Biological and Water Quality Study of Mill Creek 2016

Mill Creek upstream from Mill Creek Rd. (MC 73)

Peter A. Precario, Executive Director
James Lane, Board President

Report citation:

Midwest Biodiversity Institute (MBI). 2016. Biological and Water Quality Assessment of Mill Creek 2016. Hamilton County, Ohio. Technical Report MBI/2017-6-8. Columbus, OH 43221-0561. 73 pp. + appendices. http://www.msdgc.org/initiatives/water_quality/index.html.

Biological and Water Quality Study of Mill Creek 2016

Hamilton County, Ohio

Technical Report MBI/2017-6-8

June 30, 2017

Prepared for:

Metropolitan Sewer District of Greater Cincinnati
1081 Woodrow Street
Cincinnati, OH 45204

Submitted by:

Midwest Biodiversity Institute
P.O. Box 21561
Columbus, Ohio 43221-0561
Chris O. Yoder, Research Director
cyoder@mwbinst.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

Chris O. Yoder, MBI, served as the report editor and project manager. Contributions to the report and the analyses included Vickie L. Gordon, Matt Sarver, and Marty Knapp of MBI. Database management and data analysis was provided by Ed Rankin, MBI. Field crew leaders were Matt Sarver (fish assemblage), Marty Knapp (macroinvertebrate assemblage), and Vickie Gordon (Datasondes and chemical assessment). Field sampling assistance was provided by Alex Roller-Knapp, Jack Freda, Matt Murphy, Nathan Schuman, and Taylor Rosenhagen. Logistical support was provided by Allison Boehler and Julia Meeker. Chemical analysis was provided by MSDGC laboratory under the direction of Jennifer Richmond. Overall MSDGC project management was provided by Chris Hall. The draft report was reviewed and edited by MaryLynn Lodor and Chris Hall of MSDGC.

Glossary of Terms

Ambient Monitoring	Sampling and evaluation of receiving waters not necessarily associated with episodic perturbations.
Aquatic Assemblage	An association of interacting populations of organisms in a given waterbody, for example, the fish assemblage or the benthic macroinvertebrate assemblage.
Aquatic Community	An association of interacting assemblages in a given waterbody, the biotic component of an ecosystem.
Aquatic Life Use (ALU)	A beneficial use designation in which the waterbody provides suitable habitat for survival and reproduction of desirable fish, shellfish, and other aquatic organisms; classifications specified in State water quality standards relating to the level of protection afforded to the resident biological community by the custodial State agency.
Assemblage	Refers to all of the various species of a particular taxonomic grouping (e.g., fish, macroinvertebrates, algae, submergent aquatic plants, etc.) that exist in a particular habitat. Operationally this term is useful for defining biological assessment methods and their attendant assessment mechanisms, i.e., indices of biotic integrity (IBI), O/E models, or fuzzy set models.
Attainment Status	The state of condition of a waterbody as measured by chemical, physical, and biological indicators. Full attainment is the point at which measured indicators signify that a water quality standard has been met and it signifies that the designated use is both attained and protected. Non-attainment is when the designated use is not attained based on one or more of these indicators being below the required condition or state for that measure or parameter.
Attribute	A measurable part or process of a biological system.
Beneficial Uses	Desirable uses that acceptable water quality should support. Examples are drinking water supply, primary contact recreation (such as swimming), and aquatic life support.

Benthic Macroinvertebrates	Animals without backbones, living in or on the substrates, of a size large enough to be seen by the unaided eye, and which can be retained by a U.S. Standard No. 30 sieve (0.595 mm openings). Also referred to as benthos, infauna, or macrobenthos.
Best Management Practice	An engineered structure or management activity, or combination of these that eliminates or reduces an adverse environmental effect of a pollutant, pollution, or stressor effect.
Biological Assessment	An evaluation of the biological condition of a waterbody using surveys of the structure and function of a community of resident biota; also known as bioassessment. It also includes the interdisciplinary process of determining condition and relating that condition to chemical, physical, and biological factors that are measured along with the biological sampling.
Biological Criteria (Biocriteria)	Scientific meaning: quantified values representing the biological condition of a waterbody as measured by structure and function of the aquatic communities typically at reference condition; also known as biocriteria. Regulatory meaning: narrative descriptions or numerical values of the structure and function of aquatic communities in a waterbody necessary to protect a designated aquatic life use, implemented in, or through state water quality standards.
Biological Condition Gradient	A scientific model that describes the biological responses within an aquatic ecosystem to the increasing effects of stressors.
Biological Diversity	Refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different taxa and their relative frequencies. For biological diversity, these taxa are organized at many levels, ranging from complete ecosystems to the biochemical structures that are the molecular basis of heredity. Thus, the term encompasses different

	ecosystems, species, and genes; also known as biodiversity.
Biological Indicator	An organism, species, assemblage, or community characteristic of a particular habitat, or indicative of a particular set of environmental conditions; also known as a bioindicator.
Biological Integrity	The ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region (after Karr and Dudley 1981).
Biological Monitoring	The use of a biological entity (taxon, species, assemblage) as a detector and its response as a measure of response to determine environmental conditions. Ambient biological surveys and toxicity tests are common biological monitoring methods; also known as biomonitoring.
Biological Survey	The collection, processing, and analysis of a representative portion of the resident aquatic community to determine its structural and/or functional characteristics and hence its condition using standardized methods.
Clean Water Act (CWA)	An act passed by the U.S. Congress to control water pollution (formally referred to as the Federal Water Pollution Control Act of 1972). Public Law 92-500, as amended. 33 U.S.C. 1251 et seq.; referred to herein as the CWA.
CWA Section 303(d)	This section of the Act requires States, territories, and authorized Tribes to develop lists of impaired waters for which applicable water quality standards are not being met, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. States, territories, and authorized Tribes are to submit their list of waters on April 1 in every even-numbered year.

CWA Section 305(b)	Biennial reporting required by the Act to describe the quality of the Nation's surface waters, to serve as an evaluation of progress made in maintaining and restoring water quality, and describe the extent of remaining problems.
Criteria	Limits on a particular pollutant or condition of a waterbody presumed to support or protect the designated use or uses of a waterbody. Criteria may be narrative or numeric and are commonly expressed as a chemical concentration, a physical parameter, or a biological assemblage endpoint.
DELT Anomalies	The percentage of Deformities, Erosions (e.g., fins, barbels), Lesions and Tumors on fish assemblages (DELT). An important fish assemblage attribute that is a commonly employed metric in fish IBIs.
Designated Uses	Those uses specified in state water quality standards for each waterbody or segment whether or not they are being attained.
Disturbance	Any activity of natural or human causes that alters the natural state of the environment and its attributes and which can occur at or across many spatial and temporal scales.
Ecological integrity	The summation of chemical, physical, and biological integrity capable of supporting and maintaining a balanced, integrated adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats in the region.
Ecoregion	A relatively homogeneous geographical area defined by a similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables; ecoregions are portioned at increasing levels of spatial detail from level I to level IV.
Existing Use	A use that was actually attained in a waterbody on or after November 28, 1975, whether or not they are included in the state water quality standards (November 28, 1975 is the date on which U.S. EPA

	promulgated its first water quality standards regulation in 40CFR Part 131). Existing uses must be maintained and cannot be removed.
Index of Biotic Integrity (IBI)	An integrative expression of site condition across multiple metrics comprised of attributes of a biological assemblage. It refers to the index developed by Karr (1981) and explained by Karr et al. (1986). It has been used to express the condition of fish, macroinvertebrate, algal, and terrestrial assemblages throughout the U.S. and in each of five major continents.
MIwb	The Modified Index of Well-Being (MIwb) is based on fish assemblage measures including numbers, biomass, and two diversity indices (Shannon Index) based on numbers and biomass. The numbers and biomass metrics exclude highly tolerant species. It reflects the overall productivity and diversity of the fish assemblage and it frequently responds before the IBI to improvements in water quality and habitat.
Metric	A calculated term or enumeration representing an attribute of a biological assemblage, usually a structural aspect, that changes in a predictable manner with an increased effect of human disturbance.
Monitoring and Assessment	The entire process of collecting data from the aquatic environment using standardized methods and protocols, managing that data, analyzing that data to make assessments in support of multiple program objectives, and disseminating the assessments to stakeholders and the public.
Multimetric Index	An index that combines assemblage attributes, or metrics, into a single index value. Each metric is tested and calibrated to a scale and transformed into a unitless score prior to being aggregated into a multimetric index. Both the index and metrics are useful in assessing and diagnosing ecological condition.
Narrative Biocriteria	Written statements describing the narrative attributes of the structure and function of aquatic communities

	in a waterbody necessary to protect a designated aquatic life use.
Natural Condition	This includes the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a waterbody in the absence of measurable impacts from human activity or influence.
Numeric Biocriteria	Specific quantitative and numeric measures of the structure and function of aquatic communities in a waterbody necessary to protect a designated aquatic life use.
Qualitative Habitat Evaluation Index	A qualitative habitat evaluation assessment tool that is applied to streams and rivers in Ohio and which is used to identify habitat variables that are important to attainment of the Ohio biological criteria.
Reference Condition	The condition that approximates natural, unimpacted to best attainable conditions (biological, chemical, physical, etc.) for a waterbody. Reference condition is best determined by collecting measurements at a number of sites in a similar waterbody class or region under minimally or least disturbed conditions (by human activity), if they exist. Since undisturbed or minimally disturbed conditions may be difficult or impossible to find in some states, least disturbed conditions, combined with historical information, models or other methods may be used to approximate reference condition as long as the departure from natural or ideal is comprehended. Reference condition is used as a benchmark to establish numeric biocriteria.
Reference Site	A site selected to represent an approximation of reference condition and by comparison to other sites being assessed. For the purpose of assessing the ecological condition of other sites, a reference site is a specific locality on a waterbody that is minimally or least disturbed and is representative of the expected ecological condition of other localities on the same waterbody or nearby waterbodies.

Regional Reference Condition	A description of the chemical, physical, or biological condition based on an aggregation of data from reference sites that are representative of a waterbody type in an ecoregion, subregion, bioregion, or major drainage unit.
Stressors	Physical, chemical, and biological factors that can adversely affect aquatic organisms. The effect of stressors is apparent in the biological responses.
Use Attainability Analysis (UAA)	A structured scientific assessment of the physical, chemical, biological or economic factors affecting attainment of the uses of waterbodies.
Use Classes	A broad capture of a designated use for general purposes such as recreation, water supply, and aquatic life.
Use Subclasses	A subcategorization of use classes into discrete and meaningful descriptions. For aquatic life this would include a hierarchy of warmwater and cold water uses and additional stratification provided by different levels of warmwater uses and further stratification by waterbody types.
TALU Based Approach	This approach includes tiered aquatic life uses (TALU) based on numeric biological criteria and implementation via an adequate monitoring and assessment program that includes biological, chemical, and physical measures, parameters, indicators and a process for stressor identification.
Tiered Aquatic Life Uses (TALUs)	As defined: The structure of designated aquatic life uses that incorporates a hierarchy of use subclasses and stratification by natural divisions that pertain to geographical and waterbody class strata. TALUs are based on representative ecological attributes and these should be reflected in the narrative description of each TALU tier and be embodied in the measurements that extend to expressions of that narrative through numeric biocriteria and by extension to chemical and physical indictors and criteria.

	As used: TALUs are assigned to water bodies based on the protection and restoration of ecological potential. This means that the assignment of a TALU tier to a specific waterbody is done with regard to reasonable restoration or protection expectations and attainability. Hence knowledge of the current condition of a waterbody and an accompanying and adequate assessment of stressors affecting that waterbody are needed to make these assignments.
Total Maximum Daily Load (TMDL)	The maximum amount of a pollutant that a body of water can receive while still meeting water quality standards. Alternatively, a TMDL is an allocation of a water pollutant deemed acceptable to attain the designated use assigned to the receiving water.
Water Quality Standards (WQS)	A law or regulation that consists of the designated use or uses of a waterbody, the narrative or numerical water quality criteria (including biocriteria) that are necessary to protect the use or uses of that particular waterbody, and an antidegradation policy.
Water Quality Management	A collection of management programs relevant to a water resource protection that includes problem identification, the need for and placement of best management practices, pollution abatement actions, and measuring the effectiveness of management actions.

List of Acronyms

ALU	Aquatic Life Use
BCG	Biological Condition Gradient
CWA	Clean Water Act
EPT	Ephemeroptera, Plecoptera, Trichoptera
IBI	Index of Biotic Integrity for fish assemblages
ICI	Invertebrate Community Index
M&A	Monitoring and Assessment
NPDES	National Pollutant Discharge Elimination System
OEPA	Ohio Environmental Protection Agency
QHEI	Qualitative Habitat Evaluation Index
TALU	Tiered Aquatic Life Use
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
WLA	Waste Load Allocation
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

FOREWORD

What is a Biological and Water Quality Survey?

A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. The latter is the case with this study in that Mill Creek represents a watershed of 170 square miles in drainage area with a mix of overlapping stressors and sources in a highly urbanized and legacy industrial landscape. The 2016 assessment is a follow-up to previous surveys of the Mill Creek performed by MBI in 2011 and 2013 and Ohio EPA in 1992 (Ohio EPA 1994) and 2014 (partial assessment).

Scope of the 2016 Mill Creek Biological and Water Quality Assessment

The scope of the 2016 Mill Creek biological and water quality assessment included the mainstem and parts of three tributaries compared to the full watershed scope of the 2011 survey (MBI 2012). In addition to supporting the instream monitoring requirement of the CSO NPDES permit the overall objectives remained the same:

1. Determine the extent to which biological assemblages are impaired (using Ohio EPA methods and criteria);
2. Determine the categorical stressors and sources that are associated with those impairments; and,
3. Add to the broader databases for the Mill Creek and MSDGC watersheds to track and understand changes through time that occur as the result of abatement actions or other factors.

The data presented herein were processed, evaluated, and synthesized as a biological and water quality assessment of aquatic life and recreational use support status. The assessment of the mainstem is directly comparable to that accomplished previously in 1992 and 2014 by Ohio EPA and 2011 and 2013 by MBI, such that trends in status can be examined, and causes and sources of impairment can be confirmed, appended, or removed. This study includes an assessment of chemical and physical stressors related to the biological assemblages. It is not the purpose of this study to identify specific remedial actions on a site specific or watershed basis. However, the data produced by this study contributes to the maintenance and use of the Integrated Priority System (IPS; MBI 2015) that was developed to determine and prioritize remedial projects for the MSDGC service area.

EXECUTIVE SUMMARY

Scope and Purpose

In 2010 MSDGC and MBI developed a four-year rotational watershed assessment approach that is documented in the *Watershed Monitoring and Bioassessment Plan for the MSD Greater Cincinnati Service Area, Hamilton County, Ohio; Technical Report MBI/5-11-3* (MBI 2011). Initiated in 2011 it has provided biological and water quality monitoring data that has assisted MSDGC in better understanding current water quality, trends through time, and considerations for its capital planning and implementation of Project Groundwork to further improve water quality. The 2016 bioassessment of Mill Creek is the first of the follow-up sampling and analysis that is now being conducted primarily in support of the instream monitoring requirement of the CSO NPDES permit. The sampling and analysis in 2016 was performed by Level 3 Qualified Data Collectors and under a biological Project Study Plan approved by Ohio EPA under the specifications of the Ohio Credible Data Law.

An intensive pollution survey design that employed a high density of sampling sites and biological, chemical, and physical indicators and parameters was followed. The principal objectives of biological assessments are to assess current conditions, verify existing aquatic life and recreational use designations, assign uses to unlisted streams and stream segments, make recommendations for any changes to use designations, report attainment status following the Ohio WQS and Ohio EPA practices, and determine associated causes and sources of impairment. The determination of associated causes and sources of impairments to aquatic life and recreational uses followed practices similar to that employed by Ohio EPA. As such, these determinations are usually categorical, but can include the identification of specific pollutants. The results of this study will be incorporated in an ongoing assessment of stressors and their root causes and sources throughout the MSDGC service area via the Integrated Prioritization System (IPS; MBI 2015). The IPS includes more detailed analyses of regional patterns in stressors by relating them to the chemical, physical, and biological data generated by the surveys to ancillary data available in GIS coverages.

Highlighted Findings

General Conditions in Mill Creek

The 2016 assessment of Mill Creek provided an opportunity to gauge the effectiveness of past and ongoing attempts to improve water quality and overall conditions by comparing the results to prior assessments. The 2011 and 2013 (fish/habitat only) by MBI and the 1992, 1997, and 2014 surveys by Ohio EPA provide the most consistent basis for comparisons in terms of spatial coverage and between indicators and parameters for the Mill Creek mainstem. Highlights of these comparisons include:

- The 2016 Mill Creek results show that it continues to be a recovering system; most sites that were rated as poor or very poor in 1992 and fair to marginally good in 2011 were further improved to fair, good, and in a few instances exceptional quality in 2016;

- Of the 33 sites that were evaluated under the Warmwater Habitat suite of uses and biocriteria, 12 were in full attainment of the applicable use tier (WWH-4; MWH–8), 15 in partial attainment (WWH-12; MWH-3), and 6 were in non-attainment (WWH-4; MWH-2);
- Of the partially attaining sites the fish assemblage was the limiting determinant as the macroinvertebrate assemblage met the ICI biocriterion at all of these sites;
- Based on the results of the continuous monitoring of D.O. and temperature the effect of the concrete channel beginning at RM 6.9 and the downstream channelized reach of Mill Creek was evident. From this point downstream D.O. swings were exacerbated and temperatures were elevated above the average and maximum water quality criteria. The feasibility of restoration aside, the controlling factor is the highly modified habitat.
- The longitudinal patterns in conductivity, TDS, chlorides, nitrate, and total phosphorus clearly point to the Butler Co. Upper Mill Creek WRF as the principal source of elevated levels of these parameters in the East Fork and downstream into Mill Creek extending to the MWH reach at RM 6.9.
- Two of the non-attaining sites were in Bloody Run which failed to meet the MWH biocriteria being heavily polluted by sewage from CSOs. MSDGC is currently in the process of finalizing design on a Real Time Control Facility upstream from these locations which should improve water quality.
- The 2016 results are a distinct improvement over 2011 when 11 of 28 sites were in non-attainment and only 4 in full attainment of the MWH use – no WWH sites fully attained in 2011. In 2016, of the 33 sites sampled, 12 were in full attainment, 15 in partial attainment, and 6 in non-attainment. For the first time full attainment was observed in the WWH reaches of the mainstem.
- The incremental improvements in the biological assemblages since 1992 are due in large part to reductions in chemical pollutant loadings resulting from the collection and treatment of wastewater and the clean-up of toxic materials handling adjacent to Mill Creek and tributaries. While significant reaches non-attainment remain, these results indicate a significant incremental improvement in the Mill Creek mainstem which reflects the collective effects of water pollution abatement efforts over the past 30+ years.
- Recreational uses continue to exhibit widespread impairment based on *E. coli* results. However, *E. coli* values were reduced compared to 2011 and four sites fully attained the Primary Contact Recreation (PCR) use criteria.

