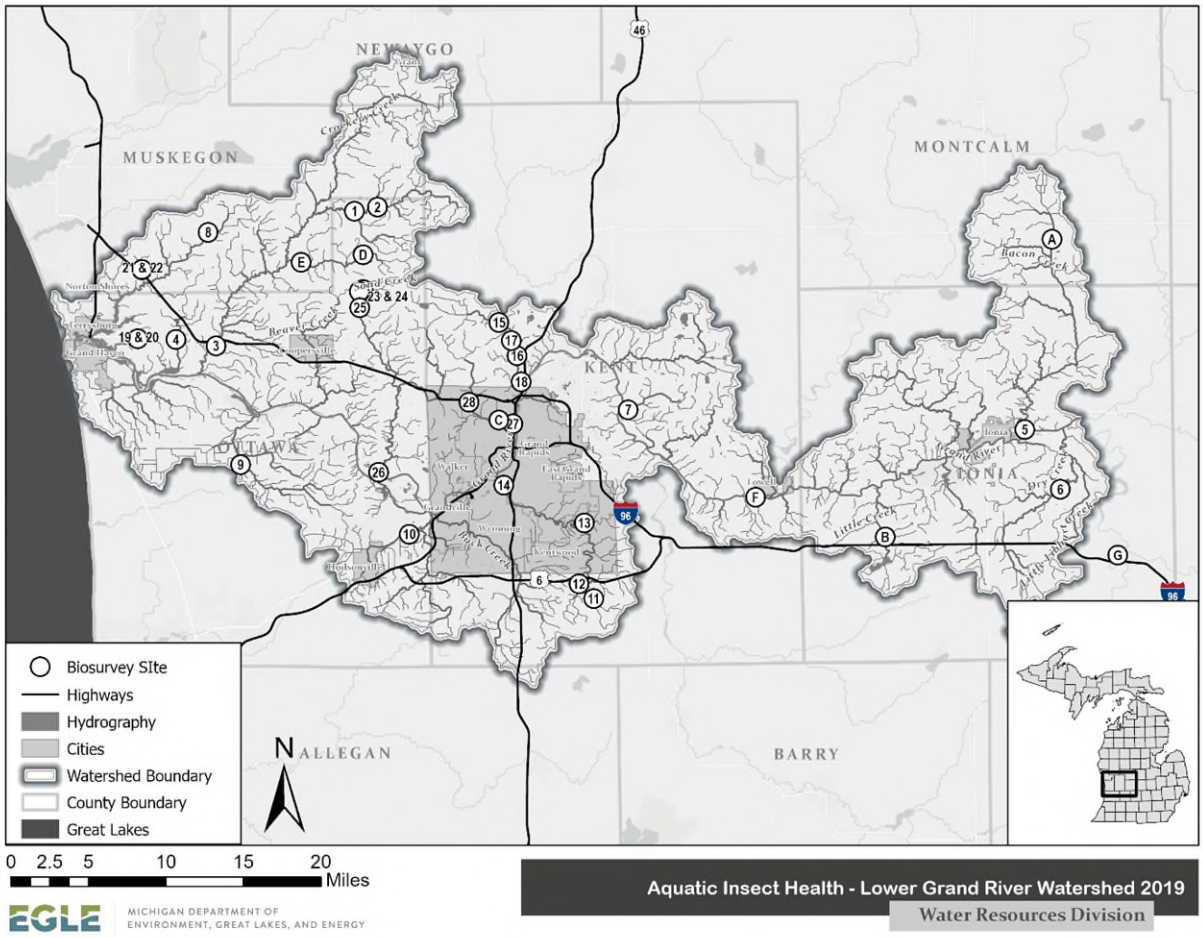

Figure 1. Monitoring locations in the lower Grand River watershed (2019). The thicker blue line denotes the main stem Grand River.

Watershed Information

Geology and Geography

The lower Grand River watershed includes the main stem of the Grand River beginning in the town of Muir (Ionia County) to where it enters Lake Michigan in the city of Grand Haven (Ottawa County; Figure 1). The main stem of the lower Grand River is characterized by a gentle profile with a slope of only 0.6 feet/mile, compared to 2.35 feet/mile in the upper Grand River. The sediment in the lower Grand River is mostly sand and silt except for an area of exposed limestone above the 6th Street Dam in Grand Rapids and an area of large boulders where the river flows through Ada (Churches and Wampler, 2013). The Grand River, together with all its tributaries, drains 5,570 square miles of lower Michigan, spanning all or part of 18 counties. Major tributaries to the lower Grand River include the Maple, Thornapple, Rogue, and Flat Rivers.

The lower Grand River and some of its tributaries (Rush, Buck, Plaster, Indian Mill, and Mill Creeks), pass through the metro area of Grand Rapids, which is densely populated (Table 1; United States Census Bureau, 2011). The Grand River typically contributes some of the largest nutrient loads to Lake Michigan (Robertson, 1997). The majority of the Grand River watershed contains agricultural land use and the main stem of the river receives treated wastewater from several urban areas (Robertson, 1997; Luscz et al., 2015).

Table 1. Predominant land use, population metrics, and wetland loss by 10-digit HUC in the lower Grand River watershed based on 2011 United States Census data. Note: data for all HUCs in the lower Grand River watershed are reported; however, only HUCs 0405000603, 0405000605, 0405000606, and 0405000607 were surveyed in 2019. Land use percentages do not sum to 100. Remaining land uses were classified as "other."

10-Digit HUC	HUC 10 Name	Developed (%)	Agriculture (%)	Wetland (%)	Forest (%)	Population	Housing Units	Historic Wetland Loss (%)
0405000601	Coopers Creek-Flat River	6	16	21	14	20815	10047	9
0405000602	Flat River	7	14	20	16	40832	17213	7
0405000603	Prairie Creek-Grand River	8	24	16	16	44431	16290	26
0405000604	Rogue River	11	12	13	17	65269	24637	27
0405000605	Rush Creek-Grand River	49	9	9	15	510379	211405	33
0405000606	Crockery Creek	3	11	7	6	12057	4569	29
0405000607	Grand River	16	14	14	17	120050	47013	36

Table 2. Land use data by 12-digit HUC in the lower Grand River watershed based on 2011 United States Census data. Note: data for all HUCs in the lower Grand River watershed are reported; however, only 10-digit HUCs 0405000603, 0405000605, 0405000606, and 0405000607 were surveyed in 2019.

12-Digit HUC	HUC 12 Name	Developed (%)	Agriculture (%)	Wetland (%)	Forest (%)
040500060101	Clear Lake-Black Creek	7	51	15	20
040500060102	Fifth Lake	8	57	15	13
040500060103	Townline Creek-Flat River	8	51	16	16
040500060104	Mud Lake-Flat River	6	59	16	14
040500060105	Hunter Lake-Flat River	7	42	11	34
040500060106	Alder Creek Drain-Black Creek	7	55	24	11
040500060107	Clear Creek	11	58	11	12
040500060108	Coopers Creek	10	31	14	37
040500060109	Perch Lake-Flat River	10	41	13	28
040500060201	Wabasis Creek	8	42	14	28
040500060202	County Farm Pond-Dickerson Creek	7	60	21	9
040500060203	Twin Lakes-Dickerson Creek	7	60	22	10
040500060204	Long Lake	7	38	28	21
040500060205	Dickerson Creek	6	33	22	34
040500060206	Sanderson Lake-Flat River	22	35	13	23
040500060207	Seely Creek	8	45	15	26
040500060208	Honey Lake-Flat River	21	44	9	22
040500060209	Flat River	9	47	7	32

12-Digit HUC	HUC 12 Name	Developed (%)	Agriculture (%)	Wetland (%)	Forest (%)
040500060301	Taylor Drain-Libhart Creek	7	83	6	3
040500060302	Libhart Creek	5	78	6	10
040500060303	Bacon Creek-Prairie Creek	6	67	16	10
040500060304	Ross and Branch Drain-Prairie Creek	5	60	20	13
040500060305	Bow Pond	6	72	15	7
040500060306	Prairie Creek	7	67	11	14
040500060307	Dry Creek-Grand River	17	47	12	21
040500060308	Sessions Creek	6	75	6	10
040500060309	Bellemy Creek-Grand River	11	66	9	13
040500060310	Crooked Creek-Grand River	5	59	10	23
040500060311	Lake Creek	10	66	6	16
040500060312	Toles Creek-Grand River	13	36	10	38
040500060313	Lee Creek-Grand River	16	25	8	46
040500060401	Hickory Creek-Rogue River	6	45	11	33
040500060402	Duke Creek	15	42	18	22
040500060403	Spring Creek-Rogue River	6	42	14	33
040500060404	Nash Creek	11	77	5	7
040500060405	Ball Creek-Rogue River	16	46	13	21
040500060406	Cedar Creek	20	47	10	21
040500060407	Freska Lake-Rogue River	18	38	14	24
040500060408	Stegman Creek-Rogue River	32	25	6	32
040500060501	Bear Creek	15	32	13	36
040500060502	Egypt Creek-Grand River	25	21	10	39
040500060503	Mill Creek	20	65	2	10
040500060504	Indian Mill Creek	47	39	3	10
040500060505	Headwaters Plaster Creek	44	38	6	11
040500060506	Plaster Creek	90	2	3	5
040500060507	Lamberton Creek-Grand River	76	4	4	11
040500060508	Sharps Creek-Buck Creek	43	35	4	14
040500060509	East Branch Rush Creek	37	47	4	9
040500060510	Buck Creek	91	3	2	4
040500060511	Rush Creek	65	23	1	7
040500060512	Walker-Grand River	64	5	7	14
040500060601	North Branch Crockery Creek	6	72	8	11
040500060602	Eastland Drain-Crockery Creek	8	61	11	18
040500060603	Rio Grande Creek-Crockery Creek	8	71	6	14
040500060604	Lawrence Drain-Crockery Creek	5	62	10	19
040500060605	Crockery Creek	8	59	14	16
040500060701	East Fork	23	62	9	5
040500060702	Headwaters Sand Creek	8	78	6	7

12-Digit HUC	HUC 12 Name	Developed (%)	Agriculture (%)	Wetland (%)	Forest (%)
040500060703	Sand Creek	20	43	9	24
040500060704	Dear Creek	12	77	6	4
040500060705	Ottawa Creek-Grand River	32	33	9	17
040500060706	Bass Creek	13	65	6	14
040500060707	Bass River	10	58	11	17
040500060708	Jubb Bayou-Grand River	8	45	13	19
040500060709	Pottawatomie Bayou	37	9	10	35
040500060710	Norris Creek	9	25	15	40
040500060711	Spring Lake	34	7	7	39
040500060712	Grand River	27	12	13	35

The Grand River Valley was formed approximately 12,000 years ago with the melting of the Laurentian ice sheets. Draining the large volume of glacial melt water left the valley with steep walls in some areas, which today results in areas where tributary streams have downcut their own steep valleys. In the mid-nineteenth century the Grand River became an important means of transportation for logs and lumber (Figure 2). The entire lower Grand River watershed is within the Southern Michigan/Northern Indiana Till Plains ecoregion, which broadly covers the majority of the southern half of the Lower Peninsula of Michigan (Omernik and Gallant,1988). In terms of the United States Geological Survey (USGS) landscape ecosystem types, the lower Grand River watershed is composed of Lansing, Jamestown, Southern Lake Michigan Lake Plain, and Greenville subsections (Albert, 1995). The eastern portion of the watershed is in the Lansing ecosystem subsection, where soils are rich loams. Pre-settlement vegetation would have supported beech and maple forests with occasional pockets of forested wetlands, which formerly occupied about 30 percent of the area. Most uplands in the fertile Lansing subsection have been converted to agriculture while most wetlands were deforested and converted to pastureland. Drainage by tiling and ditching was necessary to support agriculture in many areas, and as a result, many stream headwaters that were once sprawling wetlands are now drainage ditches and maintained drains with low gradient (less than 1 meter elevation drop per kilometer). Topography is gently rolling in the Lansing subsection. The western portion of the watershed, most of Ottawa County, is part of the Southern Lake Michigan Lake Plain subsection.

The Southern Lake Michigan Lake Plain soils are composed mainly of sandy lacustrine deposits of 50- to 350-feet thick, overlying shale bedrock, which is rarely exposed. These sandy areas were deltas formed by the periglacial Grand River. Clay dominated moraines are also present causing gentle slopes with a 6-12 percent gradient. A narrow band of the Jamestown subsection runs north-south through the eastern end of Ottawa County, where the Sand and Deer Creek watersheds are characterized by more clayey ground and end moraines and used largely for row crop agriculture. The northern portions of Kent County, in the vicinity of Indian Mill Creek and Mill Creek are in the Greenville subsection. The Greenville Subsection is characterized by a hillier landscape, with some hills up to 140-feet high resulting in occasional steep slopes. Upland soils tend to be excessively drained sands, while lowland areas are composed of poorly drained sandy outwash deposits. Due to the poor agricultural value of this land, after being cleared of forests for agriculture, much of these lands have been abandoned for this purpose and converted to residential areas near the city of Grand Rapids and old field forest succession further from the city.

Historical Information and Sampling Efforts

Beginning in 1881 the Grand River was dredged from Grand Rapids to Grand Haven to make the river much wider and deeper than it naturally was (United States Army Corps of Engineers [USACE], 1919). This dredging allowed for the movement of massive amounts of logs, as well as steamboats, from Grand Rapids to Grand Haven (Figure 2). Today, the Grand River from Grand Rapids downstream remains unnaturally deep and wide, with steep banks. Today, a navigation channel of 8 feet is maintained by the USACE from the mouth of Bass River to Lake Michigan (Hanshue and Harrington, 2011). This deep profile and steep banks often prevent large woody debris retention within the river and is not conducive to macrophyte growth, both of which would provide habitat for fish and macroinvertebrates.
Currently, there are 228 registered dams throughout the entire Grand River basin. The section of the lower Grand River covered in this report only contains 10 registered dams. The most significant dams in the lower Grand River basin are on the main stem of the river where it flows

through the city of Grand Rapids: The Sixth Street Dam and the beautification dam set. Construction of the Sixth Street Dam began in 1849, with the placement of rocks, logs, and brush in the channel. The final structure was completed in 1866. The Sixth Street Dam was originally used to divert impounded water to canals to the east and west of the river that powered sawmills. The dam is now classified as a retired hydroelectric dam and maintains about 8 feet of hydrologic head (Figure 3). The beautification dam, which is actually a set of 4 separate structures located in close proximity to each other, was constructed in 1931. The beautification dam structures only serve aesthetic purposes (Hanshue and Harrington, 2011). The impacts of low-head dams in general, such as flow and sediment transport disruption, increased downstream scouring, impoundment temperature increases, increased evaporative water loss from the impoundment, changes in macroinvertebrate communities, and fragmentation of fish communities are well documented (e.g., Allan, 1995). In the Grand River, construction of the dam in Lyons (just upstream of the Lower Grand River study area) had detrimental impacts on native mussel populations (van der Schalie, 1948). Hanshue and Harrington (2011) noted that the beautification dam structures may impede native fish movement during periods of low flow. Currently, plans are underway to remove the Sixth Street Dam and beautification dam structures.

Figure 2. Portion of massive log jam in Grand River that occurred in 1883. Photo from http://blog.mlive.com/chronicle/2008/07/grand_jam_of_1883.html.

Past sampling by EGLE staff and others have found that the lower Grand River main stem has degraded habitat (Wilhelm et al., 2005) and macroinvertebrate communities (Wessell et al., 2008; Rippke, 2011; Parker, 2016) when compared to other large rivers in the State of Michigan. Tributaries to the lower Grand River were surveyed in 2004 (Rockafellow, 2005), 2009 (Rippke, 2011) and 2014 (Parker, 2016). The depth and size of the main stem Grand River preclude the use of the EGLE Procedure 51 (Michigan Department of Environmental Quality [MDEQ], 2009) to evaluate macroinvertebrate and fish communities. EGLE has developed a procedure for evaluating aquatic communities in nonwadeable streams,

which was implemented during the 2009 survey at status and trend sites. In 2004 EGLE visited 56 sites and conducted macroinvertebrate community surveys at 45 of these stations, and fish community surveys at 21 stations. The majority of sites surveyed contained acceptable macroinvertebrate communities, with 4 sites rated poor, and 4 scoring excellent. Poor macroinvertebrate communities were found at Indian Mill Creek, Rush Creek, Red Creek, and Plaster Creek. The fish communities rated poor at 10 stations, including sites in Indian Mill Creek, Mill Creek, Plaster Creek, Bear Creek, York Creek, and Sand Creek. The coldwater fishery designated use is not being attained in Indian Mill Creek (MDEQ, 2014), a highly flashy system that flows through urbanized portions of the city of Grand Rapids. Eleven sites were sampled for common water quality chemical parameters, and results throughout the watershed indicated no exceedances of water quality standards, but an overall elevated phosphorus concentration when compared with reference sites (Lundgren, 1994).

In 2009, Rippke (2011) found that the majority of sites were attaining the OIALW designated use. Of the wadeable sites, 1 station in North Branch Crockery Creek was not attaining the OIALW designated use (Rippke, 2011). Of the nonwadeable sites on the main stem of the Grand River, 6 of 13 sites that were sampled, were not attaining the OIALW designated use. Based on the results of the Procedure 51 method, water bodies supporting high quality macroinvertebrate communities (excellent Procedure 51 score) in 2009 were Prairie and Bellamy Creeks (Ionia County). Habitat throughout the lower Grand River watershed was generally categorized as marginal-excellent. In 2014 most of the sites that were sampled were attaining the OIAWL designated use. The main stem Grand River, where it flows through Eastmanville and Little Bass Creek scored poor then (Parker, 2016). In 2019, 28 different sites were sampled using the Procedure 51 survey method (Table 3). No surveys were done in the main stem Grand River in 2019.

Table 3. Lower Grand River watershed 2019 monitoring locations and score summaries.

Type	Water body	Location	Habitat score	Hatitat rating	Macro score	Macro rating	Fish score	Fish rating
TREND	N B Crockery Creek	36th Ave	115	Good	-1	Acceptable	.	.
TREND	N B Crockery Creek	24th Ave	118	Good	-2	Acceptable	.	.
STATUS	Crockery Creek	Fitzgerald Street	105	Good	2	Acceptable	.	.
TREND	Black Creek	Cleveland St (M104) (downstream)	121	Good	-2	Acceptable	.	.
TREND	Prairie Creek	Main St (Ionia)	158	Excellent	8	Excellent	.	.
STATUS	Libhart Creek	David Highway	128	Good	4	Acceptable	.	.
STATUS	Egypt Creek	Pettis Avenue	161	Excellent	0	Acceptable	.	.
STATUS	Norris Creek	Maple Island RD	113	Good	-2	Acceptable	.	.
STATUS	Bass Creek	Pierce Street	110	Good	-6	Poor	.	.
TARGET	Rush Creek	12th AVE	65	Marginal	1	Acceptable	-2	Acceptable
TARGET	Plaster Creek	Shadyside Park	124	Good	-4	Acceptable	-5	Poor
TARGET	Plaster Creek	Leisure Creek DR SE	78	Marginal	-4	Acceptable	.	.
STATUS	Plaster Creek	Shaffer Avenue SE	90	Marginal	-1	Acceptable	.	.
TARGET	Plaster Creek	Godfrey AVE SW	110	Good	-4	Acceptable	.	.
TARGET	Mill Creek	Wahlfield Park	113	Good	-2	Acceptable	-7	Poor
TARGET	Mill Creek	6 Mile RD NW	122	Good	-6	Poor	-2	Poor*
TARGET	Mill Creek	7 Mile RD NW	100	Marginal	-6	Poor	-8	Poor
TARGET	Mill Creek	Lydell Park	99	Marginal	-6	Poor	-4	Poor*
TARGET	Unnamed trib to Lloyds Bayou	Downstream 148th AVE	161	Excellent	-3	Acceptable	.	.
TARGET	Unnamed trib to Lloyds Bayou	Upstream 148th AVE	146	Good	-4	Acceptable	.	.
TARGET	Willow Hill Creek	Downstream Farr RD - 2018	140	Good	1	Acceptable	.	.
TARGET	Willow Hill Creek	Upstream Farr RD - 2018	130	Good	0	Acceptable	.	.
TARGET	Willow Hill Creek	Downstream Farr RD - 2019	142	Good	2	Acceptable	.	.
TARGET	Willow Hill Creek	Upstream Farr RD - 2019	121	Good	-1	Acceptable	.	.
TARGET	Sand Creek	32nd AVE	68	Marginal	-2	Acceptable	.	.
TARGET	Sand Creek	Wilson ST	83	Marginal	-2	Acceptable	.	.
TARGET	Sand Creek	Taft ST	79	Marginal	-3	Acceptable	.	.