Aquatic Life Use Attainability and Use Attainment Status

The key indicator of overall condition in terms of aquatic life is the status of the attainment of aquatic life use designations based on attainment of the Ohio biological criteria. Initially the status of these uses is portrayed as full, partial, or non-attainment as explained in the methods section. Additionally, of the 33 sites that were assessed in the 2016 Mill Creek assessment, 20 sites were evaluated against the Warmwater Habitat (WWH) use and 13 were evaluated against the Modified Warmwater Habitat (MWH) use. There are no recommended use changes as the reach of Mill Creek between Center Hill Rd. (RM 7.9) and the beginning of the concrete encased channel at RM 7.3 upstream from Spring Grove Ave. was recommended to be changed from MWH to WWH in 2011.

Aquatic life use attainment status is depicted in Table 1. Out of 33 sites sampled in 2016, 12 were in full attainment, 15 in partial attainment, and 6 in non-attainment. For the first time full attainment was observed in the WWH reaches whereas it was restricted to the MWH reach in 2011. Two of the non-attaining sites were in Bloody Run leaving only four in the mainstem of Mill Creek. The partially attaining sites were all limited by the fish assemblage failing to meet the biocriteria for the IBI and/or the MIwb.

Recreational Use Status

Impairment of the Primary Contact Recreation (PCR) recreational use in Mill Creek was pervasive in 2016. The PCR 30 day (geometric mean) criterion for *E. coli* was exceeded at 29 of the 33 sites. The geometric mean is the primary criterion used to determine recreational use support for streams and rivers. The high minimum values greater than the geometric mean criterion observed in 2011 illustrated the chronic nature of the impairment and underscored the high frequency of exceedances observed throughout Mill Creek. These were reduced in 2016 even though impairment persisted. Identifying the sources of fecal bacteria in urban areas can be a complex process, but in Mill Creek they are mostly related to combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), urban runoff, and deteriorating sewage collection systems in the older urban areas.

Causes and Sources of Non-attainment

The determination of causes and sources of aquatic life use impairment was accomplished by associating the occurrence of sampling results that exceeded various chemical and physical thresholds that are known to adversely affect aquatic organisms. These categorizations are in some cases categorical (e.g., habitat alterations) and may include multiple specific types of effects and mechanisms. Others are parameter specific (e.g., dissolved oxygen) since the data are collected at that level. Yet others are at the categorical level (e.g., nutrients, toxics) which may include multiple parameters. In addition, some parameters can be proxies for a wider range of specific causes. Sources are also necessarily categorical and some are broader in their inclusion of specific activities than others. The causes and sources that are listed along with the biological impairments appear in the determination of aquatic life use attainment status (Table 1).

Trajectories in Key Indicators

Developing an understanding of the temporal trajectory of the different indicators and parameters that are provided by a spatially adequate monitoring design is important feedback to MSDGC, Ohio EPA, and stakeholders in the Mill Creek watershed. Given that Mill Creek has a complex mosaic of watershed level and site-specific impacts the complexity of being able to understand and then develop management responses to impairments is an immense challenge. The documentation of incremental improvements as opposed to as singular focus on the full restoration of impairments allows program effectiveness to receive credit short of full restoration. Furthermore, failing to recognize if waters are improving and are on a positive

***Table 1**. Aquatic life use attainment status in the 2016 Mill Creek study area with associated causes and sources of impairment listed for sites in partial and non-attainment.*

Site ID	River Mile[1]	DA (mi.[2])	IBI	MIwb	ICI	QHEI	Status	Causes	Sources
Mill Creek – WWH Reach									
MC00[H]	26.40/26.30	4.4	41	na	52	59.5	FULL		
MC12[W]	19.10/19.10	26.7	35*	7.7[ns]	44	70.5	PARTIAL	Siltation, D.O., nutrients	Hydromodification
MC10[W]	18.70/18.70	27.0	33*	7.5*	46	66	PARTIAL	Siltation, D.O., nutrients, chlorides	Urban
MC08[W]	18.10/18.10	32.4	35*	7.6[ns]	38	77	PARTIAL	Siltation, D.O., chlorides	Urban
MC101[W]	17.90/17.30	42.2	36[ns]	7.4*	38	64	PARTIAL	Siltation, D.O., nutrient effects, chlorides	UMC WRF, urban
MC06[W]	16.60/16.60	50.5	27*	5.4*	38	60	**NON**	D.O. swings, nutrient effects, chlorides , PAH	UMC WRF, urban
MC04[W]	14.80/14.80	61.3	25*	4.8*	38	53	**NON**	Siltation, flow, nutrients, chlorides, PAH	UMC WRF, urban
MC11[W]	13.90/13.90	68.8	35[ns]	7.6[ns]	VG	78	FULL		
MC104[W]	0.00/13.70	71.6	29*	6.8*	38	77	PARTIAL	Siltation, nutrients, chlorides, PAH	UMC WRF, urban
MC02[W]	13.20/13.10	72.3	27*	5.9*	42	58.5	PARTIAL	Siltation, nutrients, chlorides, PAH	UMC WRF, urban
MC01[W]	11.30/11.30	73.9	36[ns]	7.0*	VG	70.8	PARTIAL	Siltation, nutrients, chlorides, PAH	UMC WRF, urban
MC80[W]	10.00/10.45	115	31*	5.6*	40	79	**NON**	Siltation, nutrients, chlorides, PAH	UMC WRF, urban
MC79[W]	8.65/8.65	120	38[ns]	8.1	44	73.5	FULL		
MC77[W]	7.50/7.45	126	29	6.4*	G	48	PARTIAL	Siltation, nutrients, chlorides, PAH	UMC WRF, urban
Mill Creek – MWH Reach									
MC09[W]	6.80/6.80	128	22*	5.0*	MF	37	PARTIAL	Habitat, nutrients, D.O., thermal	Hydromodification
MC07[W]	6.40/6.35	135	21*	4.9*	24	27.5	PARTIAL	Habitat, nutrients, D.O., thermal	Hydromodification
MC75[W]	5.10/5.10	136	30	5.5[ns]	34	47	FULL		
MC74[W]	4.30/4.30	141	37	7.7	MG	65	FULL		
MC73[W]	3.50/3.50	154	34	6.3	MG	61.8	FULL		
MC72[W]	3.10/3.10	155	35	6.3	26	50.5	FULL		
MC05[W]	2.50/2.50	154	32	7.6	28	60.5	FULL		
MC03[B]	1.70/1.70	163	25	8.0	24	54	FULL		
MC71[B]	0.70/ --	164	23*	7.6	-	51	[PARTIAL]	Organic enrichment, habitat	CSOs, Ohio R.
MC70[B]	0.30/-	164	27	8.1	-	49.5	[FULL]		

Site ID	River Mile[1]	DA (mi.^{2})	IBI	MIwb	ICI	QHEI	Status	Causes	Sources
MC69[B]	0.05/-	164	29	7.0	-	50.5	[FULL]		
West Fork Mill Creek - WWH									
MC45[W]	0.20/0.20	36.4	25*	7.1*	48	68.5	PARTIAL	Siltation, D.O., PAH	Urban
East Fork Mill Creek - WWH									
MC18[H]	1.20/1.20	9.2	31*	na	42	57.0	PARTIAL	Habitat, flow, D.O. swings, nutrients	Hydromodification
MC15[H]	1.00/1.00	9.2	33*	na	34	73.0	PARTIAL	Chlorides, nutrients & effects	UMC WRF
MC14[H]	0.70/0.50	9.5	28*	na	40	58.5	PARTIAL	Siltation, chlorides, nutrients	UMC WRF, hydromod.
MC17[H]	0.40/ --	9.5	36[ns]	na	-	53.8	[FULL]	Siltation, chlorides, nutrients	UMC WRF, hydromod.
MC16[H]	0.10/0.05	9.6	22*	na	48	65.5	**NON**	Siltation, chlorides, nutrients & effects	UMC WRF
Bloody Run – MWH									
MC102[H]	0.00/0.30	3.8	12*	na	VP	44.5	**NON**	Organic enrichment, low D.O., nutrients, PAH	CSOs, urban
MC103[H]	0.00/0.20	3.8	12*	na	VP	40.5	**NON**	Siltation, organic enrichment, low D.O., nutrients, PAH	CSOs, urban

[1] – Fish/Macroinvertebrate site river miles.
[a] - MIwb is not applicable to headwater streams with drainage areas < 20 mi.^{2}.
[b] - VP=Very Poor; P=Poor; MF=Marginally Fair; F=Fair; MG=Marginally Good; G=Good; VG=Very Good; E=Exceptional.
[H] – Headwater Site Type: sites draining areas <20 mi.^{2}.
[W] - Wadeable Site Type: sites draining areas >20 mi.^{2} sampled with wading equipment; [B] - Boat Site Type: sampled with raft mounted electrofishing.
[ns] - Non-significant departure from the biocriteria (<4 IBI or ICI units or <0.5 MIwb units).
[*] - Significant departure from the biocriteria (>4 IBI or ICI units or >0.5 MIwb units).

Biological Criteria – Interior Plateau Ecoregion			
Index	**WWH**	**EWH**	**MWH-C**
IBI – Boat	38	48	24
IBI – Wading	40	50	24
IBI - Headwater	40	50	24
MIwb - Boat	8.7	9.6	5.8
MIwb – Wading	8.1	9.4	6.2
ICI	30	46	22

trajectory can lead to erroneous conclusions about the attainability of Clean Water Act (CWA) goals and the viability of restoration efforts. Simply put, a selective focus on individual and selected pollutants are insufficient in a complex setting like Mill Creek. It is for these reasons that being able to detect, measure, and express incremental improvements in key indicators is vital. The ability to show incremental progress not only provides confirmation that restoration efforts are working, it also provides important feedback for those programs which must be adaptive in order to succeed. As such, the type of monitoring and assessment that was employed in this survey was designed to provide results that could be used to demonstrate the degree and direction of incremental change.

The results of the bioassessment using the primary indices that comprise the Ohio biocriteria were used to quantify the degree to which overall aquatic life conditions have improved through time up to and including the 2016 survey. The Area of Degradation (ADV) and Attainment (AAV) methodology (Yoder et al. 2005) was used to illustrate the degree of change between the Ohio EPA surveys of 1992, 1997, and 2014 and the 2011, 2013, and 2016 MBI surveys of the mainstem of Mill Creek. The ADV/AAV term is an expression of the degree to which one of the biological index values is either above or below the WWH biocriterion and the distance of the mainstem over which it occurs. As such it is a quantification of the "quantity" of biological attainment and impairment. When normalized to a standard distance (e.g., per mile) it can be an effective indicator of the degree of change which is taking place through time.

The change in ADV/AAV results for the fish Index of Biotic Integrity (IBI), the Modified Index of Well-Being (MIwb), and the macroinvertebrate Invertebrate Community Index (ICI) between 1992 and 2016 indicates a substantial and continuing improvement in biological condition (Figure 1). In 1992 the ADV was significantly larger than subsequent years and the AAV was zero for all three indices in 1992. In 2016, the AAV was positive for all three indices and the largest for the macroinvertebrate assemblage. In terms of the miles of attainment and non-attainment of the WWH and MWH designated uses in Mill Creek, full attainment was evident in portions of Mill Creek for the first time in 2016. **While significant areas of degradation and non-attainment remain, these results indicate a significant incremental improvement in the Mill Creek mainstem which reflects the cumulative effects of pollution abatement efforts over the previous three decades**. Realizing further improvements will require additional reductions in pollutional impacts, but will also need to include "subsidizing" the natural features of the Mill Creek watershed such as increasing the quality of stream habitat and improving the flow regime. Restoration and abatement actions and their design will need to incorporate these important factors and understand their important role in the eventual attainment of aquatic life designated uses in Mill Creek.

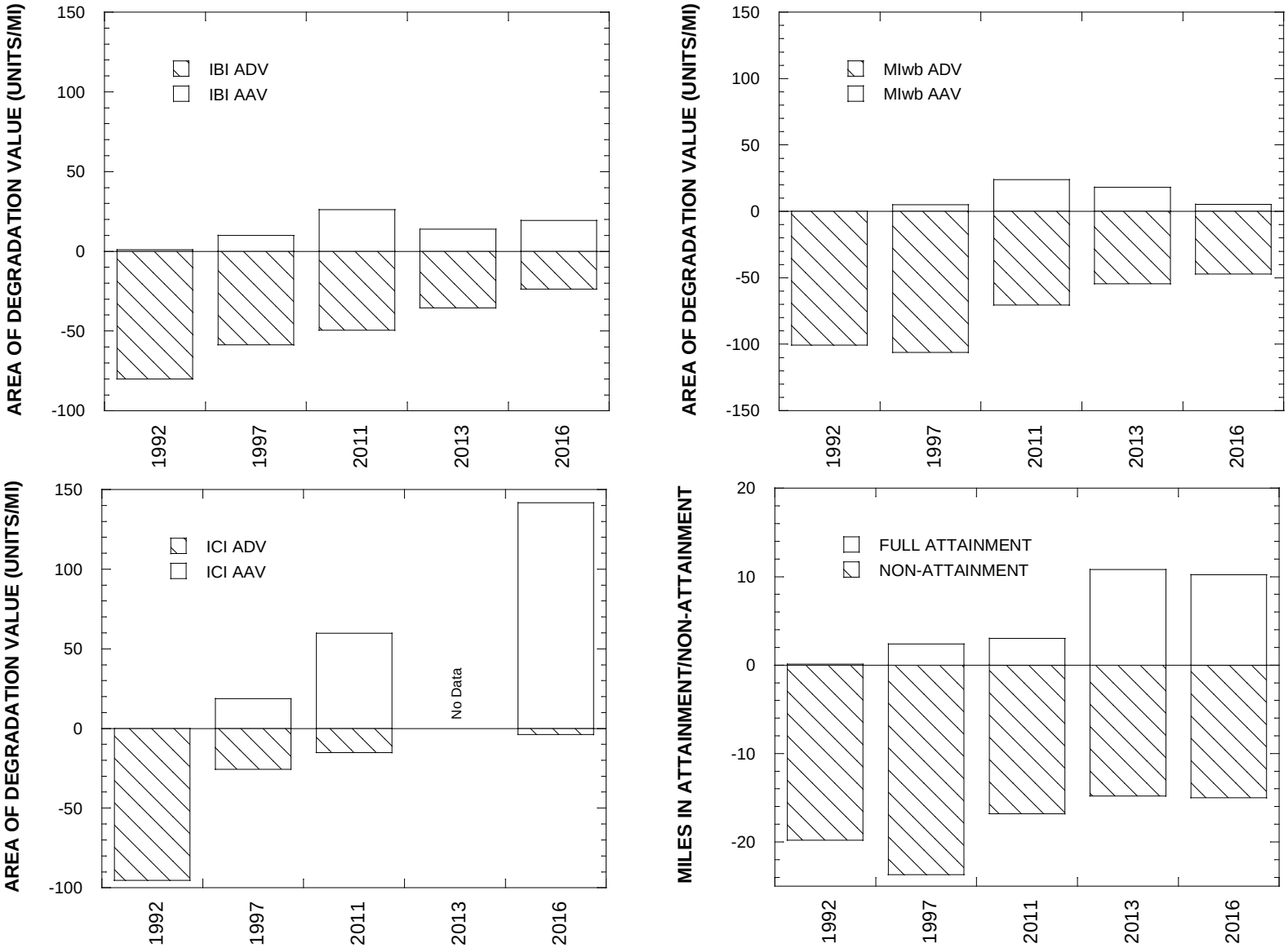

Figure 1. *Area of Degradation (ADV) and Area of Attainment (AAV) values for the IBI (upper left), MIwb (upper right), and ICI (lower right) in the Mill Creek mainstem between 1992 and 2016. The miles of full and non-attainment between 1992 and 2016 are depicted in the lower right panel.*

CONCLUSIONS and RECOMMENDATIONS

Mill Creek Watershed Designated Use Attainment Status

An original objective of the MSDGC service area watershed bioassessment plan was to evaluate existing aquatic life and recreational use designations and to recommend new uses for undesignated/unverified streams and changes to existing uses as a result of the series of 2011-14 baseline watershed assessments. Ohio EPA had last reviewed the aquatic life and recreational designations in the Mill Creek watershed in the early 1990s (Ohio EPA 1994) and localized surveys since that time (Ohio EPA 2016). Now, Ohio EPA has either adopted or is in the process of adopting the use designation recommendations from the 2011-14 MSDGC surveys[1]. As such, that objective has been largely satisfied. The MSDGC instream monitoring has shifted to a more focused approach to document status, trends, and causes/sources of impairments related to pollution control efforts by Project Groundwork and related pollution source abatement efforts by MSDGC. A continued focus on documenting status and trends will inform decisions on Project Groundwork and document post-abatement improvements. The methodology can identify and track causes and sources of impairment allowing informed decisions about the allocation of pollution abatement resources by MSDGC. The 2016 Mill Creek assessment represents the first follow-up survey five years after the 2011 baseline survey and it has revealed positive trends.

Aquatic life use attainment status was determined by comparing the biological index values of the fish and macroinvertebrate assemblages to the biological criteria in the Ohio Water Quality Standards (WQS; OAC 3745-1). The results of this process for each site in the 2016 Mill Creek study area are presented along with the causes and sources that are most associated with observed impairments. The status of recreational uses was likewise assessed.

Aquatic Life Use Recommendations

The aquatic life uses in the Ohio Water Quality Standards (WQS) that are applicable to the 2016 study area are the basis for the aquatic life use attainment status in Table 1. There are no recommendations for aquatic life use changes based on the 2016 results. The results of the 2011 Mill Creek watershed assessment (MBI 2012) were used to recommend numerous changes that were adopted by the Ohio EPA via a use designation rulemaking in 2016 that became effective on January 2, 2017.

Aquatic Life Use Attainment Status

The status of aquatic life uses in the 2016 Mill Creek study area was determined based on the verified and recommended use designations discussed previously and in accordance with Ohio EPA methods and practice. In addition to listing the status of each site, the proximate causes and sources are also indicated for any impaired site (Table 1). A map of the aquatic life attainment status is depicted in Figure 1.

[1] The 2011-14 MSDGC assessments can be found at: http://www.msdgc.org/initiatives/water_quality/index.html.

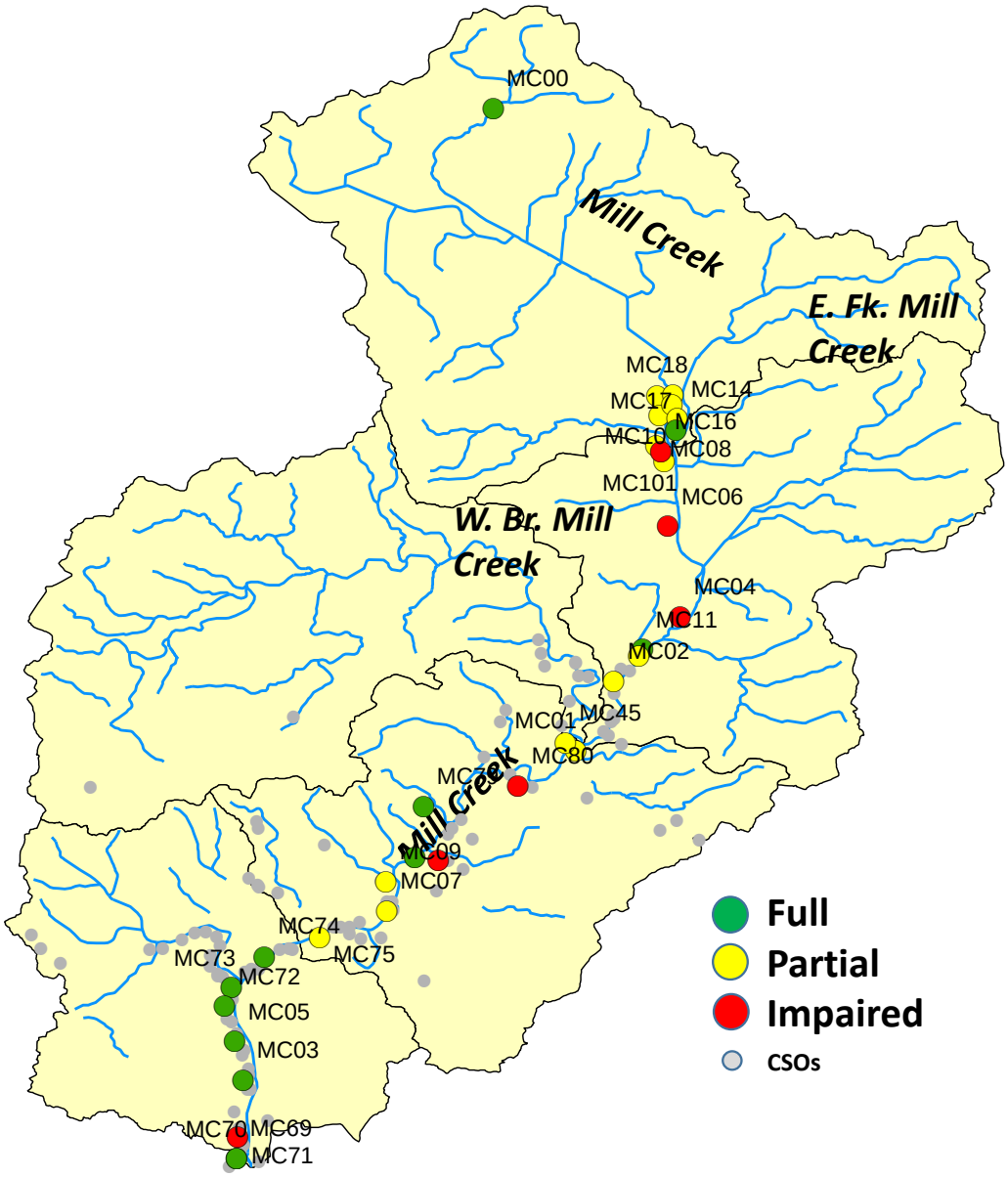

Figure 2. *Aquatic life use attainment status for the Warmwater Habitat suite of use tiers in the Mill Creek study area during 2011. Green circles – full attainment of aquatic life use tier; yellow – partial attainment; red – non-attainment. Site codes correspond to those described in Table x of the study area description. Sites recommended for evaluation as Primary Headwater Habitat (PHWH) appear as triangles with their classification results. CSO locations appear as light grey circles.*

Use attainment was expressed as full, partial, or non-attainment following Ohio EPA guidelines and practices. Of the 33 sites that were evaluated under the Warmwater Habitat suite of uses and biocriteria, 12 were in full attainment of the applicable use tier (WWH-4; MWH–8), 15 in partial attainment (WWH-12; MWH-3), and 6 were in non-attainment (WWH-4; MWH-2). Proximate causes were delineated for impaired sites (i.e., partial and non-attainment) and typified the urban setting being predominated by sedimentation, the effect of elevated nutrients, elevated urban parameters, habitat alterations, elevated PAH compounds, and occasional low D.O. values. The sources were mostly related to wet weather sources and hydromodification (Table 1).

Recreational Use Status

The status of recreational uses was based on the geometric mean of the *E. coli* results (Table 2) for the Primary Contact use and the maximum for the Secondary Contact use. The majority of the sites in the 2016 study area are designated PCR with Bloody Run as SCR. Impairment of recreation uses in the Mill Creek watershed was pervasive throughout all of the subwatersheds that were sampled. The Primary Contact 30-day (geometric mean) criterion was exceeded at 26 of 30 sites (Table 4). The geometric mean is the primary criterion used to determine recreational use support and the single sample maximum is typically only used to determine use support at public bathing beaches, but not for streams and rivers. Sites with minimum values greater than the geometric mean criterion underscored the high frequency of exceedances coded in yellow on Table 1. Identifying the sources of fecal bacteria in urban areas can be a complex process, but are likely related to CSOs, SSOs, urban runoff, and aged and deteriorating sewage collection systems in the older urban areas of Mill Creek. A map of the recreational attainment status is depicted in Figure 2.

Linking Impairments to Sources and Reductions in Pollution Required to Meet WQS

The IPS biological effect thresholds (MBI 2015) were used to assess all of the chemical parameters and habitat variables in addition to determining exceedances of water quality criteria. The IPS thresholds are portrayed as goals for each parameter that correspond to the attainment of the Ohio biological criteria for the tiered aquatic life uses (e.g., EWH, WWH, MWH). The ambient results were color coded in accordance with the narrative benchmarks used in the IPS – exceptional (EWH), blue; good (WWH), green; fair (MWH), yellow; poor (LRW), orange; very poor (no use), red. The IPS thresholds for each parameter were listed alongside the ambient results to provide an assessment of where reductions in specific parameters and attributes are needed to resolve biological impairments. Exceedances of the IPS thresholds were extensive for chlorides, conductivity, TDS, sulfate, TKN, nitrate, total phosphorus, the Hydro QHEI, substrate, and channel condition. By contrast exceedances of water quality criteria were sparse and limited to low D.O. and elevated temperature.

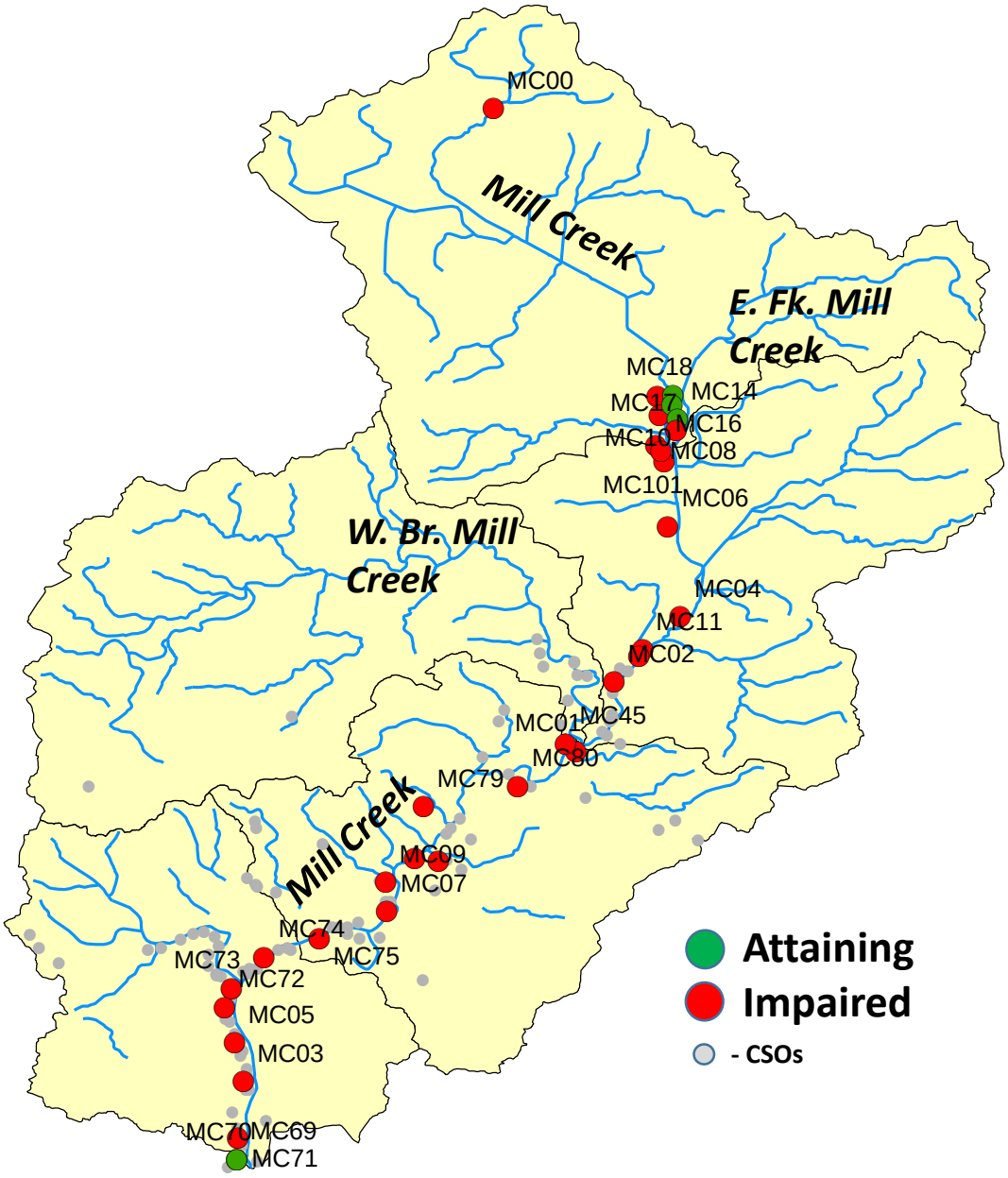

***Figure 3**. Map of recreational use attainment status for the Primary Contact Recreational use in the 2016 Mill Creek study area expressed as attainment (green) or non-attainment (red) based on E. coli values. MSDGC CSO locations appear as grey circles.*

BIOLOGICAL AND WATER QUALITY STUDY OF MILL CREEK 2016

Introduction

The 2016 Mill Creek biological and water quality assessment covered more than 60 CSOs and SSOs, one municipal WWTP, and several industrial discharges providing the basis for documenting incremental changes against the previous 25 years of standardized monitoring of the Mill Creek mainstem and major tributaries by Ohio EPA and MSDGC. The spatial and temporal sampling design and the biological, chemical, and physical indicators and parameters that were collected at each sampling site are described in the *Watershed Monitoring and Bioassessment Plan for the MSD Greater Cincinnati Service Area, Hamilton County, Ohio; Technical Report MBI/5-11-3* (MBI 2011). Biological sampling methods for fish and macroinvertebrate assemblages and habitat assessment are supported by chemical and physical measures and ancillary information about pollution sources and other stressors for the overall biological assessment. The assessment employed a targeted-intensive pollution survey design which documents changes in a longitudinal manner as the effects of multiple pollution sources accumulate in a downstream direction.

MSDGC intends to use the results and analysis of the monitoring and bioassessment program to accomplish the following:

1. Determine the status of service area rivers and streams in quantitative terms, i.e., not only if the waterbody is impaired but the spatial extent and severity of the impairment;
2. Determine the proximate stressors that contribute to the observed impairments for the purpose of targeting management actions to those stressors;
3. Evaluate the appropriateness of existing aquatic life and recreational use designations and make recommendations for any changes to those designations; and,
4. Continue the development of the Integrated Prioritization System (IPS) for a variety of purposes. Among its many uses, the IPS will assist MSDGC in making decisions about how to prioritize and design pollution abatement projects and measure their effectiveness.

To meet these objectives all data was generated by methods and implementation in conformance with the provisions of the Ohio Credible Data Law (ORC 6111.51). Under the regulations that govern the Credible Data program at Ohio EPA, data collection and analyses must be collected and performed under the direction of Level 3 Qualified Data Collectors (OAC 3745-4). MSDGC has used the data to evaluate the attainability of aquatic life and recreational uses and determine the status of service area rivers and streams since 2011. As such, the sampling and analysis of the biological and physical condition conducted herein conforms to these provisions by the development and submittal of annual Level 3 Project Study Plans (PSP).

MSDGC Watershed Bioassessment Scope and Purpose

The MSDGC project study area consists of eleven subwatersheds and the Ohio River mainstem within Hamilton County and parts of adjoining counties. These watersheds are impacted by a variety of stressors including municipal and industrial point source discharges of wastewater, habitat modifications in the form of modified stream channels, run-of-river low head dams, riparian encroachment, and channelization, and nonpoint source runoff from widely differing degrees of landscape modifications from rural to suburban to intensive urban development. The urban impact gradient is the strongest in Lower and Middle Mill Creek lessening somewhat across the Little Miami and Great Miami River subwatersheds. Combined sewer overflows (CSOs) are the most numerous in Mill Creek and adjacent Little Miami River tributaries and some have subsumed historical streams (Figure 3).

2016 Mill Creek Assessment Scope and Purpose

The 2016 Mill Creek assessment included the mainstem of Mill Creek, the lower E. Fork Mill Creek, and selected tributary locations that are part of the MSDGC service area watershed monitoring plan (MBI 2011). In addition to the baseline purposes of the MSDGC monitoring plan, specific assessment issues in Mill Creek include a high density of CSO and SSO outfalls, the extensively modified channel in lower Mill Creek, and pollution sources including direct discharges and runoff from industrial operations, urban stormwater, and permitted municipal point sources.

Cincinnati has the fifth highest volume of CSOs in the U.S. (MSDGC 2011a). As a result, water quality has been significantly impacted in the Mill Creek subwatershed. MSDGC is working to remediate these issues under a Consent Decree with the U.S. Dept. of Justice and U.S. EPA to reduce CSO volume by 2 billion gallons by 2019. To resolve the public health and water quality issues, MSDGC has implemented Project Groundwork, a multi-year and multi-billion dollar initiative that includes hundreds of sewer improvements and stormwater control projects (MSDGC 2011b). The role of the watershed monitoring program is to support these initiatives by providing current information about baseline conditions, provide feedback about the effectiveness of new and past remediation efforts via trend assessment, and to assure that restoration resources are targeted to the actions and places that have the greatest return on investment. As such the 2016 Mill Creek assessment is a continuation of that process.

The Mill Creek 2016 monitoring fulfills the MSDGC National Pollution Discharge Elimination System (NPDES) CSO permit reporting requirements.

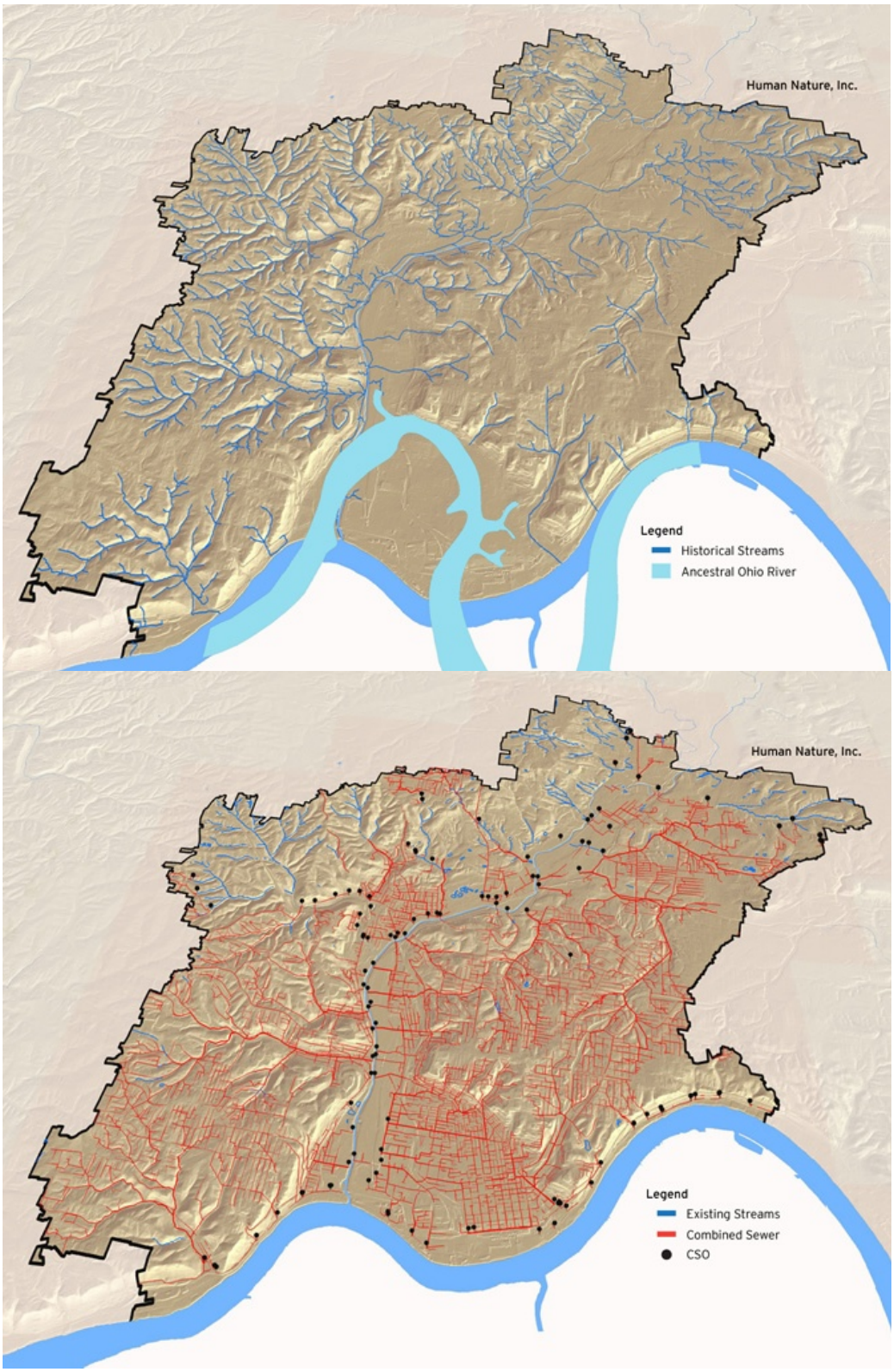

***Figure 4**. The historical occurrence of the Lower Mill Creek watershed (upper) and the current watershed (lower) showing the current MSDGC combined sewer system and the historical subjugation of natural streams (after MSDGC 2011b).*

METHODS

Monitoring Design

An intensive pollution survey design that employs a high density of sampling sites and biological, chemical, and physical indicators and parameters was followed in 2016. The principal objectives of the biological assessment are to report aquatic life and recreational use attainment status, following the Ohio WQS and Ohio EPA practices, and determine associated causes and sources of impairment. To accomplish this sites were positioned upstream and downstream from major discharges, sources of potential releases and contamination, and major physical modifications to provide a "pollution profile" along the Mill Creek mainstem. The result was a design that included chemical, physical, and biological sampling at a total of 30 sites in Mill Creek and selected tributaries. Each site was assigned a unique site code as depicted in Table 1 and Figure 1. Two new sites were added in 2016 to better assess the headwater segment and the SSO 700 discharge.

Biological and Water Quality Surveys

A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a water body specific or watershed scale. Biological, chemical, and physical monitoring and assessment techniques are employed in biosurveys to meet three major objectives:

1. Determine the extent to which use designations assigned in the state Water Quality Standards (WQS) or equivalent policies or procedures are either attained or not attained;
2. Determine if use designations and/or goals set for or assigned to a given water body are appropriate and attainable; and,
3. Determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices.