Type	Water body	Location	Habitat score	Hatitat rating	Macro score	Macro rating	Fish score	Fish rating
STATUS	Sand Creek	Luce Street	97	Marginal	-5	Poor	.	.
TARGET	Indian Mill Creek	Turner AVE NW	71	Marginal	-3	Acceptable	.	.
TARGET	Indian Mill Creek	3 Mile RD NW	157	Excellent	-2	Acceptable	.	.
TARGET	Prairie Creek	Boyer Road	63	Marginal	0	Acceptable	.	.
TARGET	Lake Creek	Grand River Ave	103	Marginal	0	Acceptable	.	.
TARGET	Indian Mill Creek	Tamarack Ave NW	115	Good	-4	Acceptable	-4	Acceptable
TARGET	Rio Grande Creek	32nd Ave	47	Poor	-1	Acceptable	.	.
TARGET	Rio Grande Creek	Blackmer Rd (downstream)	142	Good	2	Acceptable	.	.
TARGET	Grand River	Grand River Dr	147	Good	6	Excellent	.	.
TARGET	Grand River	Thompson Field Park	136	Good	3	Acceptable	.	.

2019 Macroinvertebrate and Habitat Biosurvey Sampling Results

North Branch Crockery Creek

Two trend sites in North Branch Crockery Creek, a third-order stream located in Chester Township, were surveyed at 36th and 24th Avenues. The 24th Avenue site, which is upstream of 36th Avenue had a macroinvertebrate community that scored low acceptable (-1; Appendix 2) and habitat scored good (118; Appendix 1). Twenty-one different taxa were collected; however, only 4 Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa were collected, indicating degraded water and habitat quality. Isopoda, which are tolerant of organic pollution, were the dominant taxa.

Sand was the dominant substrate (55 percent visual estimate) and some gravel and cobble was also present. The cobble was in the stream largely because some rip rap had been placed on some of the banks for stabilization. A small channel also appears to have been dug through a bank. This may have been done in an attempt to reduce flow from eroding a steep bank on the right side of the stream. In 2009, the macroinvertebrate community at this site scored poor and Rippke (2011) noted that dredging had recently occurred at this site. It is possible that Rippke (2011) had surveyed this site shortly after the channel was dug, which may have impacted macroinvertebrate communities. North Branch Crockery Creek is not a county drain and no permits were found in MiWaters for a channelization project at that site, so proper oversight may have been lacking. Overhanging vegetation, rootwads, and large woody debris were moderately available as habitat but undercut banks and macrophytes were sparse. The stream banks showed evidence of flashiness with scour greater than 20 inches above the water surface and storm debris observed in trees about 5 feet above the water surface. Despite some bank stabilization efforts, most of the banks were actively eroding. Along the left bank appeared to be a grazing pasture and along the right bank was a row crop. Large trees are along the immediate bank, which provide some canopy cover. The macroinvertebrate community appears to be improving since receiving a poor score in 2009, but habitat remains stable (Table 4).

At 36th Avenue, North Branch Crockery Creek had a macroinvertebrate community that scored low acceptable (-2; Appendix 2) and habitat scored good (115; Appendix 1). Twenty different taxa were collected, but only 3 of them were EPT, indicating degraded water and habitat quality. Calyopteridae and Chironomidae were the dominant taxa. Both of those taxa are moderately tolerant to disturbances and may become dominant in slightly disturbed systems (Voshell, 2002). The substrate at this site was a mix of boulders, cobble, gravel, sand, and silt. All habitat types, such as large woody debris, undercut banks, and overhanging vegetation were sparse. The stream appeared to have flashy flow conditions with bank scour greater than 20 inches above the water surface and storm debris observed in trees approximately 6 feet above the stream. The riparian area was forested with mature trees that provided good canopy cover. The macroinvertebrate community at this site appears stable, but habitat scores have decreased over the last 3 watershed-year cycles (Table 4). The North Branch Crockery Creek watershed is 72 percent agriculture (Table 2).

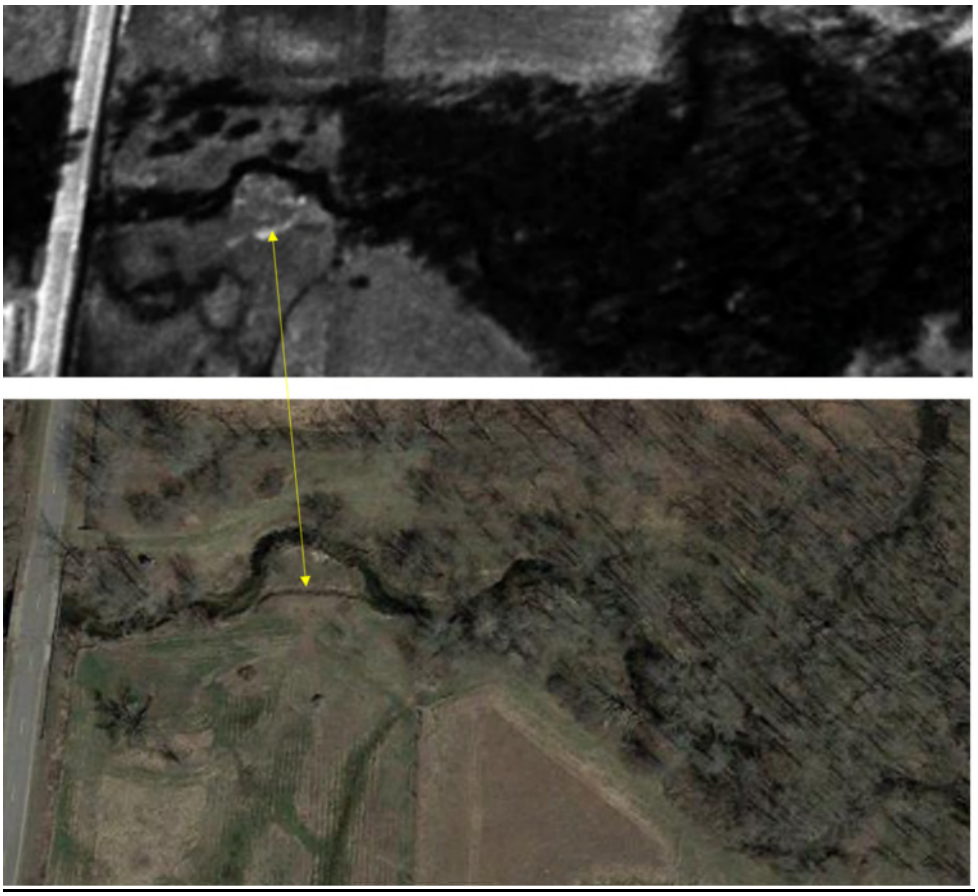

Figure 3. Aerial photos of North Branch Crockery Creek upstream of 24th Avenue. Top photo is from 1997 and bottom photo is from 2011.

Table 4. Macroinvertebrate community and habitat scores for North Branch Crockery Creek over last 3 watershed-year cycles.

Water body	Location	Metric	2009 Rippke (2011)	2014 Parker (2016)	2019 This report
North Branch Crockery Creek	24th Ave.	Macroinvertebrate community	-5	1	-2
North Branch Crockery Creek	24th Ave.	Habitat	106	119	118
North Branch Crockery Creek	36th Ave.	Macroinvertebrate community	2	-2	-1
North Branch Crockery Creek	36th Ave.	Habitat	153	134	115

Crockery Creek

Crockery Creek was surveyed at Fitzgerald Street in Crockery Township. At this location Crockery Creek is a fourth-order stream and this is one of the last road crossings before it enters the Grand River. The macroinvertebrate community scored high acceptable (2; Appendix 2) and habitat scored low good (105; Appendix 1). Only 18 different taxa were collected at this site; however, 7 of those taxa were EPT. Furthermore, the most abundant taxa were Brachycentridae, which is very sensitive to stressors (Voshell, 2002). Large woody debris was moderately available; however, all other habitat types such as undercut banks, overhanging vegetation, and rootwads were either sparse or absent. The substrate consisted of approximately 80 percent sand and 20 percent silt based on visual estimates. The stream banks showed evidence of flashiness with banks scoured more than 20 inches above the water surface and storm debris caught in trees approximately 4 feet above the stream. Stream banks were also actively eroding. The riparian area was forested though, with mature trees that provide good canopy cover. The entire Crockery Creek watershed contains 65 percent agricultural land use (Table 1). Despite agriculture being the predominant land use, the macroinvertebrate community seemed to indicate good water quality; however, habitat was lacking at that site. Crockery Creek is classified as a cold-transitional stream and the Michigan Department of Natural Resources (MDNR), Fisheries Division, continues to stock Brown Trout (*Salmo trutta*) and Steelhead (*Onchorhynchus mykiss*) in it (Hanshue and Harrington, 2011).

Black Creek

Black Creek is a second-order stream that was surveyed downstream of Cleveland Street/M-104 in Crockery Township. The macroinvertebrate community scored low acceptable (-2; Appendix 2) and habitat scored good (121; Appendix 1). Twenty-seven different taxa were collected; however, only 4 were EPT and in low numbers, indicating low habitat and/or water quality. Amphipoda were the dominant taxa (63 percent). Amphipoda are facultative (able to persist in a wide variety of environments) but tend to dominate in disturbed systems. Overhanging vegetation, undercut banks, and rootwads were moderately available but other habitat types such as large woody debris and macrophytes were sparse. The substrate was mostly sand (65 percent visual estimate) and silt (30 percent visual estimate). The stream showed some evidence of flashiness; however, an intact floodplain was adjacent to both sides of the stream. The riparian area was a forested-marsh complex with mature trees that provide some canopy cover. The greater surrounding area is a mix of developed, forested, and agricultural land use. This is a trend site and both the macroinvertebrate community and habitat scores have remained relatively stable over the last 3 watershed-year cycles (Table 5).

Table 5. Macroinvertebrate community and habitat scores for Black Creek over last 3 watershed-year cycles.

			2009	2014	2019
Water body	Location	Metric	Rippke (2011)	Parker (2016)	This report
Black Creek	M-104/Cleveland ST	Macroinvertebrate community	0	-2	-2
Black Creek	M-104/Cleveland ST	Habitat	108	113	121

Prairie Creek

Prairie Creek is a third-order stream that was surveyed at Main Street on the border of the city of Ionia and Ionia Township. Prairie Creek is a designated trout stream that is regularly stocked with brown and rainbow trout (*Onchorhynchus mykiss*) by the MDNR (Hanshue and Harrington, 2011). The macroinvertebrate community scored 8 (excellent; Appendix 2) and habitat scored excellent (158; Appendix 1). Thirty-six different taxa were collected, which included 16 EPT, indicating good water quality and habitat. Overhanging vegetation and large woody debris were moderately available but other habitat types such as rootwads and undercut banks were sparse or absent. However, substrate was mostly sand (60 percent visual estimate) with a mix of boulder, cobble and gravel (10, 15, and 5 percent visual estimate, respectively). The stream banks were well protected with minimal evidence of flashiness and bank scour. The immediate riparian area at the Main Street site contains mature trees, but beyond that it is diminished by a park, residential lot, and a large industrial complex. The soils in the Prairie Creek watershed are well-drained and Prairie Creek drains one of the few landscapes in the lower Grand River watershed with steep topographic relief (Hanshue and Harrington, 2011). Despite land use in the Prairie Creek watershed being mostly agricultural (Table 2) previous biosurveys at this trend site and in other sections of Prairie Creek have revealed macroinvertebrate communities that are representative of high water and habitat quality (Cooper and Rockafellow, 2005; Rippke, 2011; Parker, 2016).

Libhart Creek

Libhart Creek is a third-order stream that was surveyed at David Highway in Orange Township. The macroinvertebrate community scored high acceptable (4; Appendix 2) and habitat scored good (128; Appendix 1). Thirty-eight different taxa were collected including 11 EPT, indicating good water quality. Habitat types such as large woody debris, undercut banks, and overhanging vegetation were sparse. However, the substrate was an even mixture of cobble, sand, and silt with smaller amounts of gravel and boulders. The stream did not show signs of flashiness and the banks were relatively stable. Riparian vegetation was lacking on both sides of the stream. The farmsteads upstream and downstream of David Highway have been the subject of Right-to-Farm complaints to the MDARD in 2004 and 2018 regarding unrestricted cattle access to the stream. Downstream of David Highway, which was the subject of the 2004 complaint, appeared to be restricted to cattle access. From a review of aerial photos, the access issues upstream of David Highway, that were the subject of the 2018 complaint, appear to be further upstream than where we sampled. It is not clear if any remediation has taken place in response to that complaint. Despite the Libhart Creek watershed land use being primarily agricultural (Table 2), past biosurveys throughout Libhart Creek have indicated good water quality (Rockafellow, 2005; Parker, 2016).

Egypt Creek

Egypt Creek is a second-order stream that was sampled at Pettis Avenue in Ada Township. The macroinvertebrate community scored acceptable (0; Appendix 2) and habitat scored excellent (161; Appendix 1). Eighteen different taxa were collected, but only 5 were EPT, indicating intermediate water and habitat quality. Chironomidae and Simulidae were the dominant taxa at this site. Both families can occur in a wide variety of environments but tend to dominate in more disturbed systems (Voshell, 2002). Overhanging vegetation was moderately available; however, other habitat types such as large woody debris and undercut banks were either sparse or absent. The substrate was a mixture of boulder, cobble, and sand. Other prominent features within the stream were a series of small, concrete dams that were spaced apart at distances

ranging from 69-75 stream feet. An analysis of aerial and permit photos of Egypt Creek below Pettis Avenue indicates that similar dams are also present, spanning approximately 500 feet downstream of Pettis Avenue. A review of dam registries and historic maps revealed no records or explanations for the dams' purpose. It is possible that they were placed in the stream many years ago for aesthetic purposes since they create artificial riffle-pool sequences. The stream banks were stable and the site did not exhibit evidence of flashiness. A review of historic aerial photos showed Egypt Creek flowing through what appeared to be a pasture (possibly hay) at this site until 2013. In a 2016 aerial photo, the riparian area had been converted to a residential lot. Large trees are present from Pettis Avenue upstream about 130 feet, but other than that, vegetation is limited. Land use in the Egypt Creek watershed is a mix of developed, agricultural, and forested land (Table 2).

Norris Creek

Norris Creek is a second-order stream that was sampled at Maple Island Road in Sullivan Township. The macroinvertebrate community scored low acceptable (-2; Appendix 2) and habitat scored good (113; Appendix 1). Twenty-one different taxa were collected. Only six taxa were EPT and were collected in low numbers, indicating poor habitat and/or water quality. Amphipoda made up 76 percent of the taxa collected. Amphipoda are facultative but tend to dominate in more disturbed systems (Voshell, 2002). Large woody debris and undercut banks were moderately available but other habitat types such as overhanging vegetation and rootwads were either sparse or absent. The substrate was mostly sand (80 percent visual estimate), and the remaining sediment was silt. The stream banks exhibited evidence of flashiness with bank scour greater than 20 inches above the water surface. Storm debris was also observed in trees 3 feet above the water surface. The riparian area was mostly forested; however, the stream ran through a 60-foot-wide powerline swath at this site that was devoid of any trees. The Norris Creek watershed is mostly forested with smaller amounts of agriculture and developed land (Table 2).

Bass Creek

Bass Creek is a third-order stream that was sampled at Pierce Street in Robinson Township. The macroinvertebrate community scored poor (-6; Appendix 2) and habitat scored low good (110; Appendix 1). Twenty-one different taxa were collected, but only 3 were EPT (comprising 5 individuals) indicating poor water and/or habitat quality. Coenagrionidae was the dominant taxa (43 percent), which tend to be tolerant to stressors (Voshell, 2002). All habitat types such as large woody debris and undercut banks were sparsely available. The substrate was an equal mixture of sand, silt, and clay. The stream was very slow flowing (0.1 feet/second), and deposits of detritus and mud were categorized as heavy and moderate, respectively. The stream showed some evidence of flashiness and banks were actively eroding. The riparian area at this site was a wet prairie with few large trees to provide canopy cover. Most of Bass Creek is maintained as a county drain and the majority of land use in the Bass Creek watershed is agricultural (Table 2).

Rush Creek

Rush Creek is a third-order stream that was sampled for fish and macroinvertebrates at 12th Avenue in Georgetown Township. The macroinvertebrate community scored high acceptable (1; Appendix 2), the fish community scored low acceptable (-2; Appendix 3) and habitat scored marginal (65; Appendix 1). Twenty-one different macroinvertebrate taxa were collected, but only 4 were EPT. Hydropsychidae and Chironomidae were the dominant taxa.

Both taxa can occur in a wide variety of environments but tend to dominate in more disturbed systems (Voshell, 2002). Centrachidae species such as bluegill (*Lepomis macrochirus*) made up the majority of the fish collected, indicating that Rush Creek is conducive to warm water fish communities. No Salmonidae species were collected. Twenty invasive round goby (*Neogobius melanostomus*) individuals were collected. All habitat types such as large woody debris and undercut banks were sparse. The substrate was dominated by sand (77 percent visual estimate) with most of the remaining substrate silt (20 percent visual estimate). The stream was slow flowing (1 foot/second) and moderate amounts of detritus and mud were on the stream bottom. The stream banks were actively eroding and showed signs of flashiness with scour greater than 20 inches above the water surface. Storm debris was observed in tree branches about 6 feet above the water surface. Large trees are along the immediate bank, which provide some canopy cover. Otherwise, riparian vegetation is diminished by residential lots. Rush Creek is a maintained county drain and land use in the watershed is dominated by development (65 percent) and agriculture (23 percent; Table 2).

Plaster Creek

Plaster Creek is a third order, warmwater stream that has a long history of degradation. The early Ottawa tribes that occupied western Michigan referred to it as “Kee-No-Shay,” which translated to “water of the walleye.” However, in 1827 European settlers discovered gypsum mineral at the mouth of the stream where it enters the Grand River. By 1841 the first gypsum mill was built at the mouth of the creek and large-scale extraction of the mineral began for plaster production. Thus, the creek was referred to as “Plaster Creek.” The largest gypsum mill was constructed near where Godfrey Avenue SW crosses Plaster Creek (Figure 4) and by 1870, 12,000 tons of gypsum were being mined either directly from the stream bottom or the surrounding landscape (Grimsley, 1904). Later, open mine pits were often used as unlined landfills after all of the gypsum was extracted (Britten, 2013).

A. PLASTER CREEK AND ALABASTINE MILL.

Figure 4. Plaster Creek near present day Godfrey Avenue SW crossing. Photo taken between 1876 and 1904. Photograph from Grimsley (1904).

Sylvester (1977) described leachate entering Plaster Creek from an abandoned landfill, 3 major storm drains, and industrial and raw sewage discharges to Plaster Creek. Other known contamination sources at the time were a large xylene leak from a storage tank in 1975, an oil leak in 1977, and hexavalent chromium groundwater contamination. Sediments at the time contained elevated concentrations of lead, cyanide, copper, zinc, oils, cadmium, nickel, arsenic, PCBs, and phenols (Sylvester, 1977). A ditch that was connected to Cole Drain was found to contain the most contaminated sediments. The source of contamination was determined to be from Chem Central, an industrial chemical distribution center, located 1,000 feet away from the ditch. From 1957 to 1962, hazardous material had leaked into the ground via a faulty pipe used to transfer liquids between rail cars and storage tanks. In 1978 the United States Environmental Protection Agency (USEPA) excavated contaminated sediment from the ditch. In 1984 a purge well was constructed on Chem Central's property to remove contaminated groundwater and discharge it to a municipal wastewater treatment facility.

Industrial pollution has improved in Plaster Creek; however, sections of the watershed remain highly developed (Table 2) and it is currently not attaining the OIALW designated use with sedimentation/siltation listed as the cause of impairment (MDEQ, 2014). For the last several years, there has been much focus on restoring Plaster Creek by implementing BMPs meant to

reduce storm water runoff or slow down storm flows. To date, BMPs that have been implemented in the Plaster Creek watershed have included; floodplain restoration, 2 large bioswales, prairie and wetland restoration, and 74 rain gardens (for details see https://calvin.edu/plaster-creek-stewards/restoration/projects/).