Measuring Incremental Changes

Incremental change is defined here to represent a measurable and technically defensible, change in the condition of a water body within which it has been measured. Most commonly this is termed "incremental improvement" in which the condition of a water body that does not yet fully meet all applicable water quality standards (WQS) can be tracked as to the direction of any changes. The general principles of incremental change are defined as follows (after Yoder and Rankin 2008):

- ***measurement of incremental change*** can be accomplished in different ways, provided the measurement method is scientifically sound, appropriately used, and sufficiently sensitive enough to generate data from which signal can be discerned from noise;

Table 2. *List of sampling locations in the 2016 Mill Creek study area with site code, stream name, proximity to CSO, SSO, WWTP, and industrial point sources, and the biological, habitat, and chemical parameters collected at each site.*

Site ID	Basin	Stream	Stream Name	Latitude	Longitude	RM	SubType	Location-Description	CSO/SSO/Other	Drain. Area	Geo. Level	Fish	Macroinvert	Habitat	DataSonde	Field Chem	Demand	Nutrients	Metals	Organics	Supplemental	Sed. Metals	Sed. Organics
Mill Creek Mainstem																							
MC00	23	001	Mill Creek	39.375	-84.482	26.4	OH EPA	Liberty-Fairfield Rd. (SE Butler Co.)	NA	4.43	4	D,E	HD	QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X
MC12	23	001	Mill Creek	39.31225	-84.43491	19.1	MSDGC	Dst. Ikea retention pond spillway	NA	26.5	4	D,E	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC10	23	001	Mill Creek	39.29936	-84.43434	18.7	MSDGC	Dst. E. Crescentview Rd.	NA	27.0	4	D,E	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC08	23	001	Mill Creek	39.2911	-84.4353	18.1	OH EPA	200 m ust. E. Fk. confluence	NA	32.4	4	D,E	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC101	23	001	Mill Creek	39.28893	-84.434034	17.9	Modeling-New	R.R. trestle; dst. E. Fk. Mill Creek	Dst. E. Fork Mill Creek (Butler Co. Lower E. Fork Reg. WWTP [1PK00016])	42.2	3	D	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC06	23	001	Mill Creek	39.27	-84.4322	16.6	OH EPA	Ust. E. Sharon Rd.	NA	50.0	3	D	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC04	23	001	Mill Creek	39.25432	-84.42577	14.8	MSDGC	Glendale-Milford Express Way	NA	61.3	3	D	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC11	23	001	Mill Creek	39.23739	-84.439116	13.9	MSDGC	Behind asphalt plant - Cavett Dr.	NA	68.8	3	D	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC104	23	001	Mill Creek	39.23491	-84.44069	13.7	MBI New	Immediately dst. SSO 700 outfall	SSO 700 HRTF	71.0	3	D	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC02	23	001	Mill Creek	39.2292	-84.4461	13.2	OH EPA	Dst. W. Columbia Rd.	CSO 513*, CSO 514, SSO 700	72.0	3	D	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC01	23	001	Mill Creek	39.21198	-84.45465	11.3	MSDGC	Dst. E. Galbraith Rd.	CSO 508, CSO 509, CSO 510, CSO 511, CSO 512; Pristine, Inc. (1IN90002)	73.9	3	D	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC80	23	001	Mill Creek	39.20146	-84.47118	10.0	MSDGC	Dst. Anthony Wayne Ave. bridge	CSO 490, SSO 572 (via West Fork Mill Creek)	115	3	D	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC79	23	001	Mill Creek	39.19578	-84.48957	8.7	OH EPA	Ust. Este Ave. bridge	CSO 171	124	3	D	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC77	23	001	Mill Creek	39.18328	-84.49855	7.5	MSDGC	R.R. Trestle Winton Place	SSO 1065, CSO 181, 653, 544 (via Bloody Run), CSO 037, CSO 039	130	3	D	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC09	23	001	Mill Creek	39.1778	-84.506429	6.9	MSDGC	Dst. Smuckers outfall, river left looking upstream	J.M. Smucker-Crisco 001 (1IH00026); Procter & Gamble (1IN00075)	127	3	D	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC07	23	001	Mill Creek	39.16925	-84.505762	6.4	MSDGC	At RR tressel; dst. Spring Grove Ave & Smuckers	CSO 485, CSO 486, CSO 487 (via pipe @RM 6.45)	135	3	D	HD	QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X
MC75	23	001	Mill Creek	39.1622	-84.5233	5.1	OH EPA	Adj. Salway Park	CSO 025, CSO 026, CSO 028, CSO 030, CSO 033, CSO 482	136	3	P	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC74	23	001	Mill Creek	39.15721	-84.53783	4.3	MSDGC	Ust. S. Ludlow Ave, bridge	CSO 022, CSO 023, CSO 024, CSO 179	141	3	P	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC73	23	001	Mill Creek	39.14896	-84.54642	3.5	MSDGC	Ust. Mill Creek Rd.	CSO 017, CSO 019, CSO 018, CSO 021, CSO 529, CSO 530, CSO 528 (via W. Fk. Creek)	154	3	P	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC72	23	001	Mill Creek	39.1442	-84.5478	3.1	OH EPA	Dst. Mill Creek Rd.	CSO 15	155	3	P	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC05	23	001	Mill Creek	39.13572	-84.546027	2.5	MSDGC	Dst. Hopple Street bridge	CSO 010, CSO 011, CSO 012, CSO 013, CSO 014	154	3	P	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC03	23	001	Mill Creek	39.12524	-84.543167	1.7	MSDGC	Dst. Lick Run CSO (005)	CSO 005, CSO 006, CSO 007, CSO 008, CSO 009	163	2	P	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC71	23	001	Mill Creek	39.11	-84.5447	0.7	OH EPA	Ust. Gest Street bridge	CSO 152, CSO 002,CSO 003, CSO 004, SSO 1066	165	2	P		QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X
MC70	23	001	Mill Creek	39.104400	-84.545000	0.30	OH EPA	Dst. Mill Creek WWTP	CSO 428, CSO 429; MSDGC Mill Creek WWTP 001 (1PM00001)	165	2	P		QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X
MC69	23	001	Mill Creek	39.10068	-84.54382	0.05	MSDGC	R.R. trestle - Queensgate	NA	166	2	P		QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X
West Fork Mill Creek																							
MC45	23	004	W. Fk. Mill Cr.	39.213300	-84.458900	0.20	OHEPA	Elliot Ave.	SSO 572, CSO 226	36.4	4	E	HD	QHEI	X2	6X	6X	6X	6X	3X	Bact (6X)	X	X
East Fork Mill Creek																							
MC18	23	006	E. Fk. Mill Cr.	39.30444	-84.43085	1.2	Geometric	Ust. Butler Co. Upper Mill Creek WWTP	NA	9.25	6	E	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC15	23	006	E. Fk. Mill Cr.	39.30191	-84.43102	1.0	Geometric	Dst. Butler Co. Upper Mill Creek WWTP	Butler Co. Upper Mill Creek WWTP (1PK00016)	9.29	6	E	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
MC14	23	006	E. Fk. Mill Cr.	39.298100	-84.429700	0.70	MSDGC	Crescentville Rd.	NA	9.53	6	E	HD	QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X
MC16	23	006	E. Fk. Mill Cr.	39.289700	-84.432800	0.10	OHEPA	Fada Drive	NA	9.66	6	E	HD	QHEI	X1	6X	6X	6X	6X	3X	Bact (6X)	X	X
Direct Mill Creek Tributaries																							
MC102	23	017	Bloody Run	39.18262	-84.492347	0.3	OHEPA-new	Ust. Vine Street Bridge	CSO 544, CSO 653, CSO 181	3.86	7	E	QL	QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X
MC103	23	017	Bloody Run	39.18234	-84.494299	0.2	OHEPA-new	Rumpke Consolidated Co. Inc. Recycling Center (5535 Vine Street)	NA	3.87	7	E	QL	QHEI		6X	6X	6X	6X	3X	Bact (6X)	X	X

Parameter Groups & Parameters

Fish:	**Field:**	**Demand**	**Nutrients**	**Metals**	**Organics**	**Bacteria**	**Metals**	**Organics**
P - Raft	Temp.	BOD5	NH3-N	Cd	BNAs	E. coli	Cd	BNAs
D - Roller Barge	Conductivity	Chloride	NO3-N	Cu	VOCs		Cu	VOCs
E - Longline	D.O.	Sulfate	NO2-N	Pb	PAHs		Pb	PAHs
F - Backpack	pH	TDS	TKN	Zn	Pesticides		Zn	Pesticides
Macroinverts:		SSC	Total P	Fe			Fe	PCBs
HD - Artifical substrates		Cond.	Chl a	Ca			Ca	
QL - Qualitative sample		pH	Benth Chl a	Mg			Mg	
Habitat:		Bromide		As			As	
QHEI - Qualitative Habitat Evaluation Index								

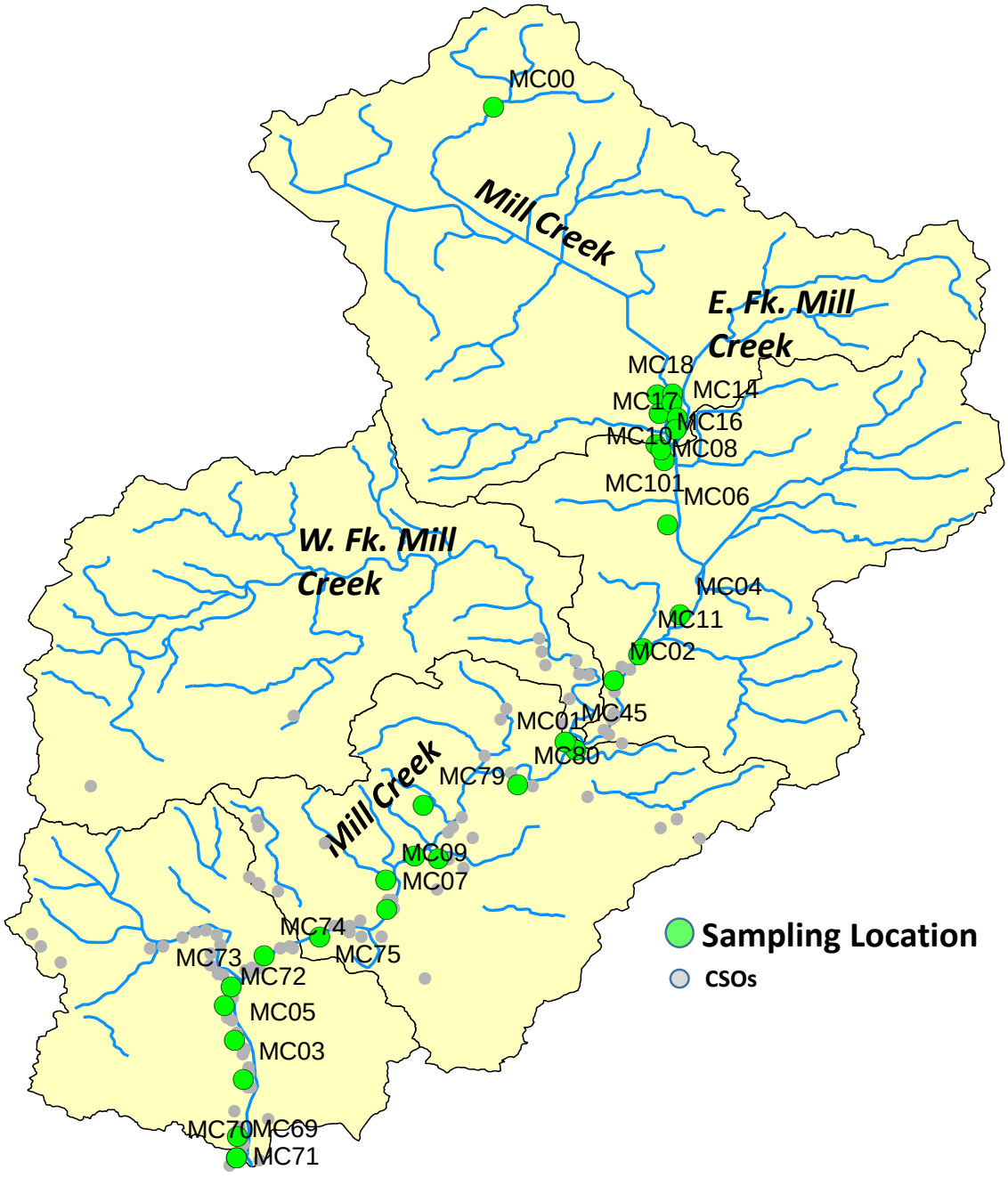

***Figure 5**. The 2016 Mill Creek study area showing sampling locations by site code (see Table 1) and the occurrence of CSO locations.*

- ***measurable parameters and indicators*** of incremental change include biological, chemical, and physical properties or attributes of an aquatic ecosystem that can be used to reliably indicate a change in condition; and,
- ***a positive change in condition*** means a measurable improvement that is related to a reduction in a specific pollutant load, a reduction in the number of impairment causes, a reduction in an accepted non-pollutant measure of degradation, or an increase in an accepted measure of waterbody condition relevant to designated use support.

This was accomplished for this study by comparing the results of prior, comparable assessments. In this case there has been a series of bioassessments beginning in 1992 by Ohio EPA (1994) which serves as the baseline against which subsequent results were compared to assess incremental changes in key parameters and indicators. Subsequent to 1992, sufficient data is available from 1997 (Ohio EPA), 2011 (MBI), 2013 (MBI), 2014 (Ohio EPA) and 2016 (MBI) to inform the analyses. Historical chemical data from the early 1970s was also accessed and is part of the analysis of chemical parameter groups in the results section.

Biological Methods

All biological sampling methods are defined by the applicable protocols published by the Ohio EPA (1987a,b; 1989a,b; 2006, 2015 a,b). These meet the specifications of the Ohio WQS and are used to assess aquatic life and recreational use designations, to determine the extent and severity of impairments, and to document incremental changes that result from pollution abatement actions.

Fish Assemblage Methods

Methods for the collection of fish at wadeable sites was performed using a tow-barge or long-line pulsed D.C. electrofishing equipment based on a T&J 1736 DCV electrofishing unit described by Ohio EPA (1989a). A Wisconsin DNR battery powered backpack electrofishing unit was used as an alternative to the long line in the smallest streams and in accordance with the restrictions described by Ohio EPA (1989a). A three person crew carried out the sampling protocol for each type of wading equipment. Sampling effort was indexed to lineal distance and ranged from 150- 200 meters in length. Non-wadeable sites were sampled with a raft-mounted pulsed D.C. electrofishing device. A Smith-Root 2.5 GPP unit was mounted on a 14' Sea eagle raft with an electrode array in keeping with Ohio EPA (1989a) electrofishing design specifications. Sampling effort for this method was 500 meters. Sampling was conducted during a June 16-October 15 seasonal index period twice at all sites. A more detailed summary of the key aspects of each method appears in the *Watershed Monitoring and Bioassessment Plan for the MSD Greater Cincinnati Service Area, Hamilton County, Ohio; Technical Report MBI/5-11-3* (MBI 2011).

Macroinvertebrate Assemblage Methods

Macroinvertebrates were sampled using modified Hester-Dendy artificial substrate samplers (quantitative sample) and a qualitative dip net/hand pick method in accordance with Ohio EPA macroinvertebrate assessment procedures (Ohio EPA 1989a, 2015a). The artificial substrates were exposed for a colonization period of six weeks between July 12 and September 14 and placed to ensure adequate stream flow over the substrates, but in general samplers should be set where flow is 0.3 feet/second over the plates. A qualitative sample using a triangular frame dip net and hand picking was collected at the time of substrate retrieval. All samples were initially preserved in a 10% solution of formaldehyde. Substrates were then transferred to the laboratory, disassembled, sieved (standard no. 30 and 40), and transferred to 70% ethyl alcohol. Laboratory sample processing of both the quantitative and qualitative samples included an initial scan and pre-pick for large and rare taxa followed by subsampling procedures in accordance with Ohio EPA (1989a, 2015a). Identifications were performed to the lowest taxonomic resolution possible for the commonly encountered orders and families, which is genus/species for most organisms. From these results, the density of macroinvertebrates per square foot is determined as well as a taxonomic richness and an Invertebrate Community Index (ICI; Ohio EPA 1987b; DeShon 1995) score for the quantitative samples and a narrative assessment for the standalone qualitative samples. A more detailed summary of the key aspects of the methods appears in the *Watershed Monitoring and Bioassessment Plan for the MSD Greater Cincinnati Service Area, Hamilton County, Ohio; Technical Report MBI/5-11-3* (MBI 2011).

Area of Degradation and Attainment Values

The ADV (Yoder and Rankin 1995; Yoder et al. 2005) was originally developed to quantify the extent and severity of departures from biocriterion within a defined river reach. For reaches that exceed a biocriterion it is expressed as an Area of Attainment Value (AAV) that quantifies the extent to which minimum attainment criteria are surpassed is. The ADV/AAV correspond to the area of the polygon formed by the longitudinal profile of IBI scores and the straight line boundary formed by a criterion, the ADV below and the AAV above. The computational formula (after Yoder et al. 2005) is:

$$ADV/AAV = \sum [(aIBIa + aIBIb) - (pIBIa + pIBIb)] * (RMa - RMb), \text{ for } a = 1 \text{ to } n, \text{ where;}$$

aIBIa = actual IBI at river mile a,
aIBIb = actual IBI at river mile b,
pIBIa = IBI biocriterion at river mile a,
pIBIb = IBI biocriterion at river mile b,
RMa = upstream most river mile,
RMb = downstream most river mile, and
n = number of samples.

The average of two contiguous sampling sites is assumed to integrate biological assemblage status for the distance between the points. The intensive pollution survey design typically positions sites in close enough proximity to sources of stress and along probable zones of

impact and recovery so that meaningful changes are adequately captured. We have observed biological assemblages as portrayed by their respective indices to change predictably in proximity to major sources and types of pollution in numerous instances (Ohio EPA1987a; Yoder and Rankin 1995; Yoder and Smith 1999; Yoder et al. 2005). Thus, the longitudinal connection of contiguous sampling points produces a reasonably accurate portrayal of the extent and severity of impairment in a specified river reach as reflected by the indices (Yoder and Rankin 1995). The total ADV/AAV for a specified river segment is normalized to ADV/AAV units/mile for making comparisons between years and rivers. The ADV is calculated as a negative (below the biocriterion) expression; the AAV is calculated as a positive (above the biocriterion) expression. Each depicts the extent and degree of impairment (ADV) and attainment (AAV) of a biological criterion, which provides a more quantitative depiction of quality than do pass/fail descriptions. It also allows the visualization of incremental changes in condition that may not alter the pass/fail status, but are nonetheless meaningful in terms of incremental change over space and time. In these analyses, the Warmwater Habitat (WWH) biocriterion for the fish and macroinvertebrate indices, which vary by use designation and ecoregion, were used as the threshold for calculating the ADV and AAV for the Mill Creek mainstem. The WWH use designation represents the minimum goal required by the Clean Water Act (CWA) for the protection and propagation of aquatic life, thus it was used as a standard benchmark for the ADV/AAV analyses.

Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are generally conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with baseline Clean Water Act goal expectations (e.g., the WWH in the Ohio WQS).

Physical habitat was also evaluated at sites draining <2.5 mi.^{2} using the Headwater Habitat Evaluation Index (HHEI) developed by Ohio EPA (2012). The HHEI scores various attributes of the physical habitat that have been found to be statistically important determinants of biological community structure in primary headwater streams. Statistical analysis of a large number of physical habitat measurements showed that three QHEI habitat variables (channel substrate composition, bank full width, and maximum pool depth) are sufficient in

distinguishing the physical habitat of primary headwater streams using the HHEI. The characterization of the channel substrate includes a visual assessment of a 200 feet stream reach using a reasonably detailed evaluation of both the dominant types of substrate and the total number of substrate types. Bank full width is a morphological characteristic of streams that is determined by the energy dynamics related to flow and has been found to be a strong discriminator of the three classes of primary headwater streams in Ohio. The bank full width is the average of 3-4 separate bank full measurements along the stream reach. The maximum pool depth within the stream reach is important since it is a key indicator of whether the stream can support a WWH fish assemblage. Streams with pools less than 20 cm in depth during the low flow periods of the year are less likely to have WWH fish assemblages and thus more likely to have viable populations of lungless salamanders, which replace fish as the key vertebrate indicator in primary headwater streams.

Chemical/Physical Methods

Chemical/physical assessment for the MSDGC service area includes the collection and analysis of water samples for chemical/physical and bacterial analysis and sediment samples for determining sediment chemical quality. Methods for the collection of water column chemical/physical and bacterial samples followed the procedures of Ohio EPA (2015b) and MSDGC (2011c). Sediment chemical sampling followed that described by Ohio EPA (2015c). All laboratory analysis was performed and/or overseen by MSDGC.

Water Column Chemical Quality

Water column chemical quality was determined by the collection and analysis of grab water samples, instantaneous measurements recorded with a water quality meter, and continuous measurements recorded at 3-4 day intervals in the mainstem and larger tributary sites and at the reference sites.

Grab Sampling

Grab samples of water were collected with a stainless steel bucket from a location as close to the center point of the stream channel as possible by MBI and MSDGC sampling crews. Samples were collected from the upper 12-24" of the surface and then transferred to sample containers in accordance with MSDGC procedures (MSDGC 2011c). Sampling was conducted between mid-June and mid-October and under "normal" summer-fall low flows – elevated flows following precipitation events were avoided and sampling was delayed until flows subsided. The frequency of sampling ranged from approximately weekly at mainstem sites and sites with multiple impacts to bi-weekly, 4 times per season, 2 times per season, and once at Primary Headwater sites. Water samples were collected provided there was sufficient water depth to collect a sample without disturbing the substrates. Instantaneous values for temperature (°C), conductivity (µS/cm2), pH (S.U.), and dissolved oxygen (D.O.; mg/l) were recorded with a YSI Model 664 meter at the time of grab sample collection.

Continuous Recordings

Continuous readings of temperature (°C), conductivity (µS/cm2), pH (S.U.), and dissolved oxygen (D.O.; mg/l) were recorded with a YSI 6920 V2 Sonde ("datasonde") instrument at mainstem, major tributary, and reference site locations. The Datasondes were set as close as possible to the Thalweg (i.e., deepest part of the stream channel) in a PVC enclosure that ensured no contact with the stream bottom or other solid objects. The Datasondes were positioned vertically where depth allowed by driving steel fence posts into the bottom and positioning the PVC enclosure in an upright position. Where the depth was too shallow the PVC enclosure was secured in a horizontal position in an area of the stream channel with continuous flow. All Datasondes were secured against theft or vandalism as much as possible. Datasondes were deployed for a 3-4 day continuous interval during periods of maximum summer temperatures and normal summer flows. Readings were taken at 15 minute intervals. At the time of retrieval data was downloaded to a YSI Model 650 Instrument with high memory capacity and then transferred to a PC for storage and later analysis.

Sediment Chemical Quality

Fine grain sediment samples were collected in the upper 4 inches of bottom material at each sampling location using decontaminated stainless steel spoons and excavated using nitrile gloves. Decontamination of sediment sampling equipment followed the procedures outlined in the Ohio EPA sediment sampling guidance manual (Ohio EPA 2015c).

Sediment grab samples were homogenized in stainless steel pans (material for VOC analysis was not homogenized), transferred into glass jars with Teflon® lined lids, placed on ice (to maintain 4°C) in a cooler, and delivered to Metropolitan Sewer District of Greater Cincinnati, Division of Industrial Waste Lab. Sediment data is reported on a dry weight basis. Sediment samples were analyzed for total analyte list inorganics (metals), nutrients, volatile organic compounds, semivolatile organic compounds, PCBs, total petroleum hydrocarbons, and cyanide.

Determining Use Attainment Status

Use attainment status is a term which describes the degree to which environmental parameters or indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). For the Mill Creek watershed assessment two use designations are being evaluated, aquatic life and recreation in and on the water by humans. Hence the process herein is referred to as the determination of aquatic life and recreational status for each sampling site. The process is applied to data collected by ambient assessments and applies to rivers and streams outside of discharge mixing zones.

Aquatic Life

Aquatic life use attainment status is determined by the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-17). Numerical biological criteria are based on multimetric biological indices which include the Index of Biotic Integrity (IBI) and modified Index of Well-Being (MIwb), which

indicate the response of the fish assemblage, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate assemblage. The IBI and ICI are multimetric indices patterned after an original IBI described by Karr (1981) and Fausch *et al.* (1984) and subsequently modified by Ohio EPA (1987b) for application to Ohio rivers and streams. The ICI was developed by Ohio EPA (1987b) and is further described by DeShon (1995). The MIwb is a measure of fish community abundance and diversity using numbers and weight information and is a modification of the original Index of Well-Being originally applied to fish community information (Gammon 1976; Gammon *et al.* 1981). Numerical biocriteria are stratified by ecoregion, use designation, and stream or river size. Three attainment status results are possible at each sampling location - full, partial, or non-attainment. Full attainment means that all of the indices meet the applicable biocriteria. Partial attainment means that one or more of the indices fails to meet the applicable biocriteria. Non-attainment means that none of the indices meet the applicable biocriteria or one of the organism groups reflects poor or very poor quality. An aquatic life use attainment table (see Table 2) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (*i.e.,* full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and comments and observations for each sampling location. The use attainment table is further organized by Ohio EPA Waterbody Assessment Unit so that the results can be used by Ohio EPA for assessment purposes.

Recreation

Water quality criteria for determining attainment of recreational uses are established in the Ohio Water Quality Standards (OAC 3745-1-07; Table 7-13) based upon the quantities of bacterial indicators *(Escherichia coli)* present in the water column. *Escherichia coli (E. coli)* bacteria are microscopic organisms that are normally present in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria of human feces (Dufour 1977). There is currently no simple way to differentiate between human and animal sources of coliform bacteria in surface waters, although methodologies for this type of analysis are being developed including recent research supported by MSDGC. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where wastes have been deposited. Pathogenic (disease-causing) organisms are typically present in the environment in such small amounts that it is impractical to directly monitor each type of pathogen. Fecal indicator bacteria by themselves, including *E. coli,* are usually not pathogenic. However, some strains of *E. coli* can be pathogenic, capable of causing serious illness. Although not necessarily agents of disease, fecal indicator bacteria such as *E. coli* may signal the potential presence of pathogenic organisms that enter the environment via the same pathways. When *E. coli* are present in extremely high numbers in a water sample, it invariably means the water has received fecal matter from one or more sources.

The Ohio WQS for recreational uses were revised in early 2016 to reflect a more rigid adherence to any form of contact with surface waters as ensuing the same level of risk. This

replaced the former framework that was stratified to account for the degree of contact with 3 levels of the Primary Contact Recreational (PCR) use as PCR-A, PCR-B, and PCR-C. Those subcategories are essentially merged into a single use. This action also obviated the recommendations made in the 2011-14 watershed assessments for assignment certain streams to one of the three former subcategories. The application of the Secondary Contact Recreational (SCR) use was also changed to a more restrictive interpretation of the potential for human contact with surface waters. Existing SCR designations remain, but could potentially be reviewed and revised to PCR by Ohio EPA. Any new SCR recommendations would need to document that there is no human contact possible due to physical restrictions to access a surface water. As a result the evaluation of the recreational uses in the 2016 Mill Creek study were done in accordance with the existing designations of PCR and SCR if applicable.

Streams in the Mill Creek watershed are designated as primary contact recreation (PCR) and/or secondary contact recreation (SCR) use in the Ohio WQS (OAC 3745-1- 30). Water bodies with a designated recreation use of PCR ". . . are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking, and scuba diving" (OAC 3745-1- 07(B)(4)(b)). Secondary Contact includes waters that ". . . result in minimal exposure potential to water borne pathogens because the waters are: rarely used for water based recreation such as, but not limited to, wading; situated in remote, sparsely populated areas; have restricted access points; and have insufficient depth to provide full body immersion, thereby greatly limiting the potential for water based recreation activities."

The *E. coli* criterion that applies to PCR is expressed as a 90-day geometric mean of ≤126 colony forming units (cfu)/100 ml with a Statistical Threshold Value of 410 cfu/100 ml[2]. The criterion that applies to SCR streams is ≤1,030 cfu/100 ml for both the 90 day geometric mean and the STV. The geometric mean is based on two or more samples and is used as the basis for determining the attainment status of the PCR use.

Determining Use Attainability

Use designation reviews and recommendations for revisions, whenever necessary, were a major product of the series of 2011-14 watershed assessments conducted throughout the MSDGC service area. Since the 2016 Mill Creek survey is a reassessment of a portion of the 2011 study area we did not expect to have any use change recommendations. The details of the 2011-14 use recommendations are available in each watershed assessment report that can be found at: http://www.msdgc.org/initiatives/water_quality/index.html. Given the status of the 2011-14 data as Level 3 credible data it was eligible to be used by Ohio EPA to revise certain use designations. All the use recommendations made for the warmwater habitat suite of uses were either adopted or are in the process of being adopted by Ohio EPA into the Ohio WQS. None of the recreational use recommendations were accepted because of the subsequent revision to the recreational uses and criteria and how these use are assigned to individual

[2] These criteria shall not be exceeded in more than ten per cent of the samples taken during any ninety-day period.

stream segments. None of the Primary Headwater Habitat (PHWH) use recommendations were adopted because Ohio EPA has not adopted PHWH as a use nor have they determined how to treat such segments. For the interim MSDGC is assuming such streams will receive protections equivalent to WWH.

Determining Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine biological status (i.e., unimpaired or impaired, narrative ratings of quality) and assigning associated causes and sources of impairment utilizing the accompanying chemical/physical data and source information (e.g., point source loadings, land use). The identification of impairment in rivers and streams is straightforward - the numerical biological indices are the principal arbiter of aquatic life use attainment and impairment following the guidelines of Ohio EPA (1987). The rationale for using the biological results in the role as the principal arbiter within a weight of evidence framework has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1991; Yoder 1995).

Describing the causes and sources associated with observed biological impairments relies on an interpretation of multiple lines of evidence including the water chemistry data, sediment data, habitat data, effluent data, land use data, and biological response signatures (Yoder and Rankin 1995; Yoder and DeShon 2003). Thus the assignment of associated causes and sources of biological impairment in this report represents the association of impairments (based on response indicators) with stressor and exposure indicators using linkages to the bioassessment data based on previous experiences within the strata of analogous situations and impacts. For example, exceedances of established chemical thresholds such as chronic and acute water quality criteria or sediment effect thresholds are grounds for listing such categories of parameters to include individual pollutants provided that they co-occur with a biological impairment.

New biological effect thresholds in the recently completed *Integrated Prioritization System (IPS) Documentation and Atlas of Biological Stressor Relationships for Southwest Ohio* (Technical Report MBI/2015-12-15, MBI 2015) were also used for the first time to evaluate MSDGC service area data. These were used either as primary or supplemental screenings for the interpretation of biological impairments consistent with the WQS for the application of biological criteria in Ohio[3].

Hierarchy of Water Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators comprised of ecological, chemical, and toxicological measures, can ensure that all pollution sources are judged objectively on the basis of environmental results. A tiered approach that links the results of administrative actions with true environmental measures was employed in our analyses and within the limitations of the data that is currently available for certain sources.

[3] OAC 3745-1-07(A)(6)(a) for full attainment and (A)(6)(b) for non-attainment.

This integrated approach is outlined in Figure 4 and includes a hierarchical continuum from administrative to true environmental indicators. The six "levels" of indicators include:

1. Actions taken by regulatory agencies (permitting, enforcement, grants);
2. Responses by the regulated community (treatment works, pollution prevention);
3. Changes in discharged quantities (pollutant loadings);
4. Changes in ambient conditions (water quality, habitat);
5. Changes in uptake and/or assimilation (tissue contamination, biomarkers, assimilative capacity); and, changes in health, ecology, or other effects (ecological condition, pathogens).

In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to

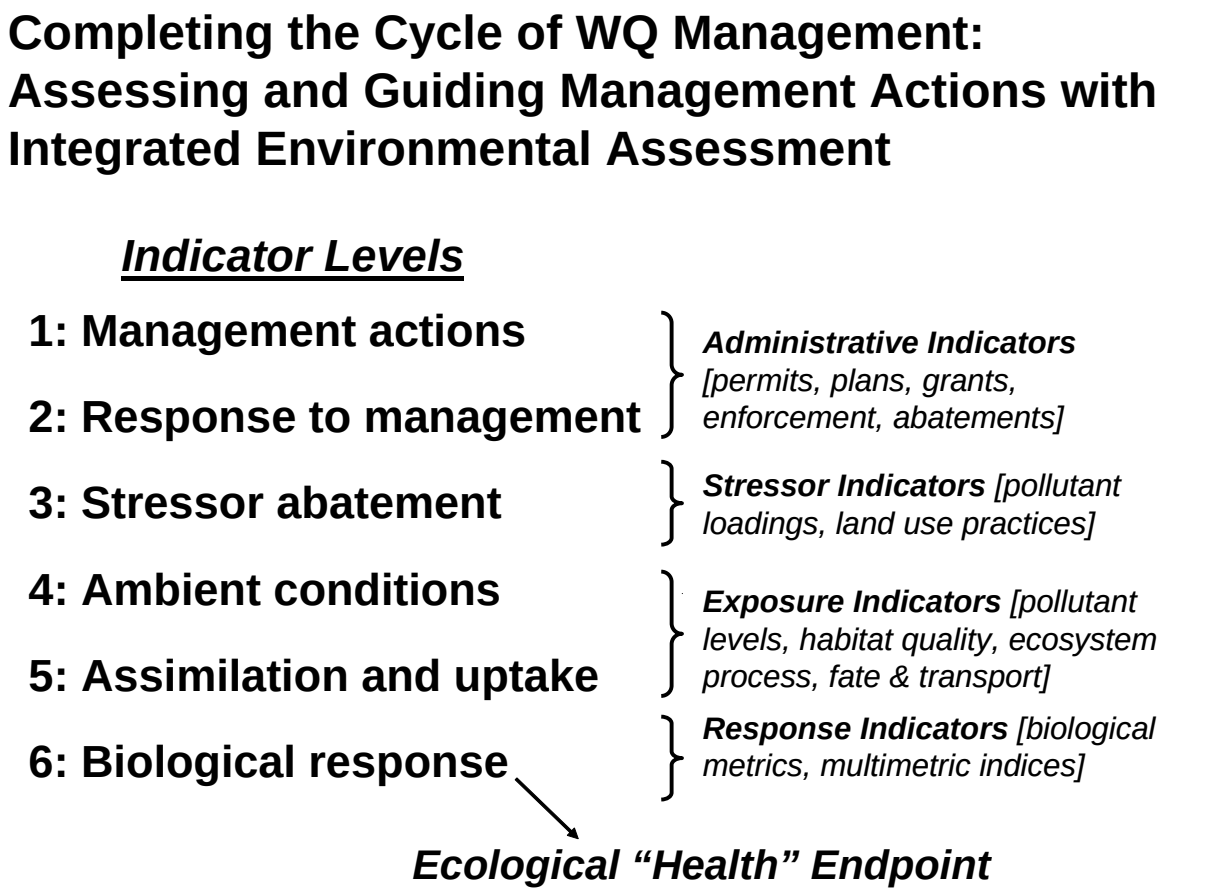

Figure 6*. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995a,b) and further enhanced by Karr and Yoder (2004).*

improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). An example is the aggregate effect of billions of dollars spent on water pollution control since the early 1970s that have been determined with quantifiable measures of environmental condition (Yoder et al. 2005). Superimposed on this hierarchy is the concept

of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise the Ohio EPA biological endpoints. Other response indicators can include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels that serve as surrogates for the recreational uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each (Yoder and Rankin 1998).

STUDY AREA DESCRIPTION

General Setting

The Mill Creek basin lies within the Interior Plateau Ecoregion of southwest Ohio and is bounded by the Great Miami River basin to the northwest, the Little Miami River basin to the east, and the Ohio River and direct tributary watersheds to the south and west. Mill Creek flows 28.1 miles from the headwaters in southeastern Butler County through central Hamilton County to a confluence with the Ohio River. The drainage area of Mill Creek is 166.2 square miles. Along its course the stream has an average gradient of 11.9 feet per mile (Ohio DNR 1960). The total fall of Mill Creek from its headwaters in Butler County to the barrier dam near the mouth in Hamilton County is approximately 350 feet in elevation. The valley bottom in the upper reaches of the watershed is wide, averaging 1½ miles narrowing considerably in the downstream reaches averaging only ½ mile through the City of Cincinnati. In the lower portion of the Mill Creek basin the valley walls are steep rising 200-300 feet above the valley floor. Major tributaries include the East Fork Mill Creek, Sharon Creek, Beaver Creek, and the West Fork Mill of Creek. The tributaries are generally underlain by thinly inter-bedded layers of shales and limestone bedrock except in the lower reaches close to their confluences with Mill Creek. Most of Mill Creek flows atop a buried valley aquifer composed of highly permeable sands and gravel from glacial deposits and outwash. The upper portion of the Mill Creek watershed located in Butler County is mostly rural, but is becoming increasingly suburban. The lower portion of Mill Creek is highly urbanized and is almost completely developed. This development consists of a mix of industrial, commercial, residential, transportation, and public properties.

Subecoregion Characteristics

Mill Creek lies within two different level III ecoregions, the Interior Plateau (IP) and the Eastern Corn Belt Plains (ECBP; Omernik 1987). Subsequent delineations of Level IV subregions provided more detail about the four components of ecoregions; surficial geology, soils, potential natural vegetation, and land use (Woods et al. 1995). The lower Mill Creek subwatershed and much of the West Fork of Mill Creek lie entirely within the Northern Bluegrass subregion (71d) of the Interior Plateau ecoregion. The remainder of the middle Mill Creek subwatershed lies within the Pre-Wisconsinan Drift Plains subregion (55d) of the Eastern Corn Belt Plains ecoregion. The southernmost portion of the upper Mill Creek watershed is within the Wisconsinan Drift Plains subregion (55d) and the northern portion and the East Fork of Mill Creek lies within the Loamy High-lime Till Plains subregion (55b) of the ECBP ecoregion. The characteristics of each subregion appears in Table 2.