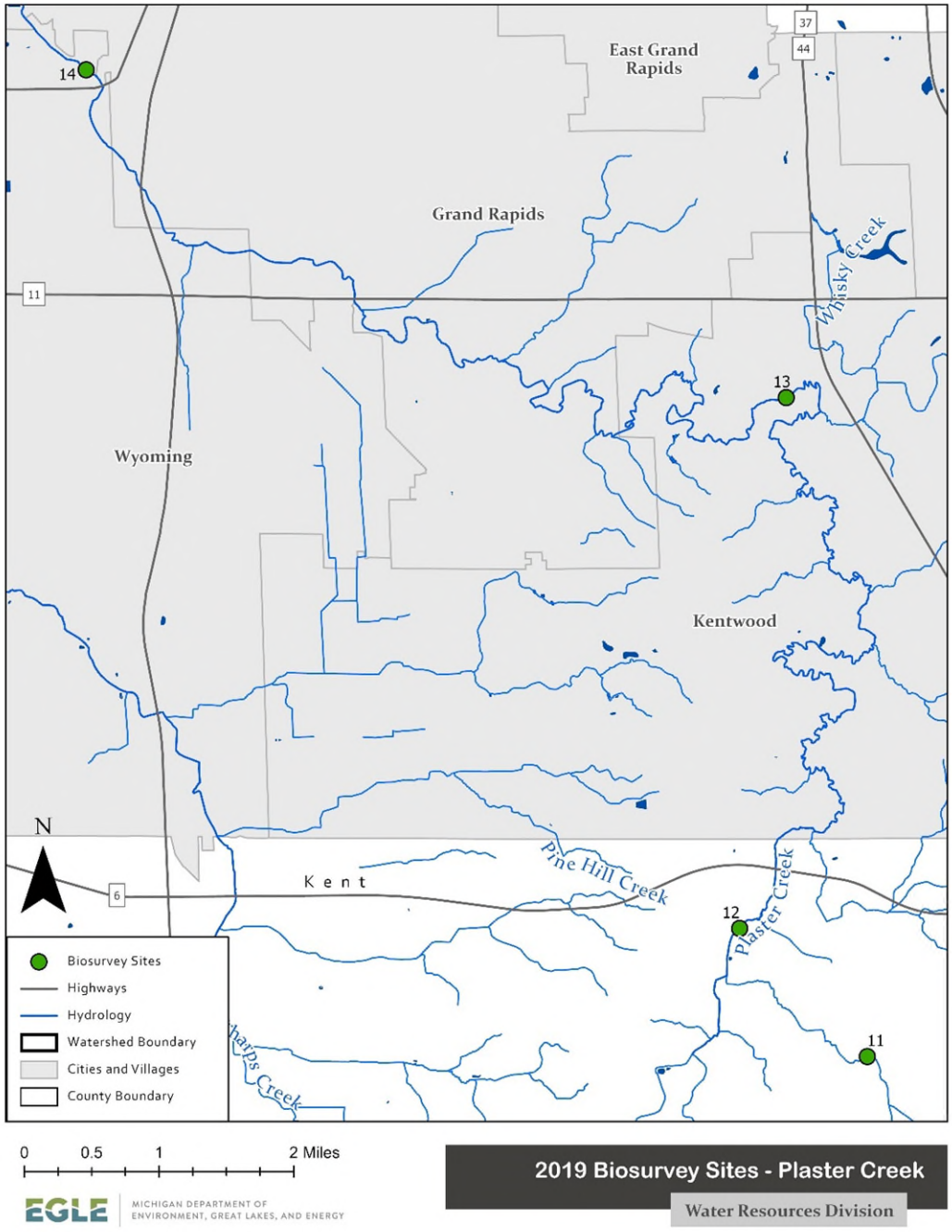

Figure 5. Four sites where biosurveys were performed in Plaster Creek. Site numbers and locations are as follows: 11; Shadyside Park, 12; Leisure Creek Drive SE, 13; Shaffer Avenue, and 14; Godfrey Avenue SW.

Plaster Creek was sampled for fish and macroinvertebrates at Shadyside Park in Gaines Township. The macroinvertebrate community scored low acceptable (-4; Appendix 2), the fish community scored poor (-5; Appendix 3) and habitat scored good (124; Appendix 1). Sixteen different macroinvertebrate taxa were collected, of which, only 2 were EPT. Chironomidae made up the majority of the taxa collected (83 percent). Large strands of *Cladophora* were present in the stream at the time of sampling and most of the Chironomidae that were collected were found within the algae. Thirteen different fish taxa were collected. Central mudminnow (*Umbra limi*), blacknose dace (*Rhinichthys atratulus*), Johnny darter (*Etheostoma nigrum*), and common shiner (*Luxilus cornutis*) made up the majority of fish that were sampled. Most of the fish that were collected are considered to be tolerant to stressors (74 percent) and no Salmonidae species were collected. This site was sampled in 2014 by Parker (2016). At that time, the macroinvertebrate and fish communities scored 1 and -2, respectively, and habitat scored 87.

The Shadyside Park location has had several BMPs implemented in and along the stream. The largest BMP was restoration of the floodplain by removing 2,540 cubic yards of soil from the stream bank and creating a flood bank. The floodplain was later planted with native plants and trees. Prior to the floodplain restoration, the stream banks were steep and actively eroding or slumping into the stream. Other BMPs at this site include a vegetated bioswale that receives parking lot runoff, 45 feet of rip rap along the banks, and 2 cross vanes. Habitat types such as large woody debris or undercut banks were sparse. Sand was the dominant substrate type (60 percent visual estimate), but cobble and boulders were also present in the area where rip rap had been installed (20 and 10 percent visual estimate, respectively). The floodplain appeared to be functioning properly because there was no evidence of flashiness and the floodplain was well vegetated. During the floodplain excavation, large trees were removed, which eliminated the canopy cover over the stream. The combination of reduced canopy cover, rock substrate additions, and nutrients from the agricultural headwaters upstream are likely what led to the algal growth during 2019. This latest survey was also performed only a few months after the last of the restoration was implemented. When the newly planted trees and riparian vegetation mature they are expected to shade the stream and hopefully reduce the amount of algal biomass. This site will be resampled again during the 2024 watershed cycle.

Plaster Creek was sampled at Leisure Creek Drive SE in Gaines Township. The macroinvertebrate community scored low acceptable (-4; Appendix 2) and habitat scored marginal (78; Appendix 1). Fifteen different taxa were collected, which only included 2 EPT, indicating degraded habitat and/or water quality. Amphipoda made up the majority of the taxa collected, which is typically indicative of stressed conditions (Voshell, 2002). All habitat types such as large woody debris and undercut banks were either sparse or absent. Substrate was a nearly equal mixture of sand, silt, and clay. Evidence of flashiness at this site was abundant; in some sections of the surveyed area, the stream at baseflow only occupied about half of the stream channel, many banks were scoured and actively eroding, and storm debris was observed in tree branches about 7 feet above baseflow. The riparian vegetation contained large, mature trees in some areas, but was punctuated by areas where residential lawns extended to the edge of the stream bank. Plans are currently underway for floodplain restoration at this site. If BMPs are implemented, then that site will be sampled again in 2024.

Plaster Creek was sampled at Shaffer Avenue in the city of Kentwood. The macroinvertebrate community scored low acceptable (-1; Appendix 2) and habitat scored marginal (90; Appendix 1). Twenty-one different taxa were collected, of which only 4 were EPT indicating degraded water and/or habitat quality. Amphipoda were the dominant taxa, which is also indicative of degraded conditions (Voshell, 2002). Habitat types such as large woody debris and

undercut banks were either sparse or absent. The substrate was mostly sand (70 percent visual estimate), and the remaining sediment was a mix of silt and clay. The stream banks showed evidence of flashiness with scour more than 20 inches above the water surface and actively eroding banks. There were also sections of the surveyed reach where Plaster Creek at baseflow only occupied about half of the stream channel. Finally, storm debris was observed in tree branches about 5 feet above the stream. The riparian area was mostly forested along the right bank; however, along the left bank riparian vegetation was diminished by residential lots.

Plaster Creek was sampled at Godfrey Avenue SW in the city of Grand Rapids. The macroinvertebrate community scored low acceptable (-4; Appendix 2) and habitat scored low good (110; Appendix 1). Only 12 taxa were collected, of which only 2 were EPT, indicating poor water and/or habitat quality. Isopoda and Hydropsychidae were the dominant taxa, which can be indicative of organic pollution (Voshell, 2002). Habitat types such as large woody debris and undercut banks were sparse. The substrate was sand (50 percent visual estimate) with smaller amounts of gravel, silt, and clay. Scattered throughout the stream bottom were bricks, broken pieces of concrete, and other refuse such as tires and metal, which provided some of the only solid substrate in the stream. The stream banks showed evidence of flashiness with scour greater than 20 inches above the water surface and storm debris in tree branches about 3 feet above the stream. Mature trees on the stream bank provide good canopy cover, but beyond the stream banks are industrial lots in the riparian area. This site received similar macroinvertebrate community (-3) and habitat (111) scores when sampled in 2014 (Parker, 2016).

Mill Creek

Mill Creek is a second order stream that was sampled in 4 different locations (Figure 6) to: (1) assess condition prior to a large floodplain restoration project at the lower end of the stream; and (2) assess nutrient concentrations because of nuisance algae conditions that had been observed in the stream earlier. The Mill Creek watershed is dominated by agriculture, especially in the upper portion, and development in the lower portion (Table 2; Grand Valley State University [GVSU], 2005). Mill Creek has a long history of degradation. The lower reach was channelized to accommodate a fish hatchery (described below) and the upper reach begins as a network of linear, agricultural drains. In 1983, a large runoff event containing chicken manure, caused a complete fish kill in 13 miles of Mill Creek's 14-mile length. Later, in 1989, an industrial discharge into Strawberry Creek, a tributary to Mill Creek, occurred and caused a fish kill (Wuycheck, 1994). Finally, Schrems West Michigan Trout Unlimited (SWMTU; 2018) found that 10 out of 20 road-stream crossings in Mill Creek were potential fish migration barriers. During our site visits, we observed impoundments at 6 Mile and 7 Mile Roads NW. Both impoundments were approximately 12-inches high and likely create additional fish migration barriers. A review of the national dam registry and MiWaters revealed no records of the dams, making them 2 of many unregistered dams in the lower Grand River watershed.

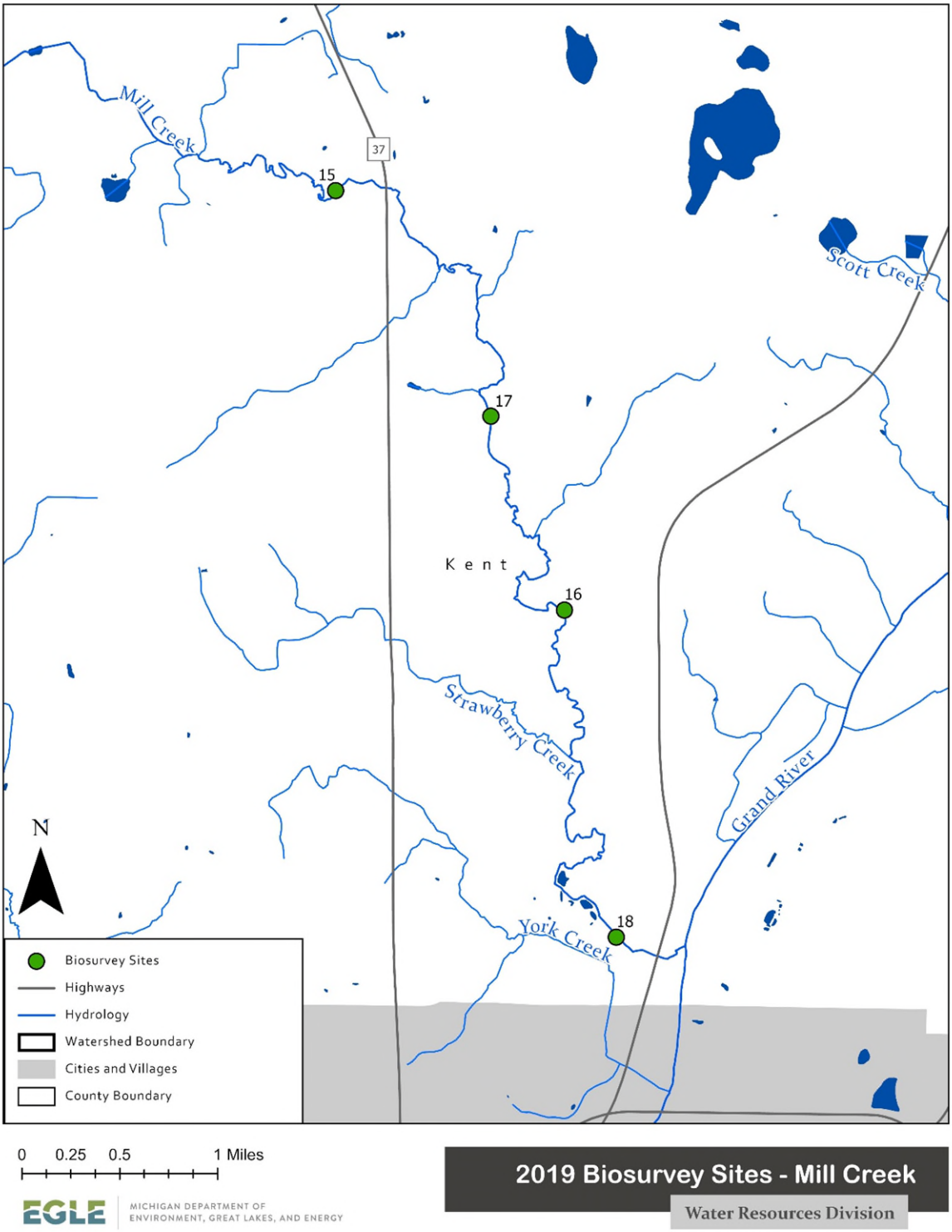

Figure 6. Four sites where biosurveys were performed in Mill Creek. Site numbers and locations are as follows: 15; Wahlfield Park, 17; 7 Mile Road NW, 16; 6 Mile Road NW, and 18; Lydell Park.

Mill Creek was sampled for fish and macroinvertebrates at Dwight Lydell Park in Plainfield Township. A plat map from 1831 shows this section of stream being sinuous. However, in the late 1890s a State fish hatchery was constructed along the stream in what is now the park. As part of the hatchery construction, Mill Creek was channelized and a significant portion of its banks were lined with concrete, vertical walls. The hatchery was later abandoned in 1946. Prior to recent removal, the concrete walls were deteriorating and, in some cases, leaning towards the stream. Current restoration efforts have removed the concrete walls along the stream and removed around 11,500 cubic yards of soil along the banks to restore the floodplain. Additionally, 265 trees and 650 shrubs were planted in the riparian area. This station was sampled for fish and macroinvertebrates to assess conditions prior to restoration efforts.

The macroinvertebrate community scored poor (-6; Appendix 2), the fish community scored poor because less than 50 fish were collected after 45 minutes of sampling effort (Appendix 3), and habitat scored marginal (99; Appendix 1). Only 14 different macroinvertebrate taxa were collected, of which only 2 were EPT, indicating poor water and/or habitat quality. Chironomidae and Isopoda, which are both tolerant to stressors (Voshell, 2002), made up the majority of the taxa collected. Only 19 individual fish were collected during 45 minutes of electrofishing effort, resulting in a poor rating for the fish community. Nine different taxa were collected including 3 brown trout and 3 rainbow trout. Overhanging vegetation was moderately available as habitat; however, other habitat types such as large woody debris and undercut banks were either sparse or absent. The substrate was mostly sand (55 percent visual estimate) with smaller amounts of clay, gravel, and bedrock. Pieces of concrete that had likely broken off the walls were also scattered throughout the stream bottom. The stream appeared to be flashy, with high water marks observed about 3 feet above the water surface on the walls. Because the stream banks were mostly artificial, not much active erosion was observed. Some large trees are present along the left bank, which provide some canopy cover. Beyond the immediate banks, the riparian area consists of the park or business lots.

Mill Creek was sampled for fish and macroinvertebrates at 6 Mile Road NW in Alpine Township. The macroinvertebrate community scored poor (-6; Appendix 2), the fish community scored poor because less than 50 fish were collected after 45 minutes of sampling effort (Appendix 3), and habitat scored good (122; Appendix 1). Only 12 different macroinvertebrate taxa were collected, of which only 2 were EPT, indicating poor water and/or habitat quality. Isopoda made up the majority of the taxa collected (89 percent), which is indicative of stressed conditions (Voshell, 2002). Only 29 individual fish were collected in 45 minutes of effort. Eight different fish species were collected including 8 rainbow trout and 4 brown trout. All habitat types such as large woody debris and undercut banks were sparsely available. The majority of the substrate was hard pan clay (50 percent visual estimate) and the remaining substrate was a mixture of boulders, cobble, and sand. A nuisance amount of *Cladophora* was covering the stream bottom at the time of sampling (40 percent visual estimate). Past visits by EGLE staff have documented greater coverage of the algae at this site and a riparian resident indicated that some algae had recently been manually removed prior to our sampling. The stream appeared to be flashy with bank scour greater than 20 inches above the water surface and storm debris was observed in tree branches about 4 feet above baseflow. There were also areas of active erosion and sections of soil slumping into the stream. Mature trees were present along the immediate banks; however, riparian vegetation is diminished by a residential lot and 6 Mile Road NW, which runs parallel to the stream for about 275 feet.

Mill Creek was sampled for fish and macroinvertebrates at 7 Mile Road NW in Alpine Township. The macroinvertebrate and fish communities both scored poor (-6 and -8 respectively; Appendix 2) and habitat scored marginal (100; Appendix 1). Twelve macroinvertebrate taxa

were collected, which only included 2 EPT, indicating poor water and/or habitat quality. Cyprinidae (minnow) species made up the majority of the fish collected and 92 percent of the individuals collected are considered to be tolerant of stressors. Three brown trout were collected at this site. Rootwads were heavily available and undercut banks were moderately available at this site. Other habitat types such as large woody debris and overhanging vegetation were sparse. The substrate was mostly sand and silt (40 and 30 percent visual estimate, respectively) with some gravel, cobble, and boulders. There was evidence of flashiness with stream banks scoured greater than 20 inches above the water surface and storm debris observed about 3 feet above baseflow. The left bank was mostly forested, but riparian vegetation was diminished along the right bank by residential lots. Mature trees were along both banks, which provide good canopy cover.

The furthest upstream site sampled for fish and macroinvertebrates in Mill Creek was at Wahlfield Park in Alpine Township. The macroinvertebrate community scored low acceptable (-2; Appendix 2), the fish community scored poor (-7; Appendix 3), and habitat scored good (113; Appendix 1). Seventeen different macroinvertebrate taxa were collected, only 2 of which were EPT. Although the number of EPT taxa was low, the macroinvertebrate community was not over-represented by one taxa. Rather, crayfish (Decapoda), Calopterygidae, and Chironomidae made up the majority of individuals collected at similar numbers. All three taxa are somewhat tolerant to stressors but can also occupy a wide range of conditions (Voshell, 2002). Seven different fish species were collected, which consisted mostly of Cyprinids, white suckers (*Catostomus commersonii*), and Johnny darters (*Etheostoma nigrum*). The majority of fish collected were considered to be tolerant to stressors and no Salmonidae taxa were collected. All habitat types, such as large woody debris and undercut banks, were either sparse or absent. The substrate was a mix of silt, sand, and gravel. The stream was slow-flowing at this site (0.6 feet/sec) and a moderate amount of muck-mud was present. All of the substrate in the stream was covered with a layer of silt. The stream banks showed evidence of flashy flow conditions with banks scoured more than 20 inches above the water surface and storm debris caught in tree branches about 4 feet above baseflow. The riparian area was mature forest that provides good canopy cover. Although this site was located in a forested section of Wahlfield Park, it was only about 1.5 river miles downstream from the point where the stream transitions from a designated county drain, known as Farmers Drain, to Mill Creek, which may explain the siltation and flashy flow conditions at this site.

Nutrient Concentrations in Mill Creek

EGLE staff were first alerted to nuisance growth of *Cladophora* in Mill Creek at 6 Mile Road NW in 2017. In 2018 sonde measurements and nutrient samples were collected mostly from Mill Creek at 6 and 7 Mile Roads NW and from 2 small tributaries between those two roads. In 2019 nutrient samples were collected at Lydell Park, 6 Mile Road NW, 7 Mile Road NW, and Wahlfield Park (Table 4). While nutrient concentrations from 2 small tributaries between 6 and 7 Mile Roads were high in 2018 the nutrient concentrations downstream of them in Mill Creek at 6 Mile Road NW did not increase and, in fact, nutrient concentrations at 7 Mile Road NW were higher (Table 6).

When Mill Creek was sampled again in 2019, nutrient concentrations were highest upstream and decreased downstream. Both total phosphorus and orthophosphate were found at elevated concentrations compared to median values collected in similar regions of the state (Schoen et al., 2019). Upstream of Wahlfield Park, which had the highest concentrations of total phosphorus and orthophosphate, the land use is predominantly agricultural. Also, above Wahlfield Park, Mill Creek is a designated county drain with numerous smaller drains as

tributaries. Most of those drains run through row crops with minimal riparian vegetation along them. Most likely, agricultural land use in the headwaters of Mill Creek is the main source of its excess nutrients.

Table 6. Sonde measurements and nutrient concentrations in Mill Creek and two small, unnamed tributaries in 2018 and 2019.

4/27/2018	Latitude	Longitude	Temperature (°C)	Dissolved oxygen (mg/l)	Conductivity (µS/cm)	pH
Stage Ave. NW	43.1077	-85.7809	12.24	6.353	398	7.77
Baumhoff Ave. NW	43.09686	-85.7194	11.68	11.99	663	7.88
Wahlfield Park	43.08946	-85.6952	10.53	11.34	653	8.01
Vinton Ave. NW	43.07839	-85.6806	11.55	11.47	676	7.91
7 Mile Rd. NW	43.07259	-85.6796	10.132	9.97	678	8.72
S. Unnamed trib. at Comstock Park NW	43.06469	-85.6798	8.98	7.72	1161	7.03
6 Mile Rd. NW	43.05839	-85.6728	9.59	8.94	715	7.56
Lamoreaux Dr. NW	43.03961	-85.6708	9.216	9.12	719	7.71
Dwight Lydell Park	43.03531	-85.6683	9.205	9.3	716	8.42

4/27/2018	Latitude	Longitude	Phycocyanin RFU	Phycocyanin conc. (µg/l)	Chlorophyll *a* RFU	Chlorophyll a conc. (µg/l)
Stage Ave. NW	43.1077	-85.7809	0.282	0.28	2.157	8.16
Baumhoff Ave. NW	43.09686	-85.7194	0.258	0.25	2.225	7.84
Wahlfield Park	43.08946	-85.6952	0.252	0.26	2.372	8.77
Vinton Ave. NW	43.07839	-85.6806	0.199	0.2	1.756	6.43
7 Mile Rd. NW	43.07259	-85.6796	0.212	0.22	1.915	6.99
S. Unnamed trib. At Comstock Park NW	43.06469	-85.6798	0.124	0.13	0.505	1.91
6 Mile Rd. NW	43.05839	-85.6728	0.177	0.17	1.188	4.49
Lamoreaux Dr. NW	43.03961	-85.6708	0.15	0.15	1.53	5.64
Dwight Lydell Park	43.03531	-85.6683	1.46	0.17	1.641	6.01

5/8/2018	Latitude	Longitude	Temperature (°C)	Dissolved oxygen (mg/l)	Conductivity (µS/cm)	pH
Comstock Park Dr. NW upstream	43.06929	-85.6794	13.456	9.3	792	8.43
N. Unnamed trib. at Comstock Park NW	43.06919	-85.6795	12.456	7.74	1051	8.01
S. Unnamed trib. at Comstock Park NW	43.06436	-85.6766	12.564	8.7	1050	8
Comstock Park Dr. NW downstream	43.06422	-85.6764	13.096	8.81	792	8.74

5/8/2018	Latitude	Longitude	Phycocyanin RFU	Phycocyanin conc. (µg/l)	Chlorophyll *a* RFU	Chlorophyll a conc. (µg/l)
Comstock Park Dr. NW upstream	43.06929	-85.6794	0.202	0.17	2.357	8.9
N. Unnamed trib. At Comstock Park NW	43.06919	-85.6795	0.292	0.25	1.323	5.12
S. Unnamed trib. At Comstock Park NW	43.06436	-85.6766	0.113	0.1	0.996	3.93
Comstock Park Dr. NW downstream	43.06422	-85.6764	0.161	0.13	1.569	5.99

5/8/2018	Latitude	Longitude	Ammonia (mg/l)	Kjeldahl nitrogen (mg/l)	Nitrate/Nitrite (mg/l)	Nitrate-calculated (mg/l)
Comstock Park Dr. NW upstream	43.06929	-85.6794	0.49	0.94	1.2	1.1
N. Unnamed trib. At Comstock Park NW	43.06919	-85.6795	0.02	0.44	0.7	0.66
S. Unnamed trib. At Comstock Park NW	43.06436	-85.6766	0.01	0.28	0.9	0.9
Comstock Park Dr. NW downstream	43.06422	-85.6764	0.02	0.37	1.1	1.1

5/8/2018	Latitude	Longitude	Nitrite (mg/l)	Ortho phosphate (mg/l)	Total phosphorus (mg/l)
Comstock Park Dr. NW upstream	43.06929	-85.6794	0.03	0.016	0.21
N. Unnamed trib. At Comstock Park NW	43.06919	-85.6795	0.042	0.16	0.034
S. Unnamed trib. At Comstock Park NW	43.06436	-85.6766	ND	ND	0.019
Comstock Park Dr. NW downstream	43.06422	-85.6764	0.027	0.014	0.031

6/25/2018	Latitude	Longitude	Temperature (°C)	Dissolved oxygen (mg/l)	Conductivity (µS/cm)	pH
7 Mile Rd. NW	43.07259	-85.6796	15.94	8.76	619	8.13
N. Unnamed trib. At Comstock Park NW	43.06919	-85.6795	15.57	6.85	754	7.83
S. Unnamed trib. At Comstock Park NW	43.06436	-85.6766	14.36	5.84	902	8.03
6 Mile Rd. NW	43.05839	-85.6728	14.83	8.56	613	8.03

6/25/2018	Latitude	Longitude	Phycocyanin RFU	Phycocyanin conc. (µg/l)	Chlorophyll *a* RFU	Chlorophyll a conc. (µg/l)
7 Mile Rd. NW	43.07259	-85.6796	0.331	0.34	0.653	2.41
N. Unnamed trib. At Comstock Park NW	43.06919	-85.6795	0.36	0.37	0.581	2.14
S. Unnamed trib. At Comstock Park NW	43.06436	-85.6766	0.409	0.42	0.476	1.75
6 Mile Rd. NW	43.05839	-85.6728	0.229	0.24	0.469	1.73

6/25/2018	Latitude	Longitude	Ammonia (mg/l)	Kjeldahl nitrogen (mg/l)	Nitrate/Nitrite (mg/l)	Nitrate-calculated (mg/l)
7 Mile Rd. NW	43.07259	-85.6796	0.02	0.38	1.3	1.3
N. Unnamed trib. At Comstock Park NW	43.06919	-85.6795	1.2	2	0.87	0.74
S. Unnamed trib. At Comstock Park NW	43.06436	-85.6766	0.02	0.34	1.5	1.5
6 Mile Rd. NW	43.05839	-85.6728	0.02	0.34	1.1	1.1

6/25/2018	Latitude	Longitude	Nitrite (mg/l)	Ortho phosphate (mg/l)	Total phosphorus (mg/l)
7 Mile Rd. NW	43.07259	-85.6796	0.022	0.062	0.089
N. Unnamed trib. At Comstock Park NW	43.06919	-85.6795	0.13	0.098	0.32
S. Unnamed trib. At Comstock Park NW	43.06436	-85.6766	ND	ND	0.01
6 Mile Rd. NW	43.05839	-85.6728	0.015	0.048	0.068

9/6/2019	Latitude	Longitude	Ammonia (mg/l)	Kjeldahl nitrogen (mg/l)	Nitrate/Nitrite (mg/l)	Nitrate-calculated (mg/l)
Wahlfield Park	43.08946	-85.6952	0.03	0.42	2.1	2.1
7 Mile Rd. NW	43.07259	-85.6796	0.01	0.3	1.5	1.5
6 Mile Rd. NW	43.05839	-85.6728	ND	0.24	1.2	1.2
Dwight Lydell Park	43.03531	-85.6683	ND	0.24	1.5	1.5

9/6/2019	Latitude	Longitude	Nitrite (mg/l)	Ortho phosphate (mg/l)	Total phosphorus (mg/l)
Wahlfield Park	43.08946	-85.6952	0.023	0.071	0.09
7 Mile Rd. NW	43.07259	-85.6796	ND	0.048	0.065
6 Mile Rd. NW	43.05839	-85.6728	ND	0.033	0.049
Dwight Lydell Park	43.03531	-85.6683	ND	0.027	0.04

Unnamed Tributary to Lloyds Bayou

On March 1, 2017, during a heavy rainstorm, a culvert failure occurred on 148th Avenue in Spring Lake Township. The culvert failure occurred when a hole developed in the middle of a 30-inch diameter pipe under about 17-18 feet of soil. Soil from the road berm washed out and eventually caused the pavement to collapse on 148th Avenue (Figure 7), causing large amounts of sediment to enter an unnamed tributary to Lloyds Bayou (Figure 8). A new, 36-inch diameter culvert has since been installed. Every year, culvert failures occur in the state, particularly in the spring, during large rain events. This stream was sampled in 2017 and again in 2019 to evaluate habitat and macroinvertebrate communities immediately after a culvert failure and in subsequent years.

The unnamed tributary to Lloyds Bayou is a first-order stream that largely originates west of 144th Avenue in Spring Lake Township and flows west into a wetland complex north of M-104. This wetland complex drains to Lloyds Bayou, one of several large bayous that are connected to the lower Grand River in Ottawa County. All tributaries to these bayous are designated trout streams (MDNR, 1997). The stream begins as two drains, one of which flows past a large auto salvage yard. Land use above 148th Avenue is a mix of industry, forest, and some residential areas.

Figure 7. Collapsed section of 148th Avenue in Spring Lake Township after a culvert failure. Image from Grand Haven Tribune online article (link no longer available).

Downstream of 148th Avenue the macroinvertebrate community scored low acceptable (-3; Appendix 2), and habitat scored excellent (161; Appendix 1). Sixteen different taxa were collected, of which only 2 were EPT, indicating poor water and/or habitat quality. Amphipoda and Isopoda were the dominant taxa collected, which are typically indicative of stressed conditions (Voshell, 2002). All habitat types such as large woody debris and undercut banks were either sparse or absent. The substrate was mostly an even mixture of sand and gravel. The gravel was most likely from when the road berm fill was deposited after the culvert failure.

The stream did not show evidence of flashiness and it had a forested floodplain, which provides good canopy cover.

A similar macroinvertebrate community was found at that site in 2017, four months after the culvert failure. In 2017 much of the stream bank was covered with bare sand from the berm, which lowered the habitat score at the time (116 [good]; Figure 8). During the 2019 visit, vegetation was growing along the banks and stabilizing the soils (Figures 8 and 9).

Figure 8. Before and after photos of stream banks below 148th Avenue. Photographs on left were taken in March 2017, shortly after the culvert failure. Photos on the right were taken in May 2020.

Figure 9. Before and after photos of stream banks below 148th Avenue. Photographs on left were taken in March 2017, shortly after the culvert failure. Photos on the right were taken in May 2020.

Upstream of 148th Avenue the macroinvertebrate community scored low acceptable (-4; Appendix 2), and habitat scored good (146; Appendix 1). Sixteen different taxa were collected, of which 1 was EPT (2 individual Hydropsychidae), indicating poor water and/or habitat quality. Amphipoda comprised 67 percent of the individuals collected, which is indicative of disturbed systems (Voshell, 2002). This section of stream flows through a wetland, so macrophytes and overhanging vegetation were heavily available as habitat. Other habitat types such as large woody debris and undercut banks were sparse. The substrate was mostly sand (80 percent visual estimate) and moderate amounts of detritus and mud were present. The stream did not appear to be flashy since it had a wetland floodplain. Large trees were lacking along the stream for canopy cover. The macroinvertebrate community and habitat were similar to when it was sampled in 2017.

Willow Hill Creek

On February 20, 2018, during a heavy rainstorm, a culvert failure occurred on Farr Road, where it crosses Willow Hill Creek, in Fruitport Charter Township. Willow Hill Creek is a first-order

stream that is a tributary to Norris Creek and is a designated trout stream (MDNR, 1997). The culvert failure contributed road berm sediment downstream and altered the geomorphology of the stream. The original culvert was 70-feet long with a 5-foot span and 5-foot rise. That culvert was replaced with a larger, 96-foot-long culvert with a 7.9-foot span and 5.6-foot rise. Willow Hill Creek was sampled upstream and downstream of Farr Road in 2018 and 2019.

2018 Sampling:

The macroinvertebrate community downstream of Farr Road, which received the road berm sand after the culvert failure, scored high acceptable (1; Appendix 2) and habitat scored good (140; Appendix 1). Sixteen different taxa were collected, of which 4 were EPT, indicating poor water and/or habitat quality. Amphipoda, which tend to dominate in disturbed systems (Voshell, 2002) made up the majority of the taxa collected (66 percent). Below Farr Road, was a deep depression (2.8 feet) that extended about 10 feet downstream from the new culvert. A steep incline of gravel was at the downstream end of the hole and gravel was present in the stream below it. Most of the stream was only 0.3-feet deep at most. The large depression may have been from material excavation following the culvert failure. The streambed was composed of about 60 percent gravel and the remaining sediment was a mix of mostly sand and silt. The large amount of gravel in the streambed was likely from the road berm fill that flowed downstream after the culvert failure. Overhanging vegetation and macrophytes were sparse; however, undercut banks, large woody debris, and rootwads were either moderate or heavy. Mature forest is present on both sides of the creek, which provides good canopy cover.

The macroinvertebrate community upstream of Farr Road scored acceptable (0; Appendix 2) and habitat scored good (130; Appendix 1). The macroinvertebrate community upstream of Farr Road was similar to the one downstream of it. Eighteen different taxa were collected, of which only 3 were EPT also indicating poor water and/or habitat quality. Amphipoda, which tend to dominate in disturbed systems (Voshell, 2002), made up the majority of the taxa collected (79 percent). The stream was shallow (average depth 0.4 feet), and the sediment consisted of 100 percent sand. Aquatic macrophytes were absent; however, undercut banks, overhanging vegetation, large woody debris, and rootwads were moderate to heavy. Along the left bank is mostly forested. Along the right bank, Willow Hill Creek flows along Stringer Road for about 275 feet. However, large, mature trees grow between the road and the stream, which provide good canopy cover. Land use in the Willow Hill Creek watershed is a mix of forest and developed areas (Table 1).

2019 Sampling:

When sampled again in 2019, the macroinvertebrate community downstream of Farr Road scored high acceptable (2; Appendix 2) and habitat scored good (142; Appendix 1). Twenty-four taxa were collected, including 6 EPT, indicating intermediate water and/or habitat quality. Amphipoda, again dominated the macroinvertebrate community, but only at 39 percent of the individuals collected. Undercut banks were heavily available and rootwads were moderately available as habitat. Other habitat types such as large woody debris and overhanging vegetation were either sparse or absent. The substrate was an even mixture of sand and gravel (45 and 40 percent visual estimate, respectively). The large depression that had been observed during the previous year had filled in and the stream was a uniform depth. The stream banks did not show signs of flashiness. The riparian area is mostly forested, which provides good canopy cover.

Upstream of Farr Road the macroinvertebrate community scored low acceptable (-1; Appendix 2) and habitat scored good (121; Appendix 1). Twenty-three different taxa were collected, of which, 5 were EPT, indicating intermediate water and/or habitat quality. Similar to the previous year, Amphipoda made up the majority of the taxa collected; however, at a lower proportion (45 percent). Undercut banks were heavily available and large woody debris and overhanging vegetation were moderately available as habitat. Sand made up the majority of the sediment (88 percent visual estimate). The stream did not show signs of flashiness and the banks were largely intact.

The macroinvertebrate communities upstream and downstream of 148th Avenue in Spring Lake Township, remained largely the same two years after the culvert failure. Although, habitat has improved, mostly in the form of revegetation in the riparian areas. Upstream and downstream of Farr Road in Fruitport Charter Township, the macroinvertebrate communities also remained similar one year after the culvert failure.

Sand Creek

Sand Creek is a third-order tributary to the Grand River in Ottawa County with a watershed that is dominated by development and agriculture. In the headwater region, land use in the watershed is 78 percent agricultural (Table 2). In 2019, 3 targeted sites and 1 status site were sampled. The 3 targeted sites were sampled in the first-order headwaters prior to multiple BMPs being implemented. Specifically, the Ottawa County Water Resources Commission has created a two-stage ditch along 5,326 linear feet of Sand Creek, restored 2.17 acres of wetland, installed 183 feet of upland soil stabilization, and installed in-stream structures such as cross vanes and toe wood.

The furthest upstream site was sampled at 32nd Avenue in Chester Township. This site is downstream from where most of the wetlands were restored. The macroinvertebrate community at 32nd Avenue scored low acceptable (-2; Appendix 2) and habitat scored marginal (68; Appendix 1). Only 12 different taxa were collected, of which 3 were EPT, indicating poor water and/or habitat quality. Only 126 individuals were collected during the entire sampling effort and of those, Isopoda, which are tolerant to stressors (Voshell, 2002), made up the majority of the taxa counted. All habitat types, such as large woody debris and undercut banks were either sparse or absent. The substrate was an even mixture of clay, silt, sand, and gravel. The banks showed signs of stream flashiness with scour greater than 18 inches above the water surface and storm debris observed in tree branches 5 feet above baseflow. Stream banks were also actively eroding. The riparian vegetation was diminished by residential and business lots on both sides of the stream. However, large trees were present on both banks, which provides good canopy cover.

Slightly downstream from 32nd Avenue, Sand Creek was sampled above Wilson Street. This site was sampled prior to the implementation of extensive lengths of two-stage ditches (Figure 10) and upland stabilization. The macroinvertebrate community at Wilson Street scored low acceptable (-2; Appendix 2) and habitat scored marginal (83; Appendix 1). Seventeen taxa were collected, of which, only 3 were EPT, indicating poor habitat and/or water quality. The taxa were dominated by a mix of Chironomidae, Isopoda, and Calopterygidae, all of which tend to dominate in stressed systems (Voshell, 2002). All habitat types such as large woody debris and undercut banks were either sparse or absent. The substrate was an even mixture of clay, silt, sand, and gravel. The stream banks showed signs of flashiness with scour greater than 18 inches above the water surface, storm debris was observed in tree branches about 7 feet above baseflow, and banks were actively eroding. The stream at baseflow was also not

occupying the entire channel and several sediment bars were present. The riparian vegetation was diminished by row crops on both sides of the stream.

Figure 10. Two-stage ditch banks at Wilson Street site (left photo) and slightly upstream (right photo) in June 2020.

Sand Creek at Taft Street was sampled because that was at the downstream end of where all of the BMPs were implemented. The macroinvertebrate community at Taft Street scored low acceptable (-3; Appendix 2) and habitat scored marginal (79; Appendix 1). Twenty-three taxa were collected, of which, only 3 were EPT, indicating poor habitat and/or water quality. The taxa were dominated by Chironomidae, which tend to dominate in stressed systems (Voshell, 2002). Overhanging vegetation was moderately available, but all other habitat types such as large woody debris and undercut banks were either sparse or absent. The substrate was about 50 percent sand, 25 percent silt, and 25 percent clay based on visual estimates. The banks were relatively stable and intact at this site. Debris was observed about 3 feet above baseflow. This site exhibited less signs of flashiness than the upstream sites. The riparian vegetation was diminished by row crops on both sides of the stream.

At Luce Street, which is the last road crossing for Sand Creek before it enters the Grand River, the macroinvertebrate community scored poor (-5; Appendix 2) and habitat scored marginal (97; Appendix 1). Twenty-four taxa were collected, of which, only 3 were EPT, indicating poor habitat and/or water quality. The taxa were dominated by Chironomidae and Oligochaetes, which tend to dominate in stressed systems (Voshell, 2002). All habitat types such as large woody debris

and undercut banks were only sparsely available. The substrate was mostly sand (60 percent visual estimate) followed by silt (25 percent visual estimate). The left bank was mostly unnatural, with a large retaining wall along the stream where Luce Street runs along Sand Creek for about 450 feet. The right bank was mostly forested. The banks were relatively stable, although the high-water mark was about 6 feet above baseflow. The reason for the low macroinvertebrate score was not readily apparent, although underneath the Luce Street bridge was an accumulation of soft sediment with anaerobic gases bubbling out of it. To explore potential sediment pollution at this site a sample was collected in 2021 (described below).