Description of Pollution Sources and Other Stressors

Pollution sources and general stressors are both numerous and overlapping in the Mill Creek watershed. These sources include permitted discharges of municipal and industrial process wastewater, discharges from combined and sanitary sewer overflows (CSO and SSO), releases from industrial facilities, urban runoff and its associated chemical pollution, hydrological

***Table 3**. Level IV subregions of the Mill Creek watershed and their key attributes (from Woods et al. 1995).*

Level IV Subregion	Physiography	Geology	Soils	Potential Natural Vegetation	Land Use/Land Cover
Loamy, High Lime Till Plains (55b)	Glaciated; level to rolling glacial till plain with low gradient streams; also end moraines and glacial outwash landforms.	Loamy, high lime, late-Wisconsinan glacial till and also glacial outwash and scattered loess overlie Paleozoic carbonates and shale.	Alfisols (Hapludalfs, Epiaqualfs, Endoaqualfs), Mollisols (Argiaquolls, Endoaquolls, Argiudolls), Entisols (Fluvaquents)	Mostly beech forest; also, oak-sugar maple forest, elm-ash swamp forest on poorly-drained valley bottoms and ground moraines.	Extensive corn, soybean, and livestock farming; also scattered beech-maple, pin oak-swamp, white oak woodlands. Urban-industrial activity in municipal areas.
Pre-Wisconsinan Drift Plains (55d)	Glaciated. Dissected glacial till plain with low to medium gradient streams.	Deeply leached, acidic pre-Wisconsinan clay-loam glacial till and thin loess overlie Paleozoic carbonates.	Alfisols (Fragiudalfs, Hapludalfs, Fragiaqualfs, Glossaqualfs), Entisols (Fluvaquents)	Mostly beech forest, elm-ash swamp forest; also oak-sugar maple forest.	Soybean, livestock, corn, general, and tobacco farming; where poorly-drained or rugged, pin oak-swamp, white oak flatwoods, and beech-maple woodlands.
Northern Bluegrass (71d)	Unglaciated and glaciated; dissected plains and hills with medium gradient, gravel bottom streams. Steep slopes, high relief near Ohio River.	Discontinuous loess and leached pre-Wisconsinan glacial till deposits. Ordovician limestone and shale.	Alfisols (Hapludalfs, Fragiudalfs), Mollisols (Hapludolls)	Mixed meso-phytic forest, mixed oak forest, oak-sugar maple forest; along Ohio River, bottomland hardwoods.	Mosaic of forest, agriculture, and urban-industrial activity near Cincinnati and elsewhere along Ohio River. Wooded where steep

alterations, and direct and indirect habitat alterations. These are described in the following discussions and major point sources, CSOs, and SSOs are included in Table 1.

Point Sources

There are approximately 20 point source discharges in the Mill Creek watershed that hold National Pollutant Discharge Elimination System (NPDES) permits. Together these sources discharge approximately 16 MGD of either treated sanitary wastewater, industrial process wastewater, or cooling water. The largest facility discharging treated sanitary wastewater in the watershed is the Butler Co. Upper Mill Creek Water Reclamation Facility. This plant discharges to the East Fork Mill Creek at RM 1.07. It currently discharges approximately 8 MGD and has been approved to expand its capacity to 16 MGD. Butler Co. is adding a denitrification

process to the treatment facility as part of the expansion to 16 MGD. The new expansion will also be constructed with anoxic zone, which is specifically designed to effectively reduce nitrate-nitrogen and ammonia-nitrogen. The facility was also required to install nutrient removal by 2006. The General Electric Aircraft Engine facility in Evendale has the largest volume of cooling water and stormwater discharges in the Mill Creek watershed. It releases approximately 5.4 MGD of cooling and stormwater to Mill Creek via the GE tributary (RM 13.8).

Wet Weather Sources

The two major sources of wet weather related pollution in Mill Creek emanate from combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs). These occur because the volume of sanitary wastewater and stormwater entering the MSDGC sewer system during precipitation events (i.e., "wet weather") exceeds the capacity of the pipes and other equipment in the collection system. While CSOs and SSOs exist throughout much of Mill Creek, the highest concentration of outfalls and loadings occurs in Mill Creek below the SSO 700 outfall. Approximately one-third of MSDGC's sewers are combined sewers and the rest are sanitary sewers (MSDGC 2006).

Riparian and Stream Habitat

In response to extensive damage caused by major floods in 1937 and 1959, the Mill Creek Valley Conservancy District (MCVCD) was formed to act as the local liaison with the U.S. Army Corps of Engineers (U.S. ACE) for designing flood control measures. Beginning in 1981, a nearly 17 mile long section of Mill Creek was channelized with further planned work being halted in 1991 due to a lack of funding. Further flooding occurred in 1998 and 2001. The U.S. ACE initiated a study in 1998 in an effort to complete the unfinished 1981 project, but this was never realized due to the failure to provide local cost sharing. A deep tunnel alternative was rejected due to the cost. In 2006, the City of Cincinnati acquired permanent conservation easements on all MVCD properties under the Mill Creek Greenway program.

The habitat modifications in the mainstem consist of traditional channelization accomplished by excavating and widening the natural channel to a trapezoidal shape. Shorter reaches of Mill Creek are encased in a concrete channel beginning approximately 1 km below Center Hill Rd. (RM 7.3) extending to 0.1 km above Clifton Ave. (RM 5.5). The remaining channelized segments are mix of unreinforced and reinforced banks with the latter consisting of concrete, rip rap, or revetments. The lower portions of some tributaries have also been encased in concrete channels. Encroachment of land uses on the riparian zone is commonplace and results in bank instability and the loss of tree cover. Some habitat improvements have been attempted and include the construction of artificial riffles in the mainstem and the removal of low head dams.

RESULTS and DISCUSSION

Chemical/Physical Water Quality

Chemical/physical water quality in the 2016 Mill Creek study area was characterized by grab sample data collected from the water column six times at each site during base flows and within a June 16-October 15 seasonal index period. Continuous measurements were made with Datasondes over 3-4 consecutive day periods at selected mainstem sites in late July and early August. Sediment chemistry was determined from samples collected at all mainstem and selected tributaries in mid-October.

The results were evaluated by assessing exceedances of criteria in the Ohio WQS, by exceedances of regionally derived biological effect thresholds (MBI 2015) for parameters that lack formal criteria in the WQS, and by exceedances of probable and threshold effect levels for sediment chemistry (MacDonald et al. 2000). The chemical/physical results also serve as indicators of exposure and stress and in support of the biological data for assessing the attainment of aquatic life uses and assigning associated causes and sources for impairments. Bacteria data were collected by grab samples at all sites and were used primarily to determine the status of recreational uses in accordance with the Ohio WQS. Ohio EPA protocols for determining attainment of the applicable designated recreational use were followed.

Flow Regime

The flow regime in the Mill Creek mainstem during the period May 1 – October 31 is depicted in Figure 5 for the years 1997, 2011, 2013, and 2016 based on the gauge operated by the U.S. Geological Survey at Carthage (RM 10.0). These are recent years with bioassessment data in Mill Creek and each represents a slightly different periodicity of both high and low flows. What is consistent between years is a high degree of flashiness as depicted by flow spikes of 10-100 times the summer base flows, which is typical of an urban watershed. The lowest flows were generally at or above the median flow which is more than 6 times less than the 10^{th} percentile flow and less than two times higher than the 80th percentile flow. What are referred to herein as normal summer-fall flows are approximated by the statistical median (50^{th} percentile) flows that vary somewhat throughout this time period. All sampling was avoided during high flow events and was not resumed until normal base flows returned. Flows in 2016 were consistently less than the 10th percentile flow setting it apart from the other three years in Figure 5. Peak flows occurred in August and September 2016 following significant precipitation events.

Water Column Chemistry

Water quality was assessed by grab samples collected at all sampling locations six times during the summer-fall index period. Parameter groupings included field, demand, ionic strength, nutrients, heavy metals, and organic compounds. Continuous measurements over 3-4 consecutive day periods were made at all mainstem sites (excepting the downstream most sites influenced by the Ohio River) for D.O. (mg/l), pH (S.U.), conductivity (µS/cm), and temperature (°C) using YSI Datasonde continuous recorders during July 11-15 and July 20-22, 2016.

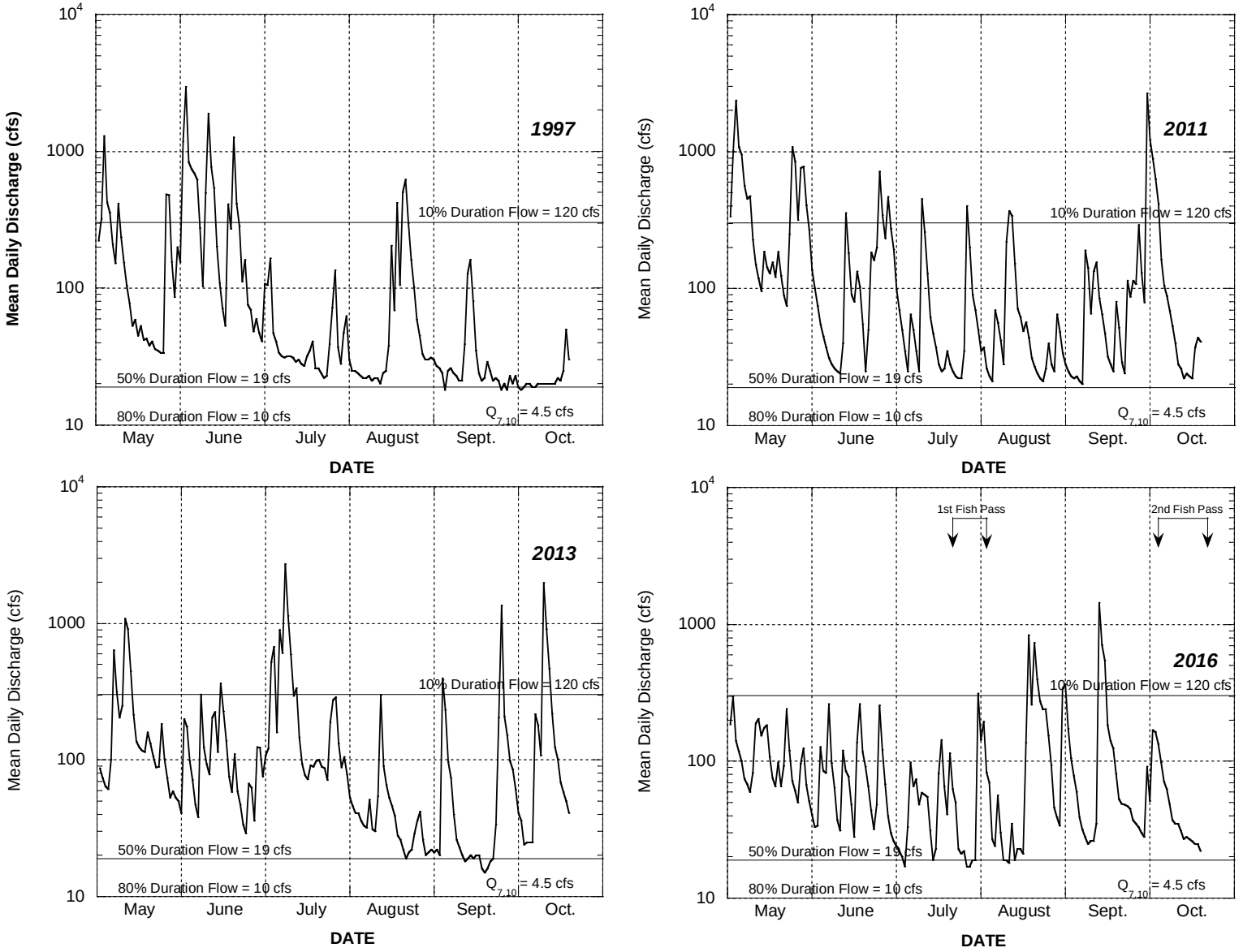

Figure 7. *Flow measured at the USGS gauge at Carthage (RM 10.0) during May 1-October 31 during 1997, 2011, 2013, and 2016. The median, 80%, 10%, and Q 7,10 flows are indicated on each hydrograph. The periods of the first and second fish passes in 2016 are also indicated.*

Water Quality Criteria Exceedances

Assessing exceedances of water quality criteria was done for parameters that have formal criteria codified in the Ohio WQS. For the 2016 Mill Creek survey this included criteria for the protection of aquatic life and for recreational uses.

Aquatic Life Criteria Exceedances

Measured exceedances of aquatic life water quality criteria for in the Ohio WQS were limited to dissolved oxygen (D.O.), temperature (°C), pH (S.U.), and selenium (Table 3). All except two of the D.O. exceedances and all of the temperature and pH exceedances were measured with the Datasondes. The D.O. exceedances were values below the 4.0 mg/l WWH minimum at one location in the upper mainstem (RM 16.6) and the upstream most site in the East Fork. Three samples in Bloody Run had extremely low D.O. values that exceeded the MWH minimum of 3.0 mg/l. The temperature exceedances were of the maximum of 29.4°C and all except one occurred in the MWH segment of Mill Creek. The single pH exceedance was of the maximum criterion (RM 3.1). Two exceedances of the selenium criterion occurred in lower Mill Creek (RM 3.1).

Recreation Criteria Exceedances

Exceedances of the *E. coli* recreational criteria in the Ohio WQS were extensive in the entirety of the Mill Creek mainstem, the West Fork, and Bloody Run. An exception was the site at the mouth of Mill Creek (RM 0.05) that attained both the geometric mean and the Statistical Threshold Value (STV) Primary Contact Recreational (PCR) criteria (Table 4). The geometric mean was attained in Mill Creek at RM 13.9, but the STV was exceeded. The applicable criteria were met in the East Fork both upstream (SCR) and downstream (PCR) from the Butler Co. Upper Mill Creek WRF, but were exceeded at the mouth (RM 0.01). The minimum values in Bloody Run were the highest by 4-5 times among all sites sampled.

E. coli geometric means in the Mill Creek mainstem in 2011, 2013, and 2016 were compared to reveal any patterns between recent years of consistent sampling (Figure 6). The 2016 results were generally lower than 2011 and comparable to 2013. Both the 2013 and 2016 results show an increase downstream from the East Fork with a general decline in values through the concrete channel portion at the upstream end of the MWH designated segment. From there values increased sharply declining at the mouth where the PCR criteria was met. The overall decline in values between 2011 and 2013/2016 also seems independent of flow conditions as all three years had multiple wet weather events. **Nevertheless the recreational uses remain impaired and this includes the upstream most site (RM 26.4) that is well outside the influence of sewage related discharges.**

Exceedances of Biological Effect Thresholds

For parameters that do not have formal criteria codified in the Ohio WQS, biological effect thresholds were employed to determine the risks to attainment of aquatic life uses. The thresholds developed as part of the *Integrated Prioritization System (IPS) Documentation and Atlas of Biological Stressor Relationships for Southwest Ohio* (Technical Report MBI/2015-12-15,

***Table 4**. Exceedances of water quality criteria for aquatic life based on grab sampling and continuous monitoring in the 2016 Mill Creek study area.*

Site ID	River Mile	Aquatic Life Use	Parameters (Values) Exceeding Ohio Aquatic Life Criteria[1]
Mill Creek – WWH Reach			
MC00	26.40	WWH	
MC12	19.10	WWH	
MC10	18.70	WWH	
MC08	18.10	WWH	
MC101	17.90	WWH	
MC06	16.60	WWH	D.O. (1.5)
MC04	14.75	WWH	
MC11	13.90	WWH	
MC104	13.70	WWH	
MC02	13.20	WWH	
MC01	11.30	WWH	
MC80	10.00	WWH	
MC79	8.70	WWH	
MC77	7.45	WWH	Temperature (29.8)
Mill Creek – MWH Reach			
MC09	6.90	MWH-C	Temperature (31.0)
MC07	6.35	MWH-C	
MC75	5.10	MWH-C	Temperature (33.0)
MC74	4.30	MWH-C	Temperature (32.7)
MC73	3.45	MWH-C	Temperature (32.5)
MC72	3.10	MWH-C	Se (34.1, 42.0); Temperature (32.5); pH (9.2)
MC05	2.50	MWH-C	Temperature (32.7)
MC03	1.70	MWH-C	Temperature (32.5)
MC71	0.70	MWH-C	
MC70	0.30	MWH-C	
MC69	0.05	MWH-C	
East Fork Mill Creek			
MC18	1.20	WWH	D.O. (3.5)
MC15	1.00	WWH	
MC14	0.70	WWH	
MC16	0.10	WWH	
West Fork Mill Creek			
MC45	0.20	WWH	
Bloody Run			
MC102	0.30	MWH-C	D.O. (0.49)
MC103	0.20	MWH-C	D.O. (1.17)(2.32)

***Table 5**. Exceedances of the E. coli criteria for the applicable recreational use at each site in the 2016 Mill Creek study area. Green highlighted values attain the geometric mean and Statistical Threshold Value criteria and orange highlighted values are exceedances. The status is expressed as Attains or Impaired.*

Site ID	River Mile	Recrea-tional Use	*E. coli* (cfu/100 ml)				Criteria		Status
			N	Min.	Geo-metric Mean	Max.	Geo-metric Mean	Statistical Threshold Value	Recreational Attainment
Mill Creek									
MC00	26.4	PCR	5	160	494.3	2420	126	410	Impaired
MC12	19.1	PCR	5	150	350	660	126	410	Impaired
MC10	18.7	PCR	5	140	407.3	1986	126	410	Impaired
MC08	18.1	PCR	5	318	780.7	2420	126	410	Impaired
MC06	16.6	PCR	5	1	159	1203	126	410	Impaired
MC04	14.75	PCR	5	1	176.7	980	126	410	Impaired
MC11	13.9	PCR	5	1	94.9	480	126	410	Impaired
MC02	13.2	PCR	5	1	133.3	1733	126	410	Impaired
MC01	11.3	PCR	5	368	615	1553	126	410	Impaired
MC80	10.0	PCR	5	228	486.6	1080	126	410	Impaired
MC79	8.7	PCR	5	218	347.3	1200	126	410	Impaired
MC77	7.45	PCR	5	73	234.5	930	126	410	Impaired
MC09	6.9	PCR	5	86	203.4	680	126	410	Impaired
MC07	6.35	PCR	5	52	143.5	880	126	410	Impaired
MC75	4.8	PCR	5	150	387.9	1350	126	410	Impaired
MC74	4.2	PCR	5	260	476.7	1720	126	410	Impaired
MC73	3.5	PCR	5	121	641.1	1660	126	410	Impaired
MC73	3.45	PCR	5	121	641.1	1660	126	410	Impaired
MC72	2.9	PCR	5	197	450.4	1990	126	410	Impaired
MC05	2.5	PCR	5	173	787.7	2990	126	410	Impaired
MC03	1.6	PCR	5	97	435.2	1280	126	410	Impaired
MC71	0.6	PCR	5	98	511.8	1137	126	410	Impaired
MC70	0.2	PCR	5	160	421.7	1420	126	410	Impaired
MC69	0.05	PCR	5	10	61.2	410	126	410	Attains
West Branch Mill Creek									
MC45	0.2	PCR	5	146	317.1	1940	126	410	Impaired
East Fork Mill Creek									
MC18	1.2	SCR	5	10	85.0	336	1030	1030	Attains
MC15	1.0	PCB/PC	5	10	47.4	272	126	410	Attains
MC14	0.5	PCB/PC	5	1	77.7	310	126	410	Attains
MC16	0.01	PCB/PC	5	260	381.4	510	126	410	Impaired
Bloody Run									
MC102	0.3	SCR	2	1296	1443	1607	1030	1030	Impaired