Indian Mill Creek

Indian Mill Creek is a second-order tributary to the Grand River in Kent County. The headwaters of Indian Mill Creek are dominated by agricultural land use and the lower reaches are in heavily urbanized areas of the cities of Walker and Grand Rapids. Past surveys of fish communities in Indian Mill Creek have scored poor, typically because less than 50 individual fish were collected (Parker, 2018). Sediment samples collected in Indian Mill Creek contain contaminated sediments that may have adverse impacts on benthic invertebrates (Parker 2017; 2018).

Indian Mill Creek was sampled at Turner Avenue NW in the city of Grand Rapids. This is one of the last road crossings before Indian Mill Creek enters the Grand River. The macroinvertebrate community scored low acceptable (-3; Appendix 2) and habitat scored marginal (71; Appendix 1). Seventeen taxa were collected, of which, only 3 were EPT, indicating poor habitat and/or water quality. The taxa were dominated by Baetidae and Isopoda, which tend to dominate in stressed systems (Voshell, 2002). Large woody debris was moderately available; however, other habitat types such as overhanging vegetation and undercut banks were sparsely available. The substrate was mostly sand (80 percent visual estimate) followed by silt (15 percent visual estimate). The stream banks showed evidence of flashiness with actively eroding banks greater than 18 inches above the water surface. Debris was also in tree branches about 3 feet above base flow. The riparian area is diminished by commercial lots and railroad tracks along the right bank. Some large trees are present along the immediate stream bank, which provide some canopy cover.

Indian Mill Creek was also sampled at 3 Mile Road NW in the city of Walker. The macroinvertebrate community scored low acceptable (-2; Appendix 2) and habitat scored excellent (157; Appendix 1). Despite the high-quality habitat at the immediate site, only 17 taxa were collected, of which, only 4 were EPT, indicating poor habitat and/or water quality. The taxa were dominated by Isopoda and Amphipoda, which tend to dominate in stressed systems (Voshell, 2002). Overhanging vegetation was moderately available as habitat, but other habitat types such as large woody debris and undercut banks were sparse or absent. This section of stream contained riffle-run sequences and contained mostly cobble substrate (45 percent visual estimate) followed by gravel and sand (20 percent visual estimate for both). There were signs of flashiness with debris about 2 feet above base flow. The riparian areas were intact with mature forest on each side of the stream. Upstream of this site are several large commercial lots and Interstate-96, which likely contribute to flashy storm flows and may explain the low macroinvertebrate score.

Targeted Monitoring – NPDES Permits

Targeted Monitoring was conducted at select surface waters in the vicinity of facilities that are authorized to discharge under an NPDES permit or Groundwater Discharge Permit to assess the macroinvertebrate community, habitat quality, and nutrients to assist with development of NPDES permits. The facilities targeted include the Betz Industries (MIG250169), Clarksville-Morrison Lake Wastewater Sewage Lagoon (WWSL) (MIG580403), Lowell Wastewater Treatment Plant (WWTP) (MI0020311), Sunset Ridge Mobile Home Park (MHP)-Portland Township (Twp) (MIG580381), Sheridan WWSL (MIG580129), Ravenna WWSL (MIG580126), and St Vincent de Paul Building Corp Hall-Conklin (MIG250504).

The macroinvertebrate community and habitat quality were assessed at 7 locations in 2019. Habitat quality was rated poor to good with no observed nutrient issues. The macroinvertebrate community was rated acceptable to excellent. The fish community was assessed at Indian Mill Creek (Site C) and was rated acceptable. The habitat, macroinvertebrate community, and fish community results are found in Table 3. Water chemistry samples in 2019 focused on total hardness, which is used to aid in Water Quality-Based Effluent Limit development. These results are summarized in Table 7.

Table 7. Total hardness results for select locations along the Grand River.

STORET	Water body	Latitude	Longitude	Sample Date	Total Hardness Results	Units
410766	Grand River	43.062147	-85.608831	8/27/2019	290	mg/l
410443	Grand River	42.951159	-85.691189	8/27/2019	280	mg/l
410876	Grand River	42.937156	-85.722928	8/27/2019	260	mg/l
410052	Grand River	42.915530	-85.768308	8/27/2019	270	mg/l
700094	Grand River	42.974199	-85.875237	8/27/2019	290	mg/l
700708	Grand River	43.010658	-85.936921	8/27/2019	280	mg/l
700707	North Channel Grand River	43.076824	-86.2260470	8/27/2019	250	mg/l
700709	South Channel Grand River	43.069972	-86.2277732	8/27/2019	270	mg/l

2021 Sediment Sampling

Sediment sampling was performed in Plaster Creek, an unnamed tributary to Plaster Creek, Egypt Creek, and Sand Creek. All results are in Appendix 4. In Plaster Creek and the unnamed tributary to Plaster Creek all of the analyzed Pesticides, PCBs, and base/neutrals and acids (not including the set of PAH17 analytes) were found to be ND. Two of the 3 surficial sediment samples (PLC21-02 and PLC21-03) had at least 1 analyte concentration above the MacDonald et al. (2000) threshold effect concentration (TEC; yellow) Sediment Quality Guidelines. None of the 3 samples had concentrations over individual PAH probable effect concentrations (PEC) and PLC21-01 had individual concentrations under the TEC. When these individual PAH analytes were summed to give us the PAH17, all 3 of the samples had summed concentrations under the MacDonald et al. (2000) PEC guideline of 22,800 micrograms per kilogram (µg/kg) and over the TEC guideline of 1,610 µg/kg. These results suggest that these concentrations do not adversely affect the benthic community since their PAH17 concentrations are below the PEC. Of the metals evaluated, no individual metal had a concentration over the TEC and none over the PEC. These concentrations suggest that metals at all 3 locations do not adversely affect the benthic community.

In Appendix 4, PAH17 analytes are also normalized with the total organic carbon (TOC) concentrations. Due to the low percent TOC at each location, the normalized concentrations

resulted in concentrations higher at all locations with only PLC21-02 resulting in a level higher than the PEC. High TOC in the sediment reduces potential adverse impacts to the benthic community due to the binding of contaminants to the carbon in the system. Low TOC in the sediment (under 1 percent), increases the potential for adverse impacts to the benthic community since there is less carbon for the contaminants to adhere to. Even though the normalized concentrations are higher than the TEC, it is not expected to have an adverse effect on the benthic community. None of the 3 samples were found to have Oil Range Organics/Diesel Range Organics (ORO/DRO) concentrations above the Region 4 Ecological Screening Levels (USEPA, 2018).

For Egypt and Sand Creeks all of the analyzed pesticides, PCBs and base/neutrals and acids (including the set of PAH17 analytes), were found to be ND by the lab. The analyzed metals were all found to be under the MacDonald et al. (2000) TEC concentration, suggesting that these concentrations do not have potential adverse effects on the benthic community. None of the samples were found to have ORO/DRO concentrations above the Region 4 Ecological Screening Levels (USEPA, 2018).

Conclusions and Recommendations

In 2019, 2 of the 11 randomly-selected sites within the lower Grand River watershed received poor macroinvertebrate community scores. The 4 sites that were sampled for the statewide trend analysis were all attaining the OIALW designated use. Mill Creek was listed as not attaining its coldwater fishery and OIALW designated use in the 2020 Integrated Report (Goodwin and Smith, 2020).

The most frequently noted impacts at stations sampled in the lower Grand River watershed were sedimentation, erosion, and lack of substrate and habitat diversity. A couple tributaries in the eastern portion of the watershed (Prairie and Libhart Creeks) contained native gravel, cobble, and boulder substrate. The soils in those subwatersheds also tend to be well-drained (Lower Grand River Organization of Watersheds [LGROW], 2011), which reduces runoff and erosion. The above factors may have contributed to the diverse, high-quality macroinvertebrate communities that were present in those streams (Table 3). The other sites that were sampled further west were in streams that drained sandy, lacustrine deposits, and clay-dominated, glacial moraines, which resulted in little native gravel, cobble, or boulder substrate. Although, even with such geologic material, the potential exists for minimal impacts to occur in-stream if the watershed is largely unimpacted.

According to LGROW (2011), 74 percent of the lower Grand River watershed is considered to contain soil properties that would be considered “prime farmland” soils. Many tracts of fertile land are in low slope areas and need to be drained or tiled to farm. Because of the ideal soil properties in the lower Grand River watershed, just over half of the entire watershed contains agricultural land use (LGROW, 2011). Development in the lower Grand River watershed typically takes place in areas with highly permeable surfaces. The combination of impervious surfaces covering highly permeable soils and agriculture dominating less permeable soils, leads to high amounts of precipitation runoff and erosion throughout the watershed (LGROW, 2011). These impacts were evident by the amount of sedimentation, bank erosion, and lack of habitat diversity at the majority of the sites that were sampled.

Future monitoring efforts in the lower Grand River watershed will include:

- Resample the 4 trend sites within the watershed.
- Resample sites in Mill Creek following BMP implementation at Lydell Park and to assess if other sites are still not meeting OIALW and coldwater fishery designated uses.
- Resample sites within the Plaster Creek subwatershed after restoration work has been completed.
- Resample Plaster Creek at Shadyside Park again after planted riparian vegetation has grown.

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Appendix 1. Raw habitat scores.

0	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
	North Branch Crockery Creek	**North Branch Crockery Creek**	**Crockery Creek**	**Black Creek**	**Prairie Creek**
	36th Avenue	**24th Avenue**	**Fitzgerald Street**	**Cleveland Street (M104) (downstream)**	**Main Street (Ionia)**
	8/29/2019	**8/29/2019**	**8/29/2019**	**8/27/2019**	**8/26/2019**
	RIFFLE/RUN	**RIFFLE/RUN**	**GLIDE/POOL**	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC					
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	11	13	8	6	12
Embeddedness (20)*	18	18			19
Velocity/Depth Regime (20)*	6	14			19
Pool Substrate Characterization (20)**			6	8	
Pool Variability (20)**			14	8	
Channel Morphology					
Sediment Deposition (20)	8	8	8	8	13
Flow Status - Maint. Flow Volume (10)	9	7	9	9	10
Flow Status - Flashiness (10)	0	1	0	2	9
Channel Alteration (20)	19	19	19	19	19
Frequency of Riffles/Bends (20)*	2	14			8
Channel Sinuosity (20)**			12	11	
Riparian and Bank Structure					
Bank Stability (L) (10)	4	2	3	7	8
Bank Stability (R) (10)	4	2	3	7	9
Vegetative Protection (L) (10)	8	7	3	9	9
Vegetative Protection (R) (10)	8	6	2	9	9

Riparian Vegetation Zone Width (L) (10)	9	4	9	9	7
Riparian Vegetation Zone Width (R) (10)	9	3	9	9	7
TOTAL SCORE (200):	115	118	105	121	158
HABITAT RATING:	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**EXCELLENT**
Date:	8/29/2019	8/29/2019	8/29/2019	8/27/2019	8/26/2019
Weather:	sunny	sunny	sunny	sunny	partly cloudy
Air Temperature: ºF	70	73	52	76	70
Water Temperature: ºF	63	64	64	66	62
Ave. Stream Width: Feet	28.61666667	11.5	44.33333333	16.66666667	30
Ave. Stream Depth: Feet					
Surface Velocity: Feet/Second	0.396807763	0.370590829	0.921556122	0.344342162	0.828106743
Estimated Flow: Cubic Feet/Second	6.165510849	3.587319224	48.89141936	4.703560891	56.60950578
Stream Modifications:	none	bank stabilization,canopy removal	none	none	relocated
Nuisance Plants (Y/N):	N	Y	N	N	N
STORET No.:	700635	700634	700703	700548	340249
County Code:	70	70	70	70	34
TRS:	09N13W05	09N13W03	08N15W23	08N15W20	07N06W16
Latitude (dd):	43.19407	43.19776	43.068277	43.07412	42.98552
Longitude (dd):	-85.87922	-85.84983	-86.056333	-86.10714	-85.0261
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Coldwater	Coldwater	Warmwater	Warmwater	Coldwater
USGS Basin Code:	4050006	4050006	4050006	4050006	4050006

* Applies only to Riffle/Run stream Surveys

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).

Appendix 1 continued. Raw habitat scores.

	STATION 6	STATION 7	STATION 8	STATION 9	STATION 10
	Libhart Creek	**Egypt Creek**	**Norris Creek**	**Bass Creek**	**Rush Creek**
	David Hwy	**Pettis Avenue**	**Maple Island Road**	**Pierce Street**	**12th Ave**
	8/26/2019	**8/30/2019**	**8/29/2019**	**9/4/2019**	**8/30/2019**
	RIFFLE/RUN	**RIFFLE/RUN**	**GLIDE/POOL**	**GLIDE/POOL**	**GLIDE/POOL**
HABITAT METRIC					
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	15	14	6	3	5
Embeddedness (20)*	14	19			
Velocity/Depth Regime (20)*	15	18			
Pool Substrate Characterization (20)**			6	6	6
Pool Variability (20)**			14	12	5
Channel Morphology					
Sediment Deposition (20)	11	18	5	10	3
Flow Status - Maint. Flow Volume (10)	9	9	5	9	9
Flow Status - Flashiness (10)	8	9	1	5	1
Channel Alteration (20)	19	14	19	19	13
Frequency of Riffles/Bends (20)*	10	18			
Channel Sinuosity (20)**			14	10	1
Riparian and Bank Structure					
Bank Stability (L) (10)	7	9	5	9	3
Bank Stability (R) (10)	8	9	6	8	2
Vegetative Protection (L) (10)	3	8	8	3	7
Vegetative Protection (R) (10)	5	8	7	6	7
Riparian Vegetation Zone Width (L) (10)	1	4	9	6	1

Riparian Vegetation Zone Width (R) (10)	3	4	8	4	2
TOTAL SCORE (200):	128	161	113	110	65
HABITAT RATING:	**GOOD**	**EXCELLENT**	**GOOD**	**GOOD**	**MARGINAL**
Date:	8/26/2019	8/30/2019	8/29/2019	9/4/2019	8/30/2019
Weather:	partly cloudy	partly cloudy	partly cloudy	cloudy	partly cloudy
Air Temperature: ºF	64	71	77	65	64
Water Temperature: ºF	63	63	62	66	66
Ave. Stream Width: Feet	23.55	10.66666667	12.33333333	19.66666667	24.3
Ave. Stream Depth: Feet					
Surface Velocity: Feet/Second	1.371980676	0.473939394	0.604434524	0.140997638	1.02368808
Estimated Flow: Cubic Feet/Second	18.30908213		2.693091601	5.070901733	33.5162302
Stream Modifications:	none	canopy removal, impounded, bank stabilization	canopy removal	canopy removal, habitat improvement	canopy removal
Nuisance Plants (Y/N):	N	N	N	N	N
STORET No.:	340218	410863	610822	700636	700580
County Code:	34	41	61	70	70
TRS:	06N05W01	07N10W8	09N15W14	07N15W36	05N13W23
Latitude (dd):	42.92879	43.00736	43.17435	42.95736	42.891927
Longitude (dd):	-84.98163	-85.53079	-86.06617	-86.02478	-85.812033
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Coldwater	Coldwater	Warmwater	Warmwater
USGS Basin Code:	4050006	4050006	4050006	4050006	4050006

* Applies only to Riffle/Run stream Surveys

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).

Appendix 1 continued. Raw habitat scores.

	STATION 11	STATION 12	STATION 13	STATION 14	STATION 15
	Plaster Creek	**Plaster Creek**	**Plaster Creek**	**Plaster Creek**	**Mill Creek**
	Shadyside Park	**Leisure Creek Drive Southeast**	**Shaffer Ave Southeast**	**Godfrey Ave**	**Wahlfield Park**
	8/26/2019	**9/6/2019**	**9/6/2019**	**9/6/2019**	**8/28/2019**
	RIFFLE/RUN	**GLIDE/POOL**	**GLIDE/POOL**	**GLIDE/POOL**	**GLIDE/POOL**
HABITAT METRIC					
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	1	6	1	17	8
Embeddedness (20)*	13				
Velocity/Depth Regime (20)*	9				
Pool Substrate Characterization (20)**		6	6	11	8
Pool Variability (20)**		6	11	13	8
Channel Morphology					
Sediment Deposition (20)	16	6	7	15	7
Flow Status - Maint. Flow Volume (10)	9	6	6	9	9
Flow Status - Flashiness (10)	9	0	0	1	1
Channel Alteration (20)	19	19	19	19	19
Frequency of Riffles/Bends (20)*	8				
Channel Sinuosity (20)**		6	7	4	9
Riparian and Bank Structure					
Bank Stability (L) (10)	9	3	5	5	4
Bank Stability (R) (10)	8	3	5	5	4
Vegetative Protection (L) (10)	6	4	5	3	9
Vegetative Protection (R) (10)	6	4	5	8	9
Riparian Vegetation Zone Width (L) (10)	5	4	4	0	9

Riparian Vegetation Zone Width (R) (10)	6	5	9	0	9
TOTAL SCORE (200):	124	78	90	110	113
HABITAT RATING:	**GOOD**	**MARGINAL**	**MARGINAL**	**GOOD**	**GOOD**
Date:	8/26/2019	9/6/2019	9/6/2019	9/6/2019	8/28/2019
Weather:	rainy	rainy	cloudy	cloudy	cloudy
Air Temperature: ºF	65	66	67	58	68
Water Temperature: ºF	66	62	62	64	65
Ave. Stream Width: Feet	15	12.66666667	34.66666667	34.33333333	13.75
Ave. Stream Depth: Feet					
Surface Velocity: Feet/Second	0.722469136	0.111808421	0.16447349	0.69851271	0.600250156
Estimated Flow: Cubic Feet/Second	3.532874074	2.102743701	10.27740015	43.40014692	5.175490237
Stream Modifications:	Canopy removal, relocated, bank stabilization, habitat improvement	bank stabilization	bank stabilization	bank stabilization	none
Nuisance Plants (Y/N):	Y	N	N	N	N
STORET No.:	410785	410865	410866	410628	410862
County Code:	41	41	41	41	41
TRS:	05N11W11	05N11W3	06N11W14	06N11W02	08N12W11
Latitude (dd):	42.83115	42.84498	42.9024	42.9359	43.08953
Longitude (dd):	-85.57641	-85.59538	-85.58675	-85.68748	-85.6947
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater	Warmwater	Warmwater	Coldwater
USGS Basin Code:	4050006	4050006	4050006	4050006	4050006

* Applies only to Riffle/Run stream Surveys

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).

Appendix 1 continued. Raw habitat scores.

	STATION 16	STATION 17	STATION 18	STATION 19	STATION 20
	Mill Creek	**Mill Creek**	**Mill Creek**	**Unnamed Tributary to Lloyds Bayou**	**Unnamed Tributary to Lloyds Bayou**
	6 Mile Rd	**7 Mile Road**	**Lydell Park**	**148th Avenue, Downstream**	**148th Avenue, Upstream**
	8/28/2019	**8/28/2019**	**6/3/2019**	**8/27/2019**	**8/27/2019**
	RIFFLE/RUN	**RIFFLE/RUN**	**RIFFLE/RUN**	**RIFFLE/RUN**	**GLIDE/POOL**
HABITAT METRIC					
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	10	8	12	13	9
Embeddedness (20)*	11	7	15	16	
Velocity/Depth Regime (20)*	18	14	18	15	
Pool Substrate Characterization (20)**					12
Pool Variability (20)**					5
Channel Morphology					
Sediment Deposition (20)	17	6	9	10	18
Flow Status - Maint. Flow Volume (10)	9	9	9	9	9
Flow Status - Flashiness (10)	2	1	1	9	9
Channel Alteration (20)	19	19	11	19	17
Frequency of Riffles/Bends (20)*	10	5	2	16	
Channel Sinuosity (20)**					15
Riparian and Bank Structure					
Bank Stability (L) (10)	4	3	6	9	9
Bank Stability (R) (10)	4	4	6	9	9
Vegetative Protection (L) (10)	6	9	5	9	9
Vegetative Protection (R) (10)	7	3	5	9	9
Riparian Vegetation Zone Width (L) (10)	2	9	0	9	7
Riparian Vegetation Zone Width (R) (10)	3	3	0	9	9
TOTAL SCORE (200):	122	100	99	161	146
HABITAT RATING:	**GOOD**	**MARGINAL**	**MARGINAL**	**EXCELLENT**	**GOOD**
Date:	8/28/2019	8/28/2019	6/3/2019	8/27/2019	8/27/2019
Weather:	partlycloudy	sunny	sunny	partlycloudy	partlycloudy
Air Temperature: ºF	67	68	60	70	71
Water Temperature: ºF	62	64		68	67
Ave. Stream Width: Feet	13.33333333	17.33333333	30	4.666666667	3
Ave. Stream Depth: Feet					
Surface Velocity: Feet/Second	0.766047062	0.471677008	2.002205267	0.640972222	0.556818182
Estimated Flow: Cubic Feet/Second	12.10354358	6.586183291	64.07056855	1.156598765	0.634772727
Stream Modifications:	impounded, canopy removal	canopy removal, impounded	relocated, bank stabilization, dredged	canopy removal, bank stabilization, relocated	canopy removal, relocated, bank stabilization

Nuisance Plants (Y/N):	Y	N	N	N	N
STORET No.:	410611	410850	410783	700690	700689
County Code:	41	41	41	70	70
TRS:	07N12W24	08N12W24	08N11W31	08N16W13	08N16W13
Latitude (dd):	43.05824	43.072594	43.03408	43.074914	43.074818
Longitude (dd):	-85.67205	-85.67958	-85.666916	-86.156107	-86.15574
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Coldwater	Coldwater	Coldwater	Coldwater	Coldwater
USGS Basin Code:	4050006	4050006	4050006	4050006	4050006

* Applies only to Riffle/Run stream Surveys

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).

Appendix 1 continued. Raw habitat scores.

	STATION 21	STATION 22	STATION 21	STATION 22	STATION 23
	Willow Hill Creek	**Willow Hill Creek**	**Willow Hill Creek**	**Willow Hill Creek**	**Sand Creek**
	downstream Farr RD	**upstream Farr Rd**	**downstream Farr RD**	**upstream Farr Rd**	**at 32nd Avenue**
	7/11/2018	**7/11/2018**	**8/27/2019**	**8/27/2019**	**9/5/2019**
	RIFFLE/RUN	**RIFFLE/RUN**	**RIFFLE/RUN**	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC					
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	13	15	9	9	3
Embeddedness (20)*	16	7	18		3
Velocity/Depth Regime (20)*	13	3	12		13
Pool Substrate Characterization (20)**				8	
Pool Variability (20)**				8	
Channel Morphology					
Sediment Deposition (20)	1	16	5	8	7
Flow Status - Maint. Flow Volume (10)	5	9	5	9	5
Flow Status - Flashiness (10)	6	9	9	9	0
Channel Alteration (20)	16	15	16	18	16
Frequency of Riffles/Bends (20)*	16	7	16		3
Channel Sinuosity (20)**				3	
Riparian and Bank Structure					
Bank Stability (L) (10)	9	9	9	9	2
Bank Stability (R) (10)	9	9	9	9	2
Vegetative Protection (L) (10)	9	9	9	9	2
Vegetative Protection (R) (10)	9	9	9	9	2
Riparian Vegetation Zone Width (L) (10)	9	10	9	10	5
Riparian Vegetation Zone Width (R) (10)	9	3	7	3	5
TOTAL SCORE (200):	140	130	142	121	68
HABITAT RATING:	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**MARGINAL**
Date:	7/11/2018	7/11/2018	8/27/2019	8/27/2019	9/5/2019
Weather:	Sunny	Sunny	sunny	sunny	sunny
Air Temperature: ºF	80	80	69	62	68
Water Temperature: ºF	64	62	62	62	67
Ave. Stream Width: Feet	6	9	8.933333333	7.266666667	14
Ave. Stream Depth: Feet	0.15	0.4			
Surface Velocity: Feet/Second	0.954241071		0.424355159	0.566837232	0.117663299
Estimated Flow: Cubic Feet/Second	0.954241071		2.293875386	1.565226543	0.869401041
Stream Modifications:	Relocated	Relocated	canopy removal, relocated, bank stabilization	canopy removal, relocated, bank stabilization	

Nuisance Plants (Y/N):	N	N	N	N	N
STORET No.:	610812	610811	610812	610811	700710
County Code:	61	61	61	61	70
TRS:	09N16W25	09N16W25	09N16W25	09N16W25	09N13W32
Latitude (dd):	43.139183	43.139448	43.139183	43.139448	43.12073
Longitude (dd):	-86.151079	-86.15099	-86.151079	-86.15099	-85.86847
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Coldwater	Coldwater	Coldwater	Coldwater	Coldwater
USGS Basin Code:	4050006	4050006	4050006	4050006	4050006

* Applies only to Riffle/Run stream Surveys

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).

Appendix 1 continued. Raw habitat scores.

	STATION 24	STATION 25	STATION 26	STATION 27	STATION 28
	Sand Creek	**Sand Creek**	**Sand Creek**	**Indian Mill Creek**	**Indian Mill Creek**
	Wilson Street	**Taft Street**	**Luce St.**	**Turner Street**	**3 Mile Rd**
	9/5/2019	**9/5/2019**	**9/4/2019**	**8/29/2019**	**8/30/2019**
	RIFFLE/RUN	**GLIDE/POOL**	**GLIDE/POOL**	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC					
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	7	7	7	8	15
Embeddedness (20)*	11				11
Velocity/Depth Regime (20)*	15				15
Pool Substrate Characterization (20)**		7	7	6	
Pool Variability (20)**		1	11	4	
Channel Morphology					
Sediment Deposition (20)	6	6	8	3	15
Flow Status - Maint. Flow Volume (10)	4	9	9	9	9
Flow Status - Flashiness (10)	0	7	4	2	3
Channel Alteration (20)	12	7	14	19	19
Frequency of Riffles/Bends (20)*	16				19
Channel Sinuosity (20)**		1	7	3	
Riparian and Bank Structure					
Bank Stability (L) (10)	1	9	9	2	9
Bank Stability (R) (10)	1	9	6	2	8
Vegetative Protection (L) (10)	2	7	0	5	9
Vegetative Protection (R) (10)	2	7	6	2	8
Riparian Vegetation Zone Width (L) (10)	3	1	1	3	9
Riparian Vegetation Zone Width (R) (10)	3	1	8	3	8
TOTAL SCORE (200):	83	79	97	71	157
HABITAT RATING:	**MARGINAL**	**MARGINAL**	**MARGINAL**	**MARGINAL**	**EXCELLENT**
Date:	9/5/2019	9/5/2019	9/4/2019	8/29/2019	8/30/2019
Weather:	sunny	sunny	partlycloudy	cloudy	partlycloudy
Air Temperature: ºF	58	55	67	81	68
Water Temperature: ºF	62	64	65	64	64
Ave. Stream Width: Feet	7.333333333	6	24.66666667	29	22.48666667
Ave. Stream Depth: Feet					
Surface Velocity: Feet/Second	0.24420765	0.71875	0.425255205	0.998719918	1.038888889
Estimated Flow: Cubic Feet/Second	0.849842623	0.975743056	27.48282635	21.51775354	14.90043704
Stream Modifications:	dredged	dredged, canopy removal, snagging	canopy removal, relocated, bank stabilization	canopy removal, bank stabilization	none
Nuisance Plants (Y/N):	N	N	N	N	N

STORET No.:	700711	700712	620218	410119	410581
County Code:	70	70	70	41	41
TRS:	09N13W32	08N13W5	07N13W33	07N12W13	07N12W04
Latitude (dd):	43.11892	43.10385	42.94984	42.994448	43.01553
Longitude (dd):	-85.87363	-85.87268	-85.84919	-85.677782	-85.7339
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Coldwater	Coldwater	Coldwater	Coldwater	Coldwater
USGS Basin Code:	4050006	4050006	4060102	4050006	4050006

* Applies only to Riffle/Run stream Surveys

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).

Appendix 1 continued. Raw habitat scores.

	STATION A	STATION B	STATION C	STATION D	STATION E
	Prairie Creek	**Lake Creek**	**Indian Mill Creek**	**Rio Grande Creek**	**Rio Grande Creek**
	Boyer Road	**Grand River Avenue**	**North of Richmond Park**	**32nd Avenue**	**Blackmer Road (downstream)**
	9/11/2019	**9/3/2019**	**9/11/2019**	**9/4/2019**	**9/4/2019**
	GLIDE/POOL	**RIFFLE/RUN**	**RIFFLE/RUN**	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC					
Substrate and Instream Cover					
Epifaunal Substrate/ Avail Cover (20)	2	8	12	6	13
Embeddedness (20)*		9	9		14
Velocity/Depth Regime (20)*		7	12		9
Pool Substrate Characterization (20)**	7			7	
Pool Variability (20)**	3			3	
Channel Morphology					
Sediment Deposition (20)	3	8	13	3	13
Flow Status - Maint. Flow Volume (10)	8	5	8	7	7
Flow Status - Flashiness (10)	3	5	4	2	5
Channel Alteration (20)	7	18	15	4	20
Frequency of Riffles/Bends (20)*		14	12		9
Channel Sinuosity (20)**	5			3	
Riparian and Bank Structure					
Bank Stability (L) (10)	6	2	5	2	8
Bank Stability (R) (10)	6	2	7	2	8
Vegetative Protection (L) (10)	5	6	4	3	8
Vegetative Protection (R) (10)	4	6	7	3	8
Riparian Vegetation Zone Width (L) (10)	2	7	2	1	10
Riparian Vegetation Zone Width (R) (10)	2	6	5	1	10
TOTAL SCORE (200):	63	103	115	47	142
HABITAT RATING:	**MARGINAL**	**MARGINAL**	**GOOD**	**POOR**	**GOOD**
Date:	9/11/2019	9/3/2019	9/11/2019	9/4/2019	9/4/2019
Weather:	cloudy	partlycloudy	sunny	partlycloudy	partlycloudy
Air Temperature: ºF	85	70	67	68	70
Water Temperature: ºF	68		61	62	64
Ave. Stream Width: Feet	18.86666667	17.03333333	21.86666667	8.533333333	25.86666667
Ave. Stream Depth: Feet					
Surface Velocity: Feet/Second	0.869565217	0.166666667	0.910345693	0.460157127	0.361552028
Estimated Flow: Cubic Feet/Second	14.47505353	1.121905778	18.68849563	1.919512773	6.027102584
Stream Modifications:	dredged, canopy removal	none	none	dredged, canopy removal	none
Nuisance Plants (Y/N):	N	N	N	N	N

STORET No.:	590372	340264	410674	700706	610476
County Code:	59	34	41	70	61
TRS:	09N06W14	06N08W24	07N11W14	09N13W21	09N14W26
Latitude (dd):	43.16311	42.886707	42.99855	43.153171	43.1464
Longitude (dd):	-84.98842	-85.205105	-85.69603	-85.868563	-85.94741
Ecoregion:	SMNITP	SMNITP	SMNITP	SMNITP	SMNITP
Stream Type:	Coldwater	Coldwater	Coldwater	Warmwater	Warmwater
USGS Basin Code:	4050006	4050006	4050006	4050006	4050006

Appendix 1 continued. Raw habitat scores.

	STATION F	STATION G
	Grand River	**Grand River**
	off Grand River Drive at Park	**at Thompson Park in Portland**
	9/5/2019	**9/5/2019**
	GLIDE/POOL	**GLIDE/POOL**
HABITAT METRIC		
Substrate and Instream Cover		
Epifaunal Substrate/ Avail Cover (20)	13	12
Embeddedness (20)*		
Velocity/Depth Regime (20)*		
Pool Substrate Characterization (20)**	17	16
Pool Variability (20)**	16	16
Channel Morphology		
Sediment Deposition (20)	15	16
Flow Status - Maint. Flow Volume (10)	9	9
Flow Status - Flashiness (10)	4	7
Channel Alteration (20)	18	16
Frequency of Riffles/Bends (20)*		
Channel Sinuosity (20)**	13	10
Riparian and Bank Structure		
Bank Stability (L) (10)	7	8
Bank Stability (R) (10)	7	8
Vegetative Protection (L) (10)	7	7
Vegetative Protection (R) (10)	7	7
Riparian Vegetation Zone Width (L) (10)	8	2
Riparian Vegetation Zone Width (R) (10)	6	2
TOTAL SCORE (200):	147	136
HABITAT RATING:	**GOOD**	**GOOD**
Date:	9/5/2019	9/5/2019
Weather:	sunny	partlycloudy
Air Temperature: ºF	65	70
Water Temperature: ºF	67	68
Ave. Stream Width: Feet	547	250
Ave. Stream Depth: Feet		
Surface Velocity: Feet/Second	0	0
Estimated Flow: Cubic Feet/Second	0	0
Stream Modifications:	none	canopy removal
Nuisance Plants (Y/N):	N	N
STORET No.:	410861	340265
County Code:	41	34
TRS:	06N09W10	06N05W33
Latitude (dd):	42.924743	42.867193

Longitude (dd):	-85.369719	-84.909792
Ecoregion:	SMNITP	SMNITP
Stream Type:	Warmwater	Warmwater
USGS Basin Code:	4050006	4050006

* Applies only to Riffle/Run stream Surveys

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).

Appendix 2. Raw macroinvertebrate scores.

TAXA	North Branch Crockery Creek 36th Avenue 8/29/2019 STATION 1	North Branch Crockery Creek 24th Avenue 8/29/2019 STATION 2	Crockery Creek at Fitzgerald Street 8/29/2019 STATION 3	Black Creek Cleveland Street (M104) (downstream) 8/27/2019 STATION 4
PLATYHELMINTHES (flatworms)				
Turbellaria			1	
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1		
Oligochaeta (worms)	1		3	6
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	4	37	18	218
Decapoda (crayfish)	2		1	1
Isopoda (sowbugs)	10	194		28
Arachnoidea				
Hydracarina		3		
Insecta				
Ephemeroptera (mayflies)				
Baetidae	12	12	17	
Heptageniidae	39	4	4	1
Odonata				
Anisoptera (dragonflies)				
Aeshnidae			6	1
Cordulegastridae				1
Libellulidae				1
Zygoptera (damselflies)				
Calopterygidae	72	25	4	22
Hemiptera (true bugs)				
Belostomatidae				1
Corixidae	6	2		
Gerridae		1		2
Mesoveliidae				1
Notonectidae		1	1	4
Pleidae				10
Veliidae	2		2	2
Megaloptera				
Corydalidae (dobson flies)	1			
Trichoptera (caddisflies)				
Brachycentridae			155	
Hydropsychidae	7	16	28	
Hydroptilidae			3	
Leptoceridae		1	1	12
Limnephilidae				7
Polycentropodidae			13	
Psychomyiidae				3
Coleoptera (beetles)				
Dytiscidae (total)	1	1		
Haliplidae (adults)		1		

Hydrophilidae (total)				1
Elmidae	17	11	1	6
Diptera (flies)				
Athericidae	1			
Ceratopogonidae				1
Chironomidae	58	4	17	7
Culicidae	1			1
Simuliidae	1	14	5	
Stratiomyidae		1		
Tabanidae	4	9		1
Tipulidae	1			1
MOLLUSCA				
Gastropoda (snails)				
Physidae	7	25		5
Pelecypoda (bivalves)				
Pisidiidae		1		1
TOTAL INDIVIDUALS	247	364	280	345

METRIC	North Branch Crockery Creek 36th Avenue 8/29/2019 STATION 1		North Branch Crockery Creek 24th Avenue 8/29/2019 STATION 2		Crockery Creek at Fitzgerald Street 8/29/2019 STATION 3		Black Creek Cleveland Street (M104) (downstream) 8/27/2019 STATION 4	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	20	0	21	0	18	0	27	1
NUMBER OF MAYFLY TAXA	2	0	2	0	2	0	1	-1
NUMBER OF CADDISFLY TAXA	1	-1	2	0	5	1	3	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	20.65	1	4.40	0	7.50	0	0.29	-1
PERCENT CADDISFLY COMPOSITION	2.83	-1	4.67	0	71.43	1	6.38	0
PERCENT DOMINANT TAXON	29.15	0	53.30	-1	55.36	-1	63.19	-1
PERCENT ISOPOD, SNAIL, LEECH	6.88	0	60.44	-1	0.00	1	9.57	0
PERCENT SURFACE AIR BREATHERS	4.05	1	1.92	1	1.07	1	6.38	1
TOTAL SCORE	-1		-2		2		-2	
MACROINVERTEBRATE COMMUNITY RATING	Acceptable		Acceptable		Acceptable		Acceptable	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Prairie Creek Main Street (Ionia) 8/26/2019 STATION 5	Libhart Creek David Hwy 8/26/2019 STATION 6	Egypt Creek Pettis Avenue 8/30/2019 STATION 7	Norris Creek Maple Island Road 8/29/2019 STATION 8
PLATYHELMINTHES (flatworms)				
Turbellaria			3	
ANNELIDA (segmented worms)				
Hirudinea (leeches)		1		
Oligochaeta (worms)	2	10		3
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	4	15	48	223
Decapoda (crayfish)	1	1	1	1
Isopoda (sowbugs)			1	
Arachnoidea				
Hydracarina	3	2	2	
Insecta				
Ephemeroptera (mayflies)				
Baetiscidae	1	2		
Baetidae	43	27	66	1
Caenidae	1	7		
Ephemeridae	1	1		
Heptageniidae	14	10		1
Isonychiidae	10	3		
Tricorythidae (Leptohyphidae)	1	3		
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	1		1
Cordulegastridae				1
Gomphidae	1	1		
Zygoptera (damselflies)				
Calopterygidae	2	27	1	9
Coenagrionidae		1		
Plecoptera (stoneflies)				
Perlidae	5			
Pteronarcyidae	1			
Hemiptera (true bugs)				
Corixidae	1	1		
Gerridae		1	1	1
Mesoveliidae			1	
Notonectidae				1
Pleidae	1			
Megaloptera				
Corydalidae (dobson flies)	1			
Trichoptera (caddisflies)				
Brachycentridae	18	1	2	3
Goeridae	1			
Helicopsychidae	1	18		
Hydropsychidae	63	89	24	4

Hydroptilidae	3	1	2	
Leptoceridae	5			
Limnephilidae	1		1	6
Psychomyiidae				5
Coleoptera (beetles)				
Curculionidae (adults)		1		
Dytiscidae (total)		2		
Gyrinidae (adults)		1		3
Haliplidae (adults)		3		
Hydrophilidae (total)	2	1		
Dryopidae		1		
Elmidae	31	16	11	1
Diptera (flies)				
Athericidae	4			
Ceratopogonidae	1			
Chironomidae	55	70	120	12
Simuliidae	25		81	2
Tabanidae	1	1		
Tipulidae	7	1	1	2
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		1		
Lymnaeidae	1			
Physidae	1	4	1	13
Pleuroceridae		3		
Viviparidae		1		
Pelecypoda (bivalves)				
Corbicula		1		
Pisidiidae		3		1
TOTAL INDIVIDUALS	314	333	367	294

METRIC	Prairie Creek Main Street (Ionia) 8/26/2019		Libhart Creek David Hwy 8/26/2019		Egypt Creek Pettis Avenue 8/30/2019		Norris Creek Maple Island Road 8/29/2019	
	STATION 5		STATION 6		STATION 7		STATION 8	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	36	1	38	1	18	0	21	0
NUMBER OF MAYFLY TAXA	7	1	7	1	1	-1	2	0
NUMBER OF CADDISFLY TAXA	7	1	4	0	4	0	4	0
NUMBER OF STONEFLY TAXA	2	1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	22.61	1	15.92	0	17.98	0	0.68	-1
PERCENT CADDISFLY COMPOSITION	29.30	1	32.73	1	7.90	0	6.12	0
PERCENT DOMINANT TAXON	20.06	0	26.73	0	32.70	0	75.85	-1
PERCENT ISOPOD, SNAIL, LEECH	0.64	1	3.00	1	0.54	1	4.42	0
PERCENT SURFACE AIR BREATHERS	1.27	1	3.00	1	0.54	1	1.70	1
TOTAL SCORE	8		4		0		-2	
MACROINVERTEBRATE COMMUNITY RATING	Excellent		Acceptable		Acceptable		Acceptable	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Bass Creek Pierce Street 9/4/2019 STATION 9	Rush Creek 12th Ave 8/30/2019 STATION 10	Plaster Creek Shadyside Park 8/26/2019 STATION 11	Plaster Creek Leisure Creek Dr SE 9/6/2019 STATION 12
ANNELIDA (segmented worms)				
Hirudinea (leeches)		3		
Oligochaeta (worms)		10	3	1
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	29	8	17	197
Decapoda (crayfish)	1	1	1	3
Isopoda (sowbugs)	28	5		
Arachnoidea				
Hydracarina	1	3	36	
Insecta				
Ephemeroptera (mayflies)				
Baetidae		1	12	
Caenidae		2		
Heptageniidae	2			1
Odonata				
Anisoptera (dragonflies)				
Aeshnidae			3	5
Zygoptera (damselflies)				
Calopterygidae	9	19		39
Coenagrionidae	142	5		1
Hemiptera (true bugs)				
Belostomatidae	1			1
Corixidae	30		1	
Gerridae	8	1	1	4
Mesoveliidae	1		1	
Nepidae			1	
Pleidae	1			
Veliidae				5
Trichoptera (caddisflies)				
Hydropsychidae		106	3	1
Leptoceridae	2	1		
Polycentropodidae	1			
Coleoptera (beetles)				
Haliplidae (adults)	1	1		
Hydrophilidae (total)				1
Elmidae	30	15		3
Diptera (flies)				
Chironomidae	26	96	435	11
Culicidae	1		1	
Dixidae				1
Simuliidae		20		
Stratiomyidae			2	
Tipulidae		1	1	
MOLLUSCA				