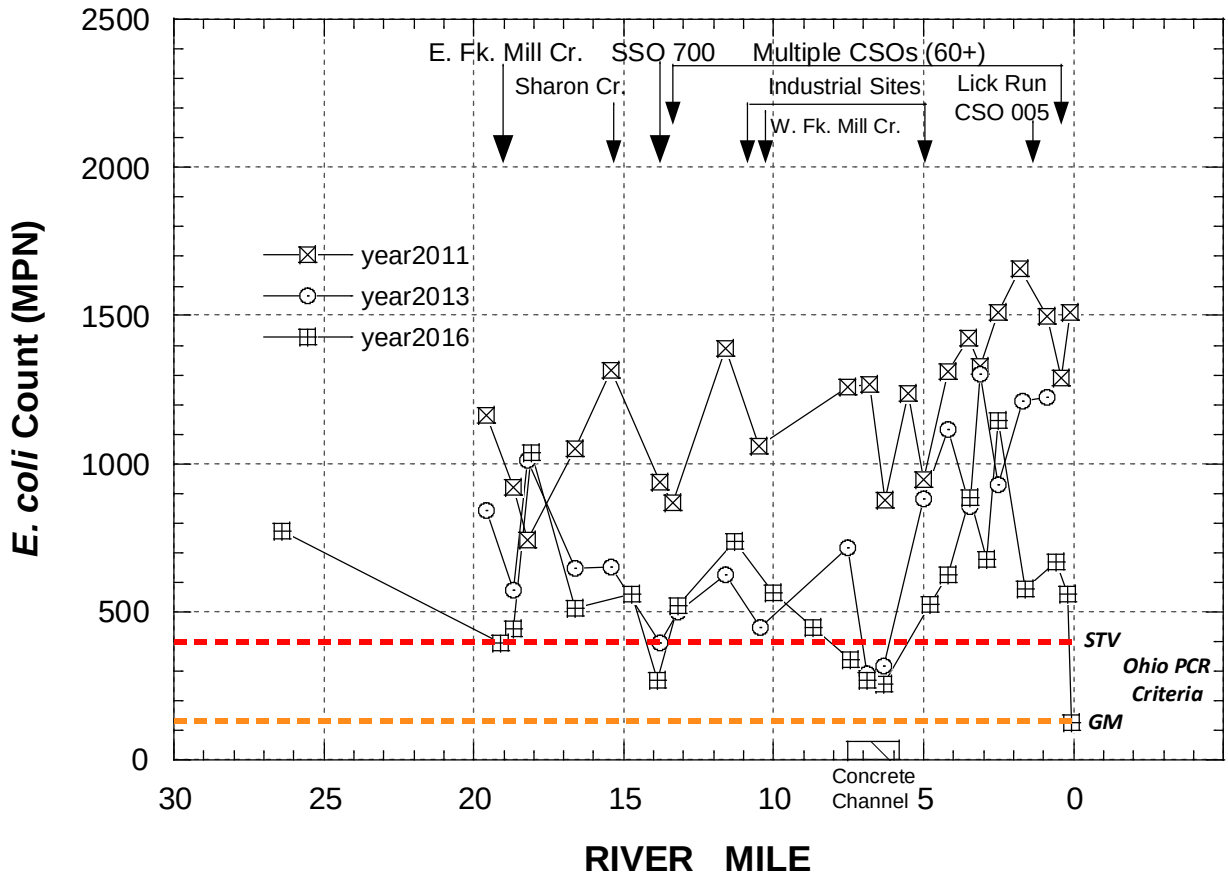

***Figure 8**. Geometric mean values for E. coli counts in the mainstem of Mill Creek in 2011, 2013, and 2016. The geometric mean (GM) and Statistical threshold Value (STV) criteria for the Primary Contact Recreational (PCR) use are indicated by dashed lines.*

MBI 2015) were used to assess conventional, ionic strength, and nutrient parameters. These "IPS thresholds" are used in place of the Ohio EPA (1999) *Appendices to Association Between Nutrients and the Aquatic Biota of Ohio River and Streams* the thresholds from which were employed in a similar fashion in the 2011-14 MSDGC service area watershed assessments. The IPS thresholds are a more robust analysis of biological stressor thresholds and especially in light of the Ohio EPA (1999) dataset being rather sparse in the Interior Plateau ecoregion. The IPS thresholds also offer discrete goals that are directly linked to the codified biological criteria and their application in the determination of aquatic life use attainment and the response to a finding of attainment and findings of non-attainment[4]. The results for selected parameters are compared to the IPS threshold goals that align with the applicable aquatic life use and stream size category and color coded in keeping with the hierarchy of the Ohio tiered aquatic life uses. The results are also graphically depicted along the Mill Creek mainstem and compared to available results using the Ohio EPA 1992 results as a historical baseline.

[4] OAC 3745-1-07(A)(6)(a) describe the options for a finding of full attainment and (A)(6)(b) for a finding of non-attainment.

Nutrients were assessed using the draft Stream Nutrient Assessment Procedure (SNAP; Ohio EPA 2015d) which is a "combined criteria" consisting of the fish and macroinvertebrate biological criteria, the diel D.O. flux, benthic chlorophyll α, and total nitrate and phosphorus. Lastly, sediment chemical data was assessed using the threshold and probable effect levels of MacDonald et al. (2000).

Conventional and Demand Parameters

This category includes D.O., temperature, pH, ammonia-N, and BOD_5. The D.O. results include both grab and continuous data. D.O. values from daytime grab samples as expected did not reveal any exceedances of the average or minimum criteria for either the WWH or MWH uses. A single average value that exceeded the maximum D.O. that is indicative of potentially excessive diel swings occurred at a single site (RM 11.3) in 2016 (Figure 7). High values were also observed further downstream in 2011 and all years had values >10 mg/l in the concrete channel reach.

Continuous D.O. data provided a more complete characterization of the D.O. regime in Mill Creek in 2016 (Figure 8). The results revealed two exceedances of the minimum D.O. criterion at single sites in Mill Creek and the East Fork. Excessively wide diel swings were evident in the upper portion of the MWH segment being widest in the concrete channel part of that segment. This effect slowly subsided downstream, but remained wider than in the WWH segment. These results clearly illustrate the role that the highly modified concrete channel habitat plays in exacerbating the effect of nutrients that is much less apparent upstream.

Continuous pH data revealed only a single exceedance of the maximum of 9.0 S.U. This parameter can also exhibit a diel swing related to increased algal activity spurred by excessive nutrients. Wide swings were observed in the MWH segment beginning in the concrete channel and only slowly subsiding downstream (Figure 9). These results mirrored the diel D.O. data and both are the result of the modified habitat and it exacerbating the effect of nutrients.

Continuous temperature data revealed consistent exceedances of the maximum criterion applicable to the Mill Creek mainstem downstream from the concrete channel in 2016 (Figure 10). One key difference is that the exceedances occurred one site further downstream into the concrete channel than where the excessive D.O. and pH swings started. This places the increased temperature downstream from the J.M. Smucker-Crisco discharge. While it is likely that the concrete channel contributes to the warming of Mill Creek temperatures the proximity to the discharge merits further investigation.

5-day biochemical oxygen demand (BOD_5) values in 2016 were at or below the minimum detection level (MDL) at all mainstem sites (Figure 11). This is a consistent reduction in values observed in 1997, 2011, and 2013 and is a positive indication of decreased loadings of carbonaceous materials. All values were well below the IPS thresholds.

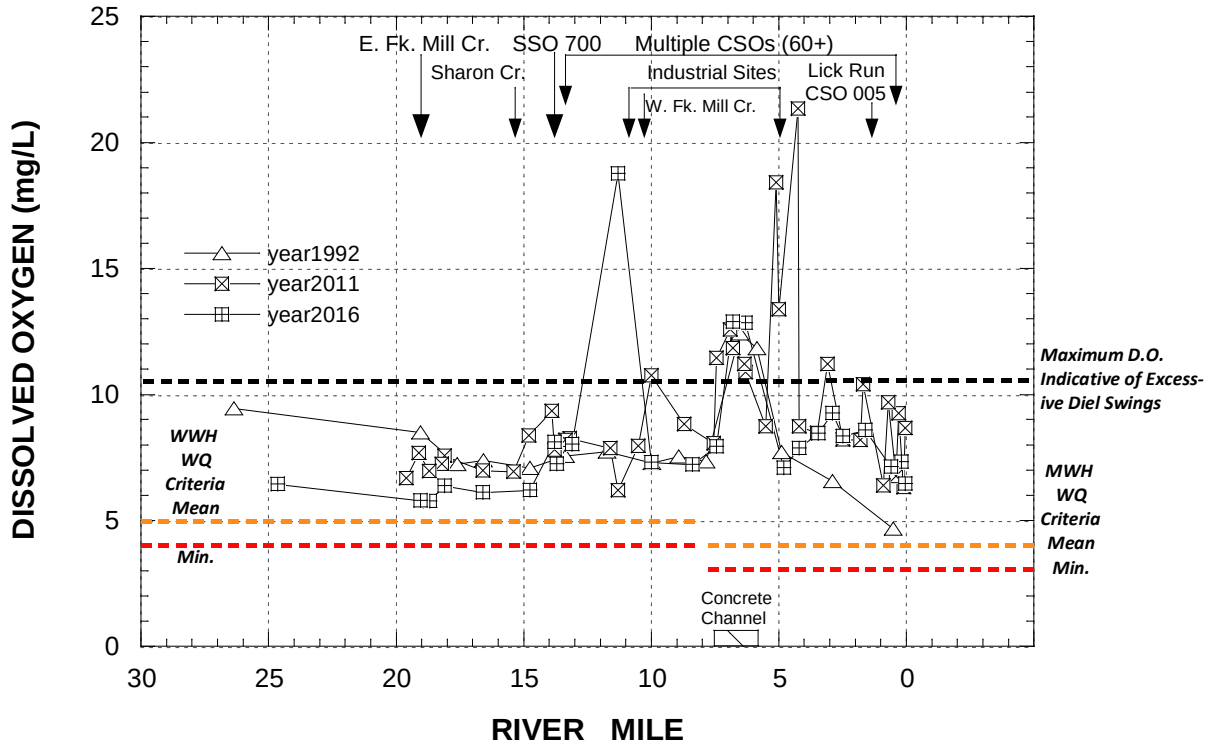

***Figure 9**. Mean dissolved oxygen (D.O.) at Mill Creek mainstem sites in 1992, 2011, and 2016. The average and minimum criteria for the WWH and MWH uses are shown as orange and red dashed lines. The D.O. concentration that indicates excessive diel swings is depicted as a black dashed line.*

Ammonia-N is included here as a conventional parameter as it has, along with BOD_5, been the target of point source controls of sewage treatment discharges and has shown historic declines in Ohio rivers and streams since the early 1990s. The 2016 results show ammonia-N at or near the MDL of 0.05 mg/l at all mainstem sites (Figure 12). Similar results were observed in 2011 and together with the 2016 results represent a significant improvement compared to 1992 and 1997. The source of ammonia-N in those two earlier years was the East Fork and presumably the Butler Co. Upper Mill Creek WRF. A second peak of ammonia-N occurred in 1992 beginning in the concrete channel which also received effluent from the former Procter and Gamble plant discharge. The reductions in ammonia-N are the result of improved wastewater treatment at point source discharges.

Nutrient Enrichment Parameters/SNAP

This includes total phosphorus, total nitrate, and total Kjeldahl nitrogen collected as grab samples. A draft Stream Nutrient Assessment Procedure (SNAP) developed by Ohio EPA (2015d) was also used to assess the overall effects of nutrient enrichment in the Mill Creek mainstem (excluding Ohio River influenced sites, RM 1.6-0.05), the East Fork (4 sites), and the West Fork (1 site). SNAP requires data for benthic chlorophyll a and the diel D.O. flux which was provided by the Datasonde results (Figure 8).

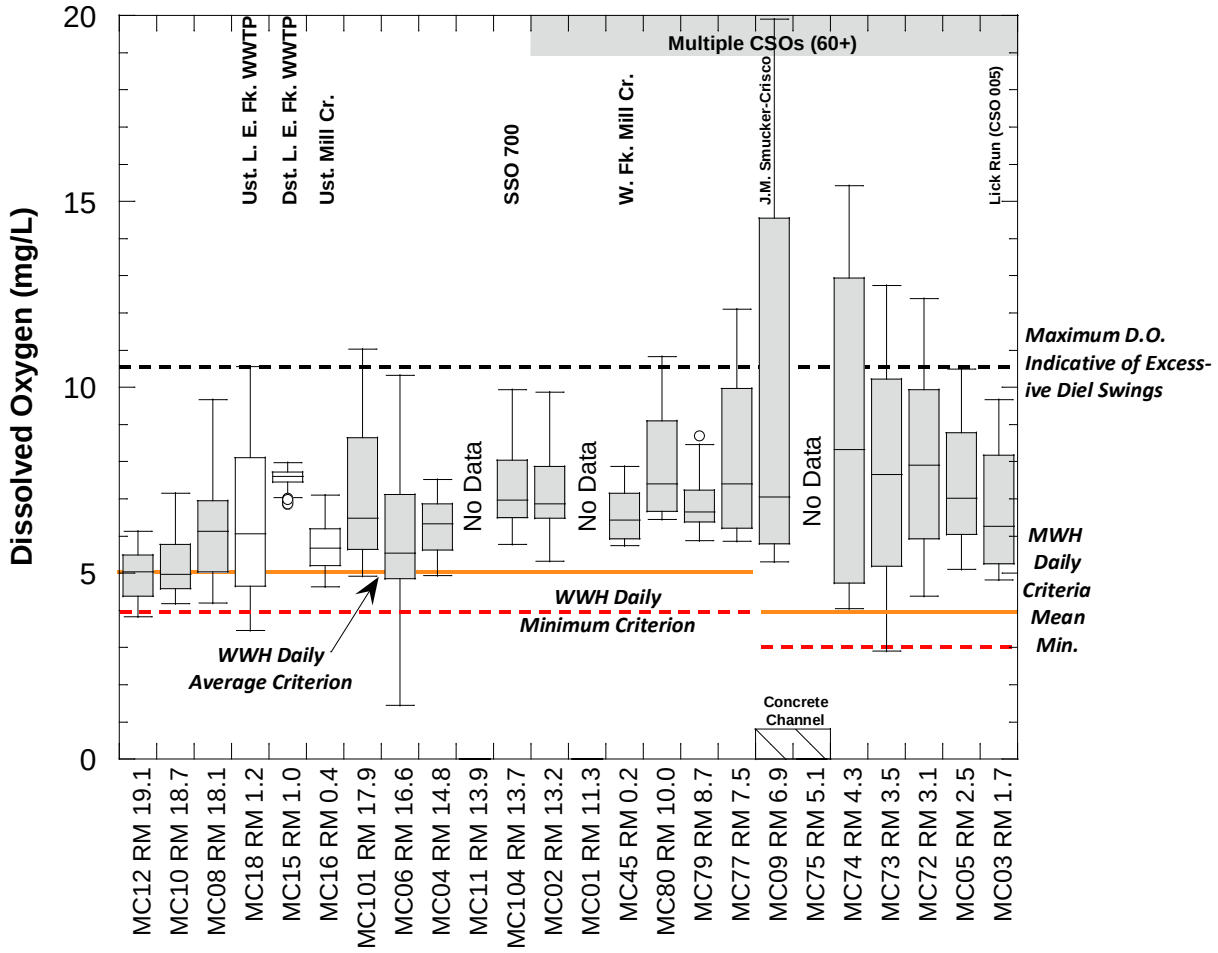

***Figure 10**. Box-and-whisker plots of continuous D.O. from Datasonde continuous recorders at 24 sites in the mainstem of Mill Creek and the lower East Fork during July 11-15 and July 20-22, 2016. The WWH and MWH daily average and minimum D.O. criteria are indicated by orange and red dashed lines and the maximum D.O. indicative of excessive diel swings is indicated by a black dashed line. Major discharges and tributaries are indicated across the top.*

Total phosphorus in the Mill Creek mainstem declined markedly between the 1992 and 1997 surveys and the 2011 survey (Figure 13). Total P increased between 2011 and 2016 to levels less than one-third of the much higher levels in 1992 and 1997. The longitudinal pattern clearly points to the East Fork Mill Creek and the Butler Co. Upper Mill Creek WRF as the primary source of these values – it was independent of all other sources. The 2011 values were all less than the IPS biological effect threshold, but exceeded it between the East Fork confluence downstream through the WWH segment. All 2016 values were well below the higher MWH IPS threshold during all years being close to the MDL in 2011 and 2016.

The IPS biological effect thresholds (MBI 2015) were used to assess all of the nutrient related parameters and some of the conventional and demand parameters (Table 5). The IPS thresholds are portrayed as goals for each parameter that correspond to the attainment of the Ohio biological criteria for the tiered aquatic life uses (e.g., EWH, WWH, MWH). The ambient results were color coded in accordance with the narrative benchmarks used in the IPS – exceptional (EWH), blue; good (WWH), green; fair (MWH), yellow; poor (LRW), orange; very

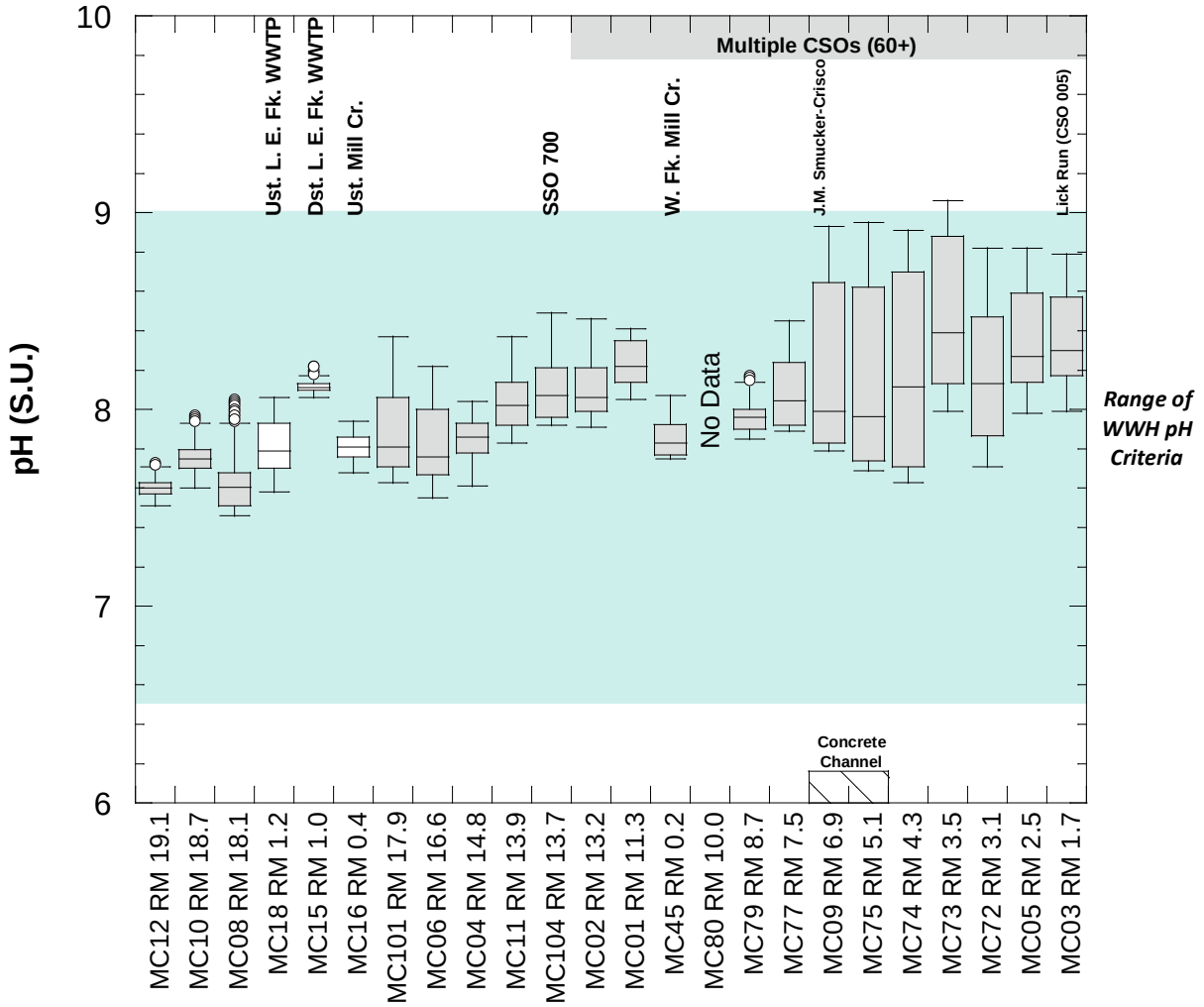

Figure 11*. Box-and-whisker plots of continuous pH from Datasonde continuous recorders at 24 sites in the mainstem of Mill Creek and the lower East Fork during July 11-15 and July 20-22, 2016. The range of the WWH maximum and minimum pH criteria are indicated by the blue shaded area. Major discharges and tributaries are indicated across the top.*

poor (no use), red. Among the nutrient parameters mean total phosphorus exceeded the WWH IPS threshold at all except one site in the WWH reach downstream from the East Fork and all were fair values. A single site upstream from the East Fork confluence exceeded the WWH IPS threshold and was in the fair range. The IPS threshold was exceeded at all three sites in the East Fork below the Butler Co. Upper Mill Creek WRF and all were poor values. All sites in the MWH reach of Mill Creek were well within the higher MWH IPS benchmark. Bloody Run had the highest total phosphorus values in the study area exceeding the MWH IPS threshold with one poor and one very poor value.