Gastropoda (snails)				
Ancylidae (limpets)	5			
Physidae	8	2	5	
Planorbidae	2	1		
Pelecypoda (bivalves)				
Pisidiidae		5		

TOTAL INDIVIDUALS	329	306	523	274

METRIC	Bass Creek Pierce Street 9/4/2019 STATION 9		Rush Creek 12th Ave 8/30/2019 STATION 10		Plaster Creek Shadyside Park 8/26/2019 STATION 11		Plaster Creek Leisure Creek Dr SE 9/6/2019 STATION 12	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	21	0	21	0	16	0	15	0
NUMBER OF MAYFLY TAXA	1	-1	2	0	1	-1	1	-1
NUMBER OF CADDISFLY TAXA	2	0	2	0	1	-1	1	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	0.61	-1	0.98	-1	2.29	-1	0.36	-1
PERCENT CADDISFLY COMPOSITION	0.91	-1	34.97	1	0.57	-1	0.36	-1
PERCENT DOMINANT TAXON	43.16	-1	34.64	0	83.17	-1	71.90	-1
PERCENT ISOPOD, SNAIL, LEECH	13.07	-1	3.59	1	0.96	1	0.00	1
PERCENT SURFACE AIR BREATHERS	13.07	0	0.65	1	1.34	1	4.01	1
TOTAL SCORE	-6		1		-4		-4	
MACROINVERTEBRATE COMMUNITY RATING	Poor		Acceptable		Acceptable		Acceptable	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Plaster Creek Shaffer AVE SE 9/6/2019 STATION 13	Plaster Creek Godfrey Ave 9/6/2019 STATION 14	Mill Creek Wahlfield Park 8/28/2019 STATION 15	Mill Creek 6 Mile Rd 8/28/2019 STATION 16
PLATYHELMINTHES (flatworms)				
Turbellaria				3
ANNELIDA (segmented worms)				
Hirudinea (leeches)				1
Oligochaeta (worms)		2	3	
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	187	6		1
Decapoda (crayfish)	1		42	1
Isopoda (sowbugs)	3	73		289
Arachnoidea				
Hydracarina	1		4	
Insecta				
Ephemeroptera (mayflies)				
Baetidae	7	2		8
Heptageniidae	5		1	
Odonata				
Anisoptera (dragonflies)				
Aeshnidae		4	6	
Zygoptera (damselflies)				
Calopterygidae	21	29	63	
Coenagrionidae	3			
Hemiptera (true bugs)				
Belostomatidae	2			
Corixidae	3			
Gerridae	1		2	1
Nepidae	1			
Notonectidae	1			1
Pleidae	1		1	1
Trichoptera (caddisflies)				
Hydropsychidae	15	59	28	11
Leptoceridae	1			
Coleoptera (beetles)				
Hydrophilidae (total)		1	1	
Dryopidae			1	
Elmidae	8	3		
Diptera (flies)				
Chironomidae	25	40	60	3
Culicidae			3	
Simuliidae		2		4
Tipulidae			3	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		1	6	
Physidae	15		2	

Pelecypoda (bivalves)				
Pisidiidae	1		11	
Unionidae (mussels)	1			

TOTAL INDIVIDUALS	303	222	237	324

METRIC	Plaster Creek Shaffer AVE SE 9/6/2019 STATION 13		Plaster Creek Godfrey Ave 9/6/2019 STATION 14		Mill Creek Wahlfield Park 8/28/2019 STATION 15		Mill Creek 6 Mile Rd 8/28/2019 STATION 16	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	21	0	12	0	17	0	12	0
NUMBER OF MAYFLY TAXA	2	0	1	-1	1	-1	1	-1
NUMBER OF CADDISFLY TAXA	2	0	1	-1	1	-1	1	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	3.96	0	0.90	-1	0.42	-1	2.47	-1
PERCENT CADDISFLY COMPOSITION	5.28	0	26.58	0	11.81	0	3.40	-1
PERCENT DOMINANT TAXON	61.72	-1	32.88	0	26.58	0	89.20	-1
PERCENT ISOPOD, SNAIL, LEECH	5.94	0	33.33	-1	3.38	1	89.51	-1
PERCENT SURFACE AIR BREATHERS	2.97	1	0.45	1	2.95	1	0.93	1
TOTAL SCORE	-1		-4		-2		-6	
MACROINVERTEBRATE COMMUNITY RATING	Acceptable		Acceptable		Acceptable		Poor	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Mill Creek 7 Mile Rd 8/28/2019 STATION 17	Mill Creek Lydell Park 6/3/2019 STATION 18	Unnamed Tributary to Lloyds Bayou 148th Ave (downstream) 8/27/2019 STATION 19	Unnamed Tributary to Lloyds Bayou 148th Ave (upstream) 8/27/2019 STATION 20
PLATYHELMINTHES (flatworms)				
Turbellaria	5		35	4
ANNELIDA (segmented worms)				
Hirudinea (leeches)	1	1		1
Oligochaeta (worms)		1	26	16
ARTHROPODA				
Crustacea				
Amphipoda (scuds)		1	93	221
Decapoda (crayfish)	15	2		1
Isopoda (sowbugs)	150	107	54	42
Arachnoidea				
Hydracarina	4	3		
Insecta				
Ephemeroptera (mayflies)				
Baetidae		5		
Heptageniidae	4			
Odonata				
Anisoptera (dragonflies)				
Aeshnidae			5	2
Corduliidae				1
Zygoptera (damselflies)				
Calopterygidae	44		11	18
Hemiptera (true bugs)				
Gerridae			1	
Mesoveliidae		1		
Notonectidae	1			
Veliidae				2
Trichoptera (caddisflies)				
Hydropsychidae	2		11	2
Leptoceridae			2	
Polycentropodidae		2		
Coleoptera (beetles)				
Dytiscidae (total)		3		
Haliplidae (adults)	1			
Elmidae			11	
Diptera (flies)				
Ceratopogonidae		1	1	
Chironomidae	13	194	24	6
Culicidae			1	
Simuliidae		1		
Tipulidae		1	3	1
MOLLUSCA				
Gastropoda (snails)				
Lymnaeidae			1	1
Physidae	3			

Valvatidae				2
Pelecypoda (bivalves)				
Pisidiidae			8	10
TOTAL INDIVIDUALS	243	323	287	330

METRIC	Mill Creek 7 Mile Road 8/28/2019 STATION 17		Mill Creek Lydell Park 6/3/2019 STATION 18		Unnamed Tributary to Lloyds Bayou 148th Ave (downstream) 8/27/2019 STATION 19		Unnamed Tributary to Lloyds Bayou 148th Ave (upstream) 8/27/2019 STATION 20	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	12	0	14	0	16	0	16	1
NUMBER OF MAYFLY TAXA	1	-1	1	-1	0	-1	0	-1
NUMBER OF CADDISFLY TAXA	1	-1	1	-1	2	0	1	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	1.65	-1	1.55	-1	0.00	-1	0.00	-1
PERCENT CADDISFLY COMPOSITION	0.82	-1	0.62	-1	4.53	0	0.61	-1
PERCENT DOMINANT TAXON	61.73	-1	60.06	-1	32.40	0	66.97	-1
PERCENT ISOPOD, SNAIL, LEECH	63.37	-1	33.44	-1	19.16	-1	13.94	-1
PERCENT SURFACE AIR BREATHERS	0.82	1	1.24	1	0.70	1	0.61	1
TOTAL SCORE	-6		-6		-3		-4	
MACROINVERTEBRATE COMMUNITY RATING	Poor		Poor		Acceptable		Acceptable	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Willow Hill Creek downstream Farr RD 7/11/2018 STATION 21	Willow Hill Creek upstream Farr Rd 7/11/2018 STATION 22	Willow Hill Creek downstream Farr RD 8/27/2019 STATION 21	Willow Hill Creek upstream Farr Rd 8/27/2019 STATION 22
ANNELIDA (segmented worms)				
Hirudinea (leeches)			2	
Oligochaeta (worms)			10	1
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	184	193	108	112
Decapoda (crayfish)		6	1	
Isopoda (sowbugs)	1	2	4	22
Insecta				
Ephemeroptera (mayflies)				
Baetidae	17	1	22	13
Heptageniidae			3	1
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	3	3	7	2
Cordulegastridae		1	1	
Zygoptera (damselflies)				
Calopterygidae	1	1	2	10
Plecoptera (stoneflies)				
Perlidae	2	2		
Perlodidae			2	
Hemiptera (true bugs)				
Gerridae	1	1	1	7
Mesoveliidae	5		1	
Notonectidae		1	1	
Megaloptera				
Corydalidae (dobson flies)	1	1	6	2
Trichoptera (caddisflies)				
Brachycentridae		17	11	5
Hydropsychidae	10		20	1
Hydroptilidae				1
Leptoceridae			1	6
Limnephilidae	1			5
Coleoptera (beetles)				
Dytiscidae (total)		1		
Haliplidae (adults)		2		1
Hydrophilidae (total)	3	3	2	1
Diptera (flies)				
Athericidae	5			
Ceratopogonidae			1	2
Chironomidae	17	8	25	22
Dixidae				1
Simuliidae	27	1	35	14
Tipulidae	1		4	2

MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)				2
Physidae		1	4	15
TOTAL INDIVIDUALS	279	245	274	248

METRIC	Willow Hill Creek downstream Farr RD 7/11/2018		Willow Hill Creek upstream Farr Rd 7/11/2018		Willow Hill Creek downstream Farr RD 8/27/2019		Willow Hill Creek upstream Farr Rd 8/27/2019	
	STATION 21		STATION 22		STATION 21		STATION 22	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	16	0	18	0	24	0	23	0
NUMBER OF MAYFLY TAXA	1	0	1	0	2	0	2	0
NUMBER OF CADDISFLY TAXA	2	0	1	-1	3	0	5	1
NUMBER OF STONEFLY TAXA	1	1	1	1	1	1	0	-1
PERCENT MAYFLY COMPOSITION	6.09	0	0.41	-1	9.12	0	5.65	0
PERCENT CADDISFLY COMPOSITION	3.94	-1	6.94	0	11.68	0	7.26	0
PERCENT DOMINANT TAXON	65.95	-1	78.78	-1	39.42	-1	45.16	-1
PERCENT ISOPOD, SNAIL, LEECH	0.36	1	1.22	1	3.65	1	15.73	-1
PERCENT SURFACE AIR BREATHERS	3.23	1	3.27	1	1.82	1	3.63	1
TOTAL SCORE	1		0		2		-1	
MACROINVERTEBRATE COMMUNITY RATING	Acceptable		Acceptable		Acceptable		Acceptable	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Sand Creek 32nd Avenue 9/5/2019 STATION 23	Sand Creek Wilson Street 9/5/2019 STATION 24	Sand Creek Taft Street 9/5/2019 STATION 25	Sand Creek Luce St. 9/4/2019 STATION 26
ANNELIDA (segmented worms)				
Hirudinea (leeches)				2
Oligochaeta (worms)	4	1	3	69
ARTHROPODA				
Crustacea				
Amphipoda (scuds)				3
Decapoda (crayfish)	9	1		
Isopoda (sowbugs)	44	76	24	12
Arachnoidea				
Hydracarina				1
Insecta				
Ephemeroptera (mayflies)				
Baetidae	6	12	3	7
Heptageniidae	8	2		
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	11	2	1
Libellulidae			2	
Zygoptera (damselflies)				
Calopterygidae		85	26	18
Hemiptera (true bugs)				
Belostomatidae				1
Corixidae			16	12
Gerridae		4	14	
Mesoveliidae			9	
Notonectidae			1	1
Pleidae				1
Veliidae	1	3		
Trichoptera (caddisflies)				
Hydropsychidae	32	17	6	4
Leptoceridae			1	1
Coleoptera (beetles)				
Dytiscidae (total)			3	1
Gyrinidae (adults)			1	
Haliplidae (adults)			2	1
Hydrophilidae (total)			1	1
Elmidae	1	7		4
Haliplidae (larvae)				1
Diptera (flies)				
Ceratopogonidae			4	
Chironomidae	18	55	90	115
Culicidae				3
Dixidae	1			
Simuliidae		2		1
Tabanidae		1	7	20
Tipulidae		1	1	

MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)				1
Hydrobiidae			1	
Physidae		11	39	6
Pelecypoda (bivalves)				
Pisidiidae	1	5	1	
TOTAL INDIVIDUALS	126	294	257	287

METRIC	Sand Creek 32nd Avenue 9/5/2019 STATION 23		Sand Creek Wilson Street 9/5/2019 STATION 24		Sand Creek Taft Street 9/5/2019 STATION 25		Sand Creek Luce St. 9/4/2019 STATION 26	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	12	0	17	0	23	1	24	0
NUMBER OF MAYFLY TAXA	2	0	2	0	1	0	1	-1
NUMBER OF CADDISFLY TAXA	1	-1	1	-1	2	0	2	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	11.11	0	4.76	0	1.17	-1	2.44	-1
PERCENT CADDISFLY COMPOSITION	25.40	0	5.78	0	2.72	-1	1.74	-1
PERCENT DOMINANT TAXON	34.92	0	28.91	0	35.02	0	40.07	-1
PERCENT ISOPOD, SNAIL, LEECH	34.92	-1	29.59	-1	24.90	-1	7.32	0
PERCENT SURFACE AIR BREATHERS	0.79	1	2.38	1	18.29	0	7.32	0
TOTAL SCORE	-2		-2		-3		-5	
MACROINVERTEBRATE COMMUNITY RATING	Acceptable		Acceptable		Acceptable		Poor	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Indian Mill Creek Turner Street 8/29/2019 STATION 27	Indian Mill Creek 3 Mile Rd 8/30/2019 STATION 28
PLATYHELMINTHES (flatworms)		
Turbellaria		5
ANNELIDA (segmented worms)		
Hirudinea (leeches)	2	1
Oligochaeta (worms)	6	
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	7	47
Decapoda (crayfish)	1	5
Isopoda (sowbugs)	119	141
Arachnoidea		
Hydracarina	8	
Insecta		
Ephemeroptera (mayflies)		
Baetidae	54	36
Heptageniidae		20
Odonata		
Anisoptera (dragonflies)		
Aeshnidae	1	
Zygoptera (damselflies)		
Calopterygidae		4
Hemiptera (true bugs)		
Gerridae	1	
Veliidae	2	1
Trichoptera (caddisflies)		
Hydropsychidae	5	40
Hydroptilidae	1	2
Coleoptera (beetles)		
Gyrinidae (adults)	1	
Elmidae		25
Diptera (flies)		
Chironomidae	27	17
Simuliidae	22	13
Tipulidae	1	3
MOLLUSCA		
Gastropoda (snails)		
Physidae	1	1
Pelecypoda (bivalves)		
Pisidiidae		2
TOTAL INDIVIDUALS	259	363

METRIC	Indian Mill Creek Turner Street 8/29/2019		Indian Mill Creek 3 Mile Rd 8/30/2019	
	STATION 27		STATION 28	
	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	17	0	17	0
NUMBER OF MAYFLY TAXA	1	-1	2	0
NUMBER OF CADDISFLY TAXA	2	0	2	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	20.85	1	15.43	0
PERCENT CADDISFLY COMPOSITION	2.32	-1	11.57	0
PERCENT DOMINANT TAXON	45.95	-1	38.84	-1
PERCENT ISOPOD, SNAIL, LEECH	47.10	-1	39.39	-1
PERCENT SURFACE AIR BREATHERS	1.54	1	0.28	1
TOTAL SCORE	-3		-2	
MACROINVERTEBRATE COMMUNITY RATING	Acceptable		Acceptable	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Prairie Creek Boyer Road 9/11/2019 STATION A	Lake Creek Grand River Ave 9/3/2019 STATION B	Indian Mill Creek Tamarack Ave NW 9/11/2019 STATION C	Rio Grande Creek 32nd Avenue 9/4/2019 STATION D
PLATYHELMINTHES (flatworms)				
Turbellaria	1		15	1
ANNELIDA (segmented worms)				
Hirudinea (leeches)	5			1
Oligochaeta (worms)	12	41	6	
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	46	7	5	7
Decapoda (crayfish)	1	4	1	7
Isopoda (sowbugs)			280	2
Arachnoidea				
Hydracarina	2		4	3
Insecta				
Ephemeroptera (mayflies)				
Baetidae	13	42	58	7
Caenidae	6			
Heptageniidae	6			19
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	2			7
Zygoptera (damselflies)				
Calopterygidae	13	3	1	8
Coenagrionidae	3			
Hemiptera (true bugs)				
Belostomatidae	5			
Corixidae	3			5
Gerridae	1	1	1	6
Nepidae	1			
Notonectidae		1		1
Pleidae	1			
Veliidae	1	8	2	1
Megaloptera				
Sialidae (alder flies)	4			
Trichoptera (caddisflies)				
Brachycentridae	15			
Goeridae		1		
Hydropsychidae	2	135	59	15
Hydroptilidae	2			
Leptoceridae	2			
Limnephilidae				1
Coleoptera (beetles)				
Dytiscidae (total)	1			
Haliplidae (adults)	1			1
Elmidae	21	4	3	6
Diptera (flies)				

Chironomidae	12	31	6	24
Dixidae				6
Simuliidae		2	7	
Tabanidae	2			1
Tipulidae		1	1	4
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	12	8		16
Physidae	52			175
Planorbidae	2			
Viviparidae	1			
Pelecypoda (bivalves)				
Pisidiidae	4			1
TOTAL INDIVIDUALS	255	289	449	325

METRIC	Prairie Creek Boyer Road 9/11/2019 STATION A		Lake Creek Grand River Avenue 9/3/2019 STATION B		Indian Mill Creek Tamarack Ave NW 9/11/2019 STATION C		Rio Grande Creek 32nd Avenue 9/4/2019 STATION D	
	Value	Score	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	33	1	15	0	15	0	25	1
NUMBER OF MAYFLY TAXA	3	0	1	-1	1	-1	2	0
NUMBER OF CADDISFLY TAXA	4	0	2	0	1	-1	2	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	9.80	0	14.53	0	12.92	0	8.00	0
PERCENT CADDISFLY COMPOSITION	8.24	0	47.06	1	13.14	0	4.92	0
PERCENT DOMINANT TAXON	20.39	0	46.71	-1	62.36	-1	53.85	-1
PERCENT ISOPOD, SNAIL, LEECH	28.24	-1	2.77	1	62.36	-1	59.69	-1
PERCENT SURFACE AIR BREATHERS	5.49	1	3.46	1	0.67	1	4.31	1
TOTAL SCORE	0		0		-4		-1	
MACROINVERTEBRATE COMMUNITY RATING	Acceptable		Acceptable		Acceptable		Acceptable	

Appendix 2 continued. Raw macroinvertebrate scores.

TAXA	Rio Grande Creek Blackmer Road (downstream) 9/4/2019 STATION E	Grand River off Grand River Drive at Park 9/5/2019 STATION F	Grand River at Thompson Park in Portland 9/5/2019 STATION G
PORIFERA (sponges)		3	
PLATYHELMINTHES (flatworms)			
Turbellaria		1	1
BRYOZOA (moss animals)		1	
ANNELIDA (segmented worms)			
Hirudinea (leeches)	1		
Oligochaeta (worms)		1	4
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	10	16	44
Decapoda (crayfish)	2		
Isopoda (sowbugs)	3		1
Arachnoidea			
Hydracarina	1		
Insecta			
Ephemeroptera (mayflies)			
Baetidae	60	24	88
Caenidae		1	
Ephemeridae		1	
Heptageniidae	48	38	12
Isonychiidae	1	5	8
Tricorythidae (Leptohyphidae)		34	21
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	1	2	1
Macromiidae		1	1
Zygoptera (damselflies)			
Calopterygidae	3	1	2
Coenagrionidae		12	26
Plecoptera (stoneflies)			
Perlidae		3	
Hemiptera (true bugs)			
Belostomatidae		1	
Corixidae			1
Gerridae	3	1	2
Naucoridae		1	
Nepidae		1	
Veliidae	1		
Megaloptera			
Corydalidae (dobson flies)	1	2	
Trichoptera (caddisflies)			
Brachycentridae		18	17
Goeridae		1	

Helicopsychidae		1	
Hydropsychidae	124	16	3
Hydroptilidae			1
Leptoceridae		2	3
Limnephilidae		9	2
Polycentropodidae		1	5
Uenoidae		1	2
Coleoptera (beetles)			
Gyrinidae (adults)		5	10
Haliplidae (adults)		1	
Psephenidae (adults)	1		1
Elmidae	45	54	48
Diptera (flies)			
Athericidae	2		
Chironomidae	21	4	13
Culicidae		1	1
Dixidae	3		
Simuliidae	19	1	7
Tabanidae		1	
Tipulidae	4		
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)	1	3	1
Lymnaeidae		39	31
Physidae	1	10	10
Viviparidae		17	1
Pelecypoda (bivalves)			
Corbicula		4	2
Pisidiidae		6	
Unionidae (mussels)		10	5
TOTAL INDIVIDUALS	356	355	375

METRIC	Rio Grande Creek Blackmer Road (downstream) 9/4/2019 STATION E		Grand River off Grand River Drive at Park 9/5/2019 STATION F		Grand River at Thompson Park in Portland 9/5/2019 STATION G	
	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	23	0	43	1	33	1
NUMBER OF MAYFLY TAXA	3	0	6	1	4	1
NUMBER OF CADDISFLY TAXA	1	-1	8	1	7	1
NUMBER OF STONEFLY TAXA	0	-1	1	1	0	-1
PERCENT MAYFLY COMPOSITION	30.62	1	29.01	1	34.40	1
PERCENT CADDISFLY COMPOSITION	34.83	1	13.80	0	8.80	0
PERCENT DOMINANT TAXON	34.83	0	15.21	1	23.47	0
PERCENT ISOPOD, SNAIL, LEECH	1.69	1	19.44	-1	11.73	-1
PERCENT SURFACE AIR BREATHERS	1.40	1	3.10	1	4.00	1

TOTAL SCORE	2	6	3
MACROINVERTEBRATE COMMUNITY RATING	Acceptable	Excellent	Acceptable

Appendix 3. Raw fish scores.

TAXA	Rush Creek 12th Ave 8/30/2019 STATION 10	Tributary to Plaster Creek Shadyside Park 8/26/2019 STATION 11	Indian Mill Creek Tamarack Ave NW 9/11/2019 STATION C
Salmonidae (trouts)			
Oncorhynchus mykiss (Rainbow trout)			35
Salmo trutta (Brown trout)			13
Oncorhynchus tshawytscha (Chinook salmon)			1
Umbridae (mudminnows)			
Umbra limi (Central mudminnow)		139	2
Cyprinidae (minnows and carps)			
Cyprinus carpio (Carp)	1		
Luxilus cornutus (Common shiner)		94	
Notropis stramineus (Sand shiner)		13	
Pimephales notatus (Bluntnose minnow)		9	
Rhinichthys atratulus (Blacknose dace)		140	
Rhinichthys cataractae (Longnose dace)		1	
Catostomidae (suckers)			
Catostomus commersoni (White sucker)	1	11	19
Ictaluridae (Bullhead, Catfish)			
Ameiurus melas (Black bullhead)			2
Gasterosteidae (sticklebacks)			
Culaea inconstans (Brook stickleback)		8	
Centrarchidae (sunfish)			
Ambloplites rupestris (Rock bass)			2
Lepomis cyanellus (Green sunfish)			1
Lepomis gibbosus (Pumpkinseed sf)	5	20	
Lepomis gulosus (Warmouth)	3	11	
Lepomis macrochirus (Bluegill sf)	40	1	
Micropterus salmoides (Largemouth bass)	3	1	
Percidae (perch)			
Etheostoma nigrum (Johnny darter)	5	125	
Gobiidae (gobies)			
Neogobius melanostomus (Round goby)	20		
TOTAL INDIVIDUALS	78	573	75
Number of hybrid sunfish			
Number of anomalies			
Percent anomalies			
Percent salmonids			
Reach sampled (ft)	300	300	600
Area sampled (sq ft)			12,000
Density (# fish/sq ft)			
Gear	bps	bps	bps

METRIC	Rush Creek 12th Ave 8/30/2019 STATION 10 Value	Score	Plaster Creek Shadyside Park 8/26/2019 STATION 11 Value	Score	Indian Mill Creek Tamarack Ave NW 9/11/2019 STATION C Value	Score
TOTAL NUMBER OF TAXA	8	-1	13	0	8	-1
NO. OF DARTER, SCULPIN, MADTOM TAXA	1	-1	1	-1	0	-1
NUMBER OF SUNFISH TAXA	3	0	3	0	2	0
NUMBER OF SUCKER TAXA	1	-1	1	-1	1	-1
NUMBER OF INTOLERANT TAXA	0	-1	1	-1	4	0
PERCENT TOLERANT	8.97	1	74.00	-1	29.33	0
PERCENT OMNIVOROUS TAXA	2.56	1	52.18	-1	30.67	0
PERCENT INSECTIVOROUS TAXA	89.74	1	45.72	0	1.33	-1
PERCENT PISCIVOROUS TAXA	3.85	0	0.17	-1	2.67	0
% SIMPLE LITHOPHILIC SPAWNER TAXA	1.28	-1	42.93	1	25.33	0
TOTAL SCORE	-2		-5		-4	
FISH COMMUNITY RATING	Acceptable		Poor		Acceptable	

Appendix 3 continued. Raw fish scores.

TAXA	Mill Creek Wahlfield Park 8/28/2019 STATION 1	Mill Creek 6 Mile Rd 8/28/2019 STATION 2	Mill Creek 7 Mile Road 8/28/2019 STATION 3	Mill Creek Lydell Park 6/3/2019 STATION 4
Salmonidae (trouts)				
Oncorhynchus mykiss (Rainbow trout)		8		3
Salmo trutta (Brown trout)		4	3	3
Umbridae (mudminnows)				
Umbra limi (Central mudminnow)	1	1	5	
Cyprinidae (minnows and carps)				
Nocomis biguttatus (Horneyhead chub)			1	
Semotilus atromaculatus (Creek chub)	6		25	1
Luxilus cornutus (Common shiner)	14			
Pimephales notatus (Bluntnose minnow)	3			
Rhinichthys atratulus (Blacknose dace)	19	2	30	2
Catostomidae (suckers)				
Catostomus commersoni (White sucker)	10	9	8	4
Moxostoma anisurum (Silver redhorse)		1		
Gasterosteidae (sticklebacks)				
Culaea inconstans (Brook stickleback)			3	
Centrarchidae (sunfish)				
Ambloplites rupestris (Rock bass)				1
Lepomis gulosus (Warmouth)		1		3
Micropterus dolomieu (Smallmouth bass)				1
Percidae (perch)				
Etheostoma nigrum (Johnny darter)	10	3	11	1
TOTAL INDIVIDUALS	63	29	86	19
Number of hybrid sunfish				
Number of anomalies				0
Percent anomalies				
Percent salmonids				
Reach sampled (ft)	150	200	150	560
Area sampled (sq ft)				
Density (# fish/sq ft)				
Gear	bps	bps	bps	bps

METRIC	Mill Creek Wahlfield Park 8/28/2019 STATION 1 Value	Score	Mill Creek 6 Mile Rd 8/28/2019 STATION 2 Value	Score	Mill Creek 7 Mile Road 8/28/2019 STATION 3 Value	Score	Mill Creek Lydell Park 6/3/2019 STATION 4 Value	Score
TOTAL NUMBER OF TAXA	7	-1	8	0	8	-1	9	-1
NO. OF DARTER, SCULPIN, MADTOM TAXA	1	-1	1	-1	1	-1	1	-1
NUMBER OF SUNFISH TAXA	0	-1	1	-1	0	-1	2	0
NUMBER OF SUCKER TAXA	1	-1	2	1	1	-1	1	-1
NUMBER OF INTOLERANT TAXA	0	-1	3	0	1	-1	4	0
PERCENT TOLERANT	77.78	-1	51.72	0	91.86	-1	42.11	0
PERCENT OMNIVOROUS TAXA	61.90	-1	41.38	0	79.07	-1	36.84	0
PERCENT INSECTIVOROUS TAXA	38.10	0	13.79	-1	17.44	-1	5.26	-1
PERCENT PISCIVOROUS TAXA	0.00	-1	0.00	-1	0.00	-1	10.53	0
% SIMPLE LITHOPHILIC SPAWNER TAXA	68.25	1	41.38	1	44.19	1	31.58	0
TOTAL SCORE	-7		-2		-8		-4	
FISH COMMUNITY RATING	Poor		Poor		Poor		Poor	

Appendix 4. Sediment chemistry results for Plaster Creek and unnamed tributary to Plaster Creek.

	Station ID	PLC21-01	PLC21-02	SVC21-01
	Description	Plaster Creek off bike path	Unnamed tributary to Plaster Creek; near Hillcroft Park	Plaster Cr d/s of Silver Cr daylight @ Roosevelt Park
	Date	8/25/2021	8/25/2021	8/25/2021
	Latitude	42.9086509	42.9024618	42.9366459
	Longitude	-85.6432447	-85.67514	-85.688088
	Matrix	Sediment	Sediment	Sediment
BNA/SVOC ug/kg	N-Nitrosodimethylamine	ND	ND	ND
	Phenol	ND	ND	ND
	Bis(2-chloroethyl)ether	ND	ND	ND
	2-Chlorophenol	ND	ND	ND
	Benzyl Alcohol	ND	ND	ND
	2-Methylphenol (o-Cresol)	ND	ND	ND
	Bis(2-chloroisopropyl)ether	ND	ND	ND
	Hexachloroethane	ND	ND	ND
	N-Nitrosodi-n-propylamine	ND	ND	ND
	3 & 4-Methylphenol	ND	ND	ND
	Nitrobenzene	ND	ND	ND
	Isophorone	ND	ND	ND
	2-Nitrophenol	ND	ND	ND
	2,4-Dimethylphenol	ND	ND	ND
	Bis(2-chloroethoxy)methane	ND	ND	ND
	2,4-Dichlorophenol	ND	ND	ND
	1,2,4-Trichlorobenzene	ND	ND	ND
	Hexachlorobutadiene	ND	ND	ND
	4-Chloro-3-methyl-phenol	ND	ND	ND
	Hexachlorocyclopentadiene	ND	ND	ND
	2,4,6-Trichlorophenol	ND	ND	ND
	2,4,5-Trichlorophenol	ND	ND	ND
	2-Chloronaphthalene	ND	ND	ND
	2-Nitroaniline	ND	ND	ND
	Dimethyl phthalate	ND	ND	ND
	2,6-Dinitrotoluene	ND	ND	ND
	3-Nitroaniline	ND	ND	ND

	2,4-Dinitrophenol	ND	ND	ND
	Dibenzofuran	ND	ND	ND
	2,4-Dinitrotoluene	ND	ND	ND
	4-Nitrophenol	ND	ND	ND
	Diethyl phthalate	ND	ND	ND
	4-Chlorodiphenylether	ND	ND	ND
	4-Nitroaniline	ND	ND	ND
	2-Methyl-4,6-dinitrophenol	ND	ND	ND
	N-Nitrosodiphenylamine	ND	ND	ND
	Azobenzene	ND	ND	ND
	4-Bromophenyl phenyl ether	ND	ND	ND
	Hexachlorobenzene	ND	ND	ND
	Pentachlorophenol	ND	ND	ND
	Carbazole	ND	ND	ND
	Di-n-butyl phthalate	ND	ND	ND
	Bis(2-ethylhexyl)phthalate	ND	ND	ND
	Di-n-octyl phthalate	ND	ND	ND
	Station ID	**PLC21-01**	**PLC21-02**	**SVC21-01**
BNA/PAH17 ug/kg	Acenaphthene	60	65	60
	Acenaphthylene	60	65	60
	Anthracene	60	65	60
	Benzo(a)-anthracene	60	560	140
	Benzo(a)-pyrene	125	730	120
	Benzo(b)-fluoroanthene	125	1,000	280
	Benzo(g,h,i)-perylene	125	350	120
	Benzo(k)-fluoroanthene	125	550	120
	Chrysene	160	730	210
	Dibenzo(a,h)-anthracene	125	125	120
	Fluoranthene	400	1,500	470
	Fluorene	60	65	60
	Indeno(1,2,3-cd)-pyrene	125	340	120
	2-Methynaphthalene	155	160	155
	Naphthalene	60	65	60
	Phenanthrene	60	520	160
	Pyrene	280	1,100	330
	∑PAH17	2,165	7,990	2,645
	∑PAH17 N1%	13,531	23,500	11,021
TPH ug/kg	DRO^*	ND	41,000	ND
	ORO^*	ND	240,000	ND
TOC	%TOC	0.16	0.34	0.24
	Station ID	**PLC21-01**	**PLC21-02**	**SVC21-01**

Pesticides ug/kg	a-BHC	ND	ND	ND
	b-BHC	ND	ND	ND
	g-BHC (Lindane)	ND	ND	ND
	d-BHC	ND	ND	ND
	Heptachlor	ND	ND	ND
	Aldrin	ND	ND	ND
	Heptachlor epoxide	ND	ND	ND
	g-Chlordane	ND	ND	ND
	Endosulfan I	ND	ND	ND
	a-Chlordane	ND	ND	ND
	4,4'-DDE	ND	ND	ND
	Dieldrin	ND	ND	ND
	Endrin	ND	ND	ND
	Endosulfan II	ND	ND	ND
	4,4'-DDD	ND	ND	ND
	2,4'-DDT	ND	ND	ND
	Endrin aldehyde	ND	ND	ND
	Endosulfan sulfate	ND	ND	ND
	4,4'-DDT	ND	ND	ND
	Endrin ketone	ND	ND	ND
	Hexabromobenzene	ND	ND	ND
	Methoxychlor	ND	ND	ND
	Mirex	ND	ND	ND
	PBB (BP-6)	ND	ND	ND
	Toxaphene	ND	ND	ND
PCBs ug/kg	Aroclor 1016	ND	ND	ND
	Aroclor 1221	ND	ND	ND
	Aroclor 1232	ND	ND	ND
	Aroclor 1242	ND	ND	ND
	Aroclor 1248	ND	ND	ND
	Aroclor 1254	ND	ND	ND
	Aroclor 1260	ND	ND	ND
	Aroclor 1262	ND	ND	ND
	Aroclor 1268	ND	ND	ND
	Total PCBs	ND	ND	ND
	Station ID	**PLC21-01**	**PLC21-02**	**SVC21-01**
General Chemistry mg/kg	% Total Solids	80.1	79.3	81.8
	Available Cyanide	--	--	--
	Total Cyanide	--	--	--
Metals mg/kg	Antimony	ND	ND	1.1
	Arsenic	0.7	1.3	0.9
	Barium[#]	6.3	8.3	8.4

	Beryllium+	ND	ND	ND
	Cadmium	ND	ND	ND
	Chromium	2.7	6.2	3.6
	Cobalt#	1.1	1.6	1
	Copper	1.6	15	3.6
	Iron	2,400	4,200	3,000
	Lead	2.5	21	5.3
	Manganese	46	58	52
	Mercury	ND	ND	ND
	Molybdenum+	ND	ND	ND
	Nickel	2.2	4.4	2.4
	Selenium	ND	0.3	0.3
	Silver	ND	ND	ND
	Thallium+	ND	ND	ND
	Vanadium+	3.5	6.4	4.5
	Zinc	12	44	20

Notes:

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* 16 Parent EPA PAHs plus 2-Methyl

^ lab results compared to USEPA R4 Sediment Screening Values ESVs equivalent to TEC

Region 4 Sediment Screening Ecological Screening Values (ESV)

+ No screening value available

Summation PAH17 N 1% represents the PAH concentrations in sediments normalized to 1% TOC

Lab results greater than the McDonald et al 2000 TEC Value

Lab results greater than the McDonald et al 2000 PEC Value

Appendix 4 continued. Sediment chemistry results for Egypt Creek.

	EGC21-01	EGC21-02	EGC21-03
	Egypt Creek U/S Pettis Ave NE	Egypt Creek near old landfill, U/S Shagbark	Egypt Creek D/S 3 Mile Rd
	8/25/2021	8/25/2021	8/25/2021
	43.007396	43.022274	43.015645
	-85.53053	-85.491424	-85.476798
	Sediment	Sediment	Sediment
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
BNA/SVOC ug/kg	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND

	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	EGC21-01	**EGC21-02**	**EGC21-03**
BNA/PAH17 ug/kg	100	65	70
	100	65	70
	100	65	70
	100	65	70
	200	125	135
	200	125	135
	200	125	135
	200	125	135
	100	65	70
	200	125	135
	100	65	70
	100	65	70
	200	125	135
	255	160	170
	100	65	70
	100	65	70
	100	65	70
	2,455	1,560	1,680
	909	6,783	2,049
TPH ug/kg	120,000	ND	ND
	320,000	ND	ND
TOC	2.7	0.23	0.82
	EGC21-01	**EGC21-02**	**EGC21-03**
Pesticides ug/kg	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND

	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
PCBs ug/kg	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	EGC21-01	**EGC21-02**	**EGC21-03**
General Chemistry mg/kg	49.5	78.6	74
	--	--	--
	--	--	--
Metals mg/kg	ND	ND	ND
	1.9	1.1	ND
	37	15	11
	ND	ND	ND
	ND	ND	ND
	5.8	2.5	2.6

	1.9	0.6	0.9
	5.4	ND	1.7
	5,900	2,500	2,000
	4.2	1.3	2
	340	110	24
	ND	ND	ND
	ND	ND	ND
	4	1.4	1.8
	0.5	ND	0.2
	ND	ND	ND
	ND	ND	ND
	7.3	4	3.6
	18	4.1	7

Notes:

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^ lab results compared to USEPA R4 Sediment Screening Values ESVs equivalent to TEC

Region 4 Sediment Screening Ecological Screening Values (ESV)

+ No screening value available

Summation PAH17 N 1% represents the PAH concentrations in sediments normalized to 1% TOC

Lab results greater than the McDonald et al 2000 TEC Value

Lab results greater than the McDonald et al 2000 PEC Value

Appendix 4 continued. Sediment chemistry results for Sand Creek.

	SDC21-01	SDC21-02	SDC21-03
	Sand Creek U/S Leonard St NW	Sand Creek U/S - M45/Lake Michigan Dr	Sand Creek @ Linden Dr/Luce St
	8/25/2021	8/25/2021	8/25/2021
	42.991605	42.9727054	42.950152
	-85.831166	-85.8397092	-85.848485
	Sediment	Sediment	Sediment
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
BNA/SVOC ug/kg	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND

	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	SDC21-01	**SDC21-02**	**SDC21-03**
BNA/PAH17 ug/kg	70	65	70
	70	65	70
	70	65	70
	70	65	70
	135	130	140
	135	130	140
	135	130	140
	135	130	140
	70	65	70
	135	130	140
	70	65	70
	70	65	70
	135	130	140
	170	160	175
	70	65	70
	70	65	70
	70	65	70
	1,680	1,590	1,715
	2,897	3,786	3,649
TPH ug/kg	ND	32,000	ND
	ND	130,000	ND
TOC	0.58	0.42	0.47
	SDC21-01	**SDC21-02**	**SDC21-03**
Pesticides ug/kg	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND

	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
PCBs ug/kg	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	ND	ND	ND
	SDC21-01	**SDC21-02**	**SDC21-03**
General Chemistry mg/kg	73.1	77	70.6
	--	--	--
	--	--	--
Metals mg/kg	ND	ND	ND
	1.1	0.7	1
	19	11	15
	ND	ND	ND
	ND	ND	ND
	3.1	ND	2.7

	1.3	0.8	1.1
	2.3	1.3	2.1
	4,300	2,400	3,200
	2.9	1.6	2.2
	95	68	110
	ND	ND	ND
	ND	ND	ND
	2.7	1.6	2.2
	0.3	0.2	0.5
	ND	ND	ND
	ND	ND	ND
	4.7	3.2	3.9
	14	6.8	9.6

Notes:

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^ lab results compared to USEPA R4 Sediment Screening Values ESVs equivalent to TEC

Region 4 Sediment Screening Ecological Screening Values (ESV)

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Summation PAH17 N 1% represents the PAH concentrations in sediments normalized to 1% TOC

Lab results greater than the McDonald et al 2000 TEC Value

Lab results greater than the McDonald et al 2000 PEC Value