The mean total nitrate-N exceeded the WWH IPS threshold in the Mill Creek mainstem between the East Fork confluence and RM 10 (MC 80; Figure 14). All except two sites were in the poor range. The three sites below the Butler Co. Upper Mill Creek WRF in the East Fork were all poor values. Like total phosphorus the longitudinal pattern indicates the source of

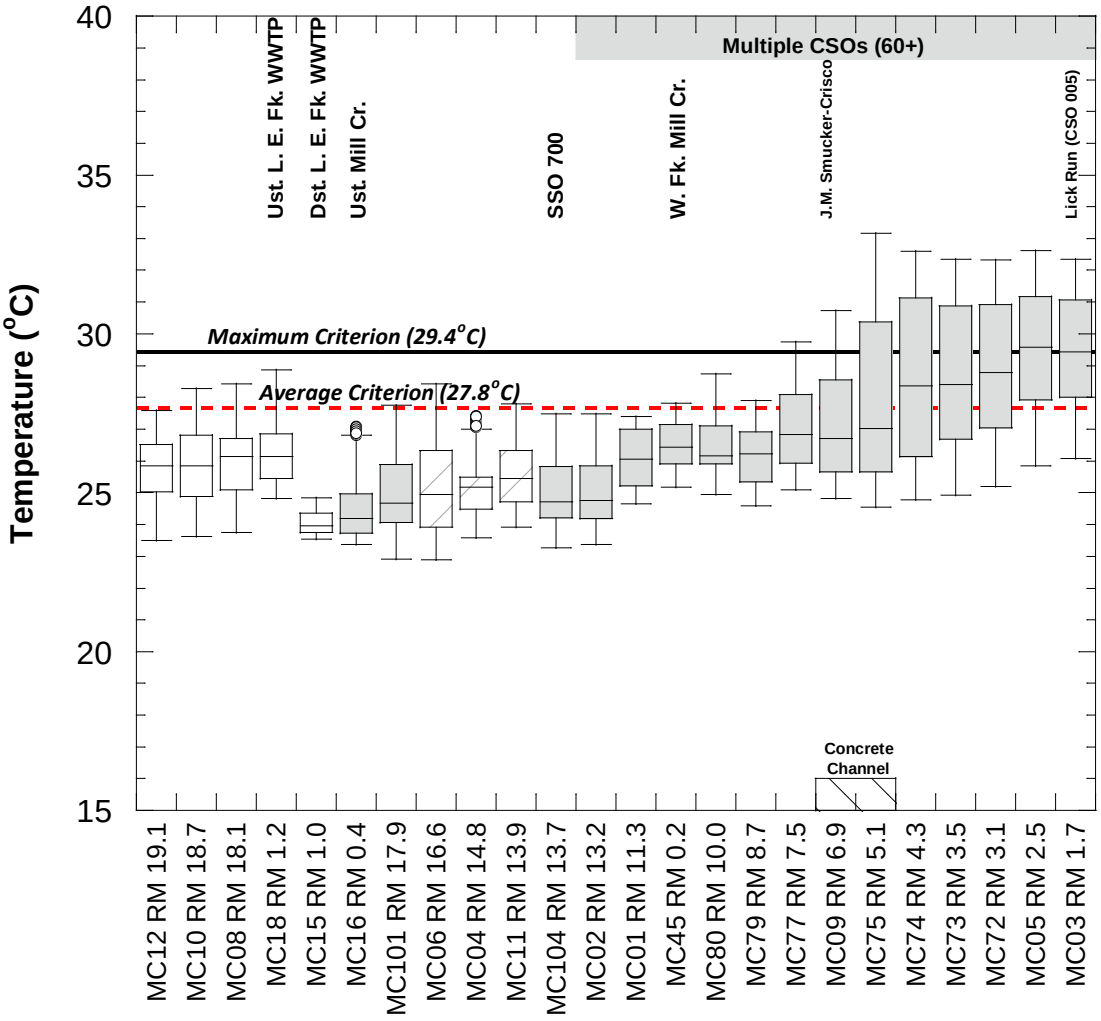

Figure 12. *Box-and-whisker plots of continuous temperature from Datasonde continuous recorders at 24 sites in the mainstem of Mill Creek and the lower East Fork during July 11-15 and July 20-22, 2016. The WWH average and maximum temperature criteria are indicated by a red dashed and solid black lines. Major discharges and tributaries are indicated across the top.*

nitrate-N enrichment is the East Fork and the Butler Co. Upper Mill Creek WRF. Mean nitrate-N values declined through the MWH segment declining to near background levels.

Mean TKN values exceeded the WWH IPS threshold in the WWH segment of Mill Creek beginning with two sites upstream from the East Fork, returning to good at the site immediately upstream from the East Fork, and exceeding the threshold downstream from the East Fork to the MWH segment (Figure 15). Similar to total P and nitrate, TKN was elevated above the WWH IPS threshold at all three sites in the East Fork below the Butler Co. Upper Mill Creek WRF with one fair, one poor, and one very poor value.

Among the conventional and demand parameters included in Table 5, ammonia-N was below all IPS thresholds at all sites, D.O. was only slightly below the WWH threshold at four scattered sites, and BOD_5 was below all thresholds at all sites except Bloody Run. Both D.O. and BOD_5

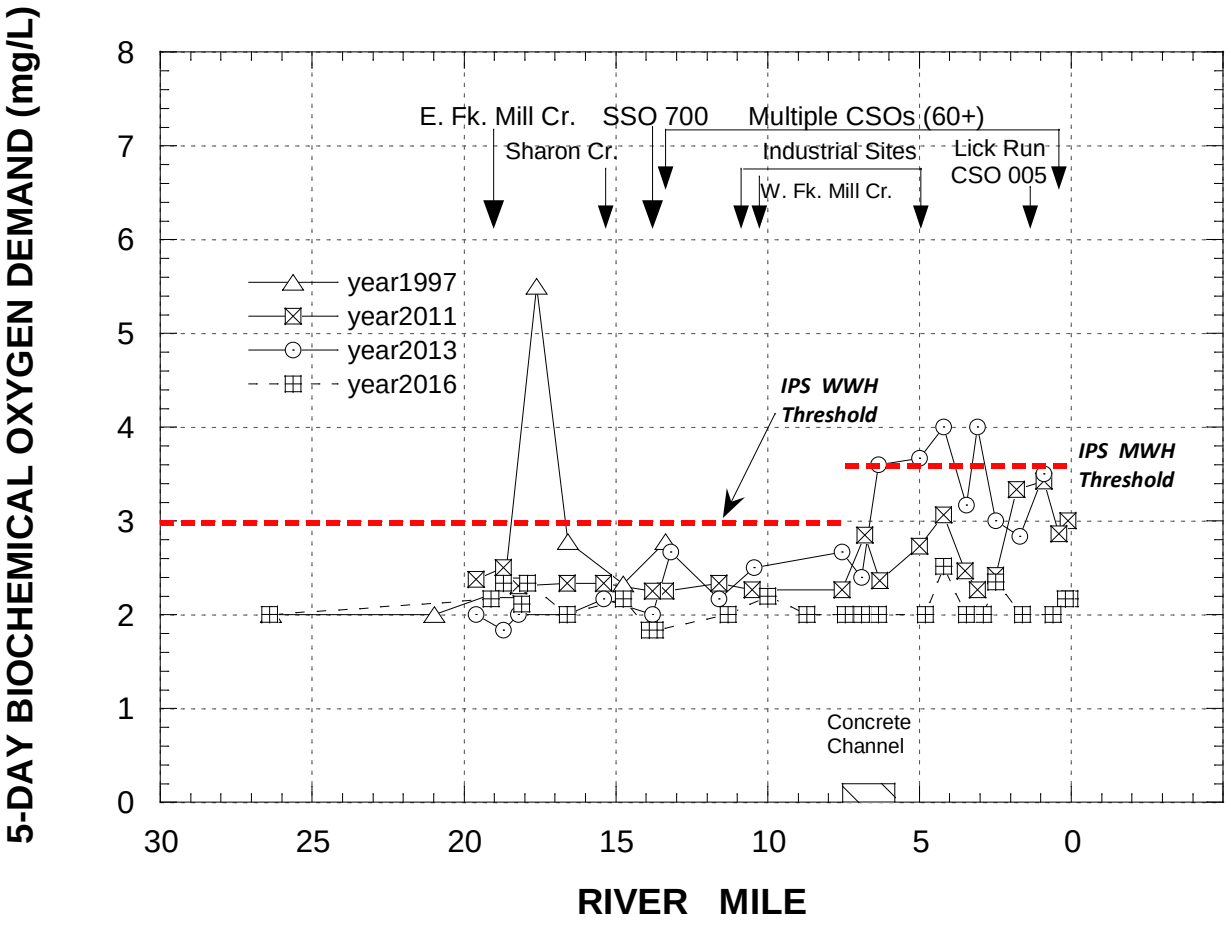

Figure 13. *Mean 5-day BOD at Mill Creek mainstem sites in 1997, 2011, 2013, and 2016. The IPS biological effect thresholds for the WWH and MWH uses are shown as red dashed lines.*

were in the very poor range at both sites in Bloody Run which along with the extremely elevated total P is indicative of raw sewage. *E. coli* levels as previously described (Table 4) were also highly elevated in Bloody Run compared to other sites in the study area.

The draft Ohio EPA SNAP procedure was used to assess the overall effect of nutrient enrichment in the Mill Creek mainstem, the East Fork, and the West Fork sites (Table 6). SNAP uses the IBI, MIwb, and ICI, the aquatic life use attainment status (impaired or attaining), the total P and nitrate results, the maximum and minimum D.O., the diel D.O. swing, and benthic chlorophyll a to arrive at trophic status determination for sites that are impaired for the biocriteria. Impaired sites are assessed for the likelihood that nutrient enrichment is the primary cause. Only two of 16 impaired sites were determined to be likely associated with nutrient enrichment. Two were in Mill Creek, one downstream from the East Fork (MC06) and the other at the beginning of the concrete channel (MC09). Four sites were rated as a possible threat with three in the concrete channel and immediately downstream in the MWH segment of Mill Creek. The other site was immediately downstream from the East Fork (MC101). The two sites immediately downstream from the Butler Co. Upper Mill Creek WRF were rated as a

Table 6*. Conventional, demand, and nutrient parameters in the 2016 Mill Creek study. Mean ambient values are color coded by their IPS ranges that correspond to tiered uses and narrative quality; blue – EWH (exceptional); green – WWH (good); yellow – MWH (fair); orange – LRW (poor); red – very poor quality. IPS threshold goals for each site are in the column to the right of each value.*

Site ID	River Mile	Year	Aq. Life Use	Dissolved Oxygen (mg/L)/Goal		Mean BOD_5 (mg/L)/Goal		Mean TKN (mg/L)/Goal		Mean Total Ammonia (mg/L)/Goal		Mean Nitrate (mg/L)/Goal		Mean Total Phosphorus (mg/L)/Goal		Benthic Chlorophyll-a (mg/m^3)	Sestonic Chlorophyll-a (mg/m^3)
Mill Creek – WWH Reach																	
MC00	26.4	2016	WWH	5.62		2.00	**2.48**	0.18	**0.51**	0.017	**0.31**	0.41	**0.96**	0.089	**0.17**	69.1	1.7
MC12	19.1	2016	WWH	4.04		2.17		0.73		0.042		0.28		0.141		24.7	12.5
MC10	18.7	2016	WWH	4.29		2.17		0.75		0.031		1.62		0.376		109.1	6.2
MC08	18.1	2016	WWH	5.84		2.12		0.47		0.023		0.14		0.108		51.9	5.1
MC101	17.9	2016	WWH	7.79		2.33		0.97		0.028		2.69		0.647		143	6.7
MC06	16.6	2016	WWH	5.21		2.00		0.87		0.017		2.5		0.613		167	3.1
MC04	14.75	2016	WWH	4.95	**5.0**	2.17		0.79		0.028		2.02		0.491		42.6	4.1
MC11	13.9	2016	WWH	5.82		1.83	**2.96**	0.63	**0.58**	0.018	**0.53**	1.84	**1.38**	0.336	**0.17**	10.2	4.4
MC104	13.7	2016	WWH	7.24		1.83		0.66		0.022		1.92		0.340		115	3.7
MC02	13.2	2016	WWH	7.24		2.00		0.61		0.027		2.00		0.349		148	4.1
MC01	11.3	2016	WWH	7.28		2.00		0.60		0.035		1.82		0.305		107	3.2
MC80	10.0	2016	WWH	6.26		2.20		0.62		0.023		1.61		0.295		34.9	6.6
MC79	8.7	2016	WWH	6.78		2.00		0.63		0.040		1.36		0.243		13.7	11.3
MC77	7.45	2016	WWH	7.02		2.00		0.63		0.037		1.20		0.211		47.1	12.7
Mill Creek– MWH Reach																	
MC09	6.9	2016	MWH-C	10.42		2.00		0.70		0.013		0.96		0.209		101	20.4
MC07	6.35	2016	MWH-C	8.41		2.00		0.53		0.012		1.02		0.170		154	20.3
MC75	4.8	2016	MWH-C	5.81		2.00		0.56		0.013		0.83		0.160		17.1	12.5
MC74	4.2	2016	MWH-C	4.48		2.52		0.58		0.020		0.81		0.197		22	12.8
MC73	3.45	2016	MWH-C	5.43		2.00		0.53		0.029		0.85		0.143		14.7	10.4
MC72	2.9	2016	MWH-C	6.72	**4.0**	2.00	**3.35**	0.56	**1.63**	0.028	**0.83**	0.61	**1.70**	0.130	**0.70**	25.8	12.1
MC05	2.5	2016	MWH-C	7.64		2.35		0.62		0.035		0.51		0.172		27.9	12.5
MC03	1.6	2016	MWH-C	6.44		2.00		0.58		0.017		0.66		0.127			12.2
MC71	0.6	2016	MWH-C	5.88		2.00		0.72		0.070		0.55		0.154			30.1
MC70	0.2	2016	MWH-C	5.93		2.17		0.77		0.092		0.42		0.153			20.5
MC69	0.05	2016	MWH-C	5.06		2.17		0.54		0.043		0.62		0.102			15.1
West Branch Mill Creek																	
MC45	0.2	2016	WWH	4.60	**5.0**	1.83	**2.96**	0.45	**0.58**	0.010	**0.53**	0.49	**1.38**	0.132	**0.17**	62.2	3.6
East Fork Mill Creek																	
MC18	1.2	2016	WWH	5.68		1.83		0.37		0.022		0.05		0.135		67.7	1.6
MC15	1.0	2016	WWH	7.67	**5.0**	1.85	**2.96**	1.17	**0.58**	0.047	**0.53**	2.95	**1.38**	0.790	**0.17**	151	1.9
MC14	0.5	2016	WWH	6.05		1.83		1.14		0.054		2.82		0.884		298	0.8
MC16	0.01	2016	WWH	6.66		1.83		2.04		0.070		3.00		0.934		238	0.9
Bloody Run																	
MC102	0.3	2016	MWH-C	0.47	**5.0**	155	**2.48**	0.79	**0.51**	0.033	**0.31**	0.16	**0.96**	1.886	**0.70**		0.5
MC103	0.2	2016	MWH-C	1.17		11.0		0.97		0.006		0.01		4.03			0.5

high risk based primarily on highly elevated total P and nitrate values. These sites also had two of the highest benthic chlorophyll a values in the 2016 study area, but all were lower than the SNAP thresholds for high concentrations. Wide D.O. swings occurred primarily in the MWH segment and in the concrete channel and immediately downstream. This is more a function of the habitat and lack of shading and was deemed a possible threat. However, the habitat modification in this reach overwhelms everything else plus the MWH use if fully attained. A principal conclusion from the SNAP assessment is that nutrients are not a widespread cause of non-attainment in Mill Creek, partly due to the highly modified habitat and altered flow regime and partly due to low benthic chlorophyll a values.

Urban Parameters

Urban parameters include ionic strength measures such as conductivity, total dissolved solids, total chlorides, and total sulfates and selected heavy metals such as copper, lead, and zinc. These parameters are commonly elevated in urban areas and are the result of stormwater runoff, but can also be indicative of other industrial and municipal sources of pollution. In addition to graphical depictions of these parameters the IPS biological effect thresholds (MBI 2015) were used to assess all of the urban parameters similar to the preceding analyses of nutrient and demand parameters (Table 7).

Conductivity was measured by grab sampling at all 2016 study area sites and Datasonde continuous monitors deployed in the mainstem of Mill Creek, the lower East Fork, and at the mouth of the West Fork. The longitudinal results show a sharp increase downstream of the East Fork and gradually declining downstream along the length of Mill Creek (Figure 16). The 2011, 2013, and 2016 results were well in excess of both the WWH and MWH IPS thresholds at all except the sites in the lower 2 miles of Mill Creek. Unlike the reductions demonstrated for conventional, demand, and nutrient parameters, conductivity has increased markedly since 1992. The continuous data (Figure 16) reflect a clear pattern of values indicating the Butler Co. Upper Mill Creek WRF as the primary source of elevated conductivity in Mill Creek. This is the same conclusion reached in 2011 showing no changes over the past 5 years.

Total chlorides show a similar longitudinal and temporal pattern to conductivity (Figure 17) increasing sharply downstream from the East Fork and increasing in 2011 and 2016 over values measured in 1992 and 1997. The value at MC75 (RM 5.1) was the highest ever recorded and may be indicative of an unknown source. Increases in dissolved solids and chloride in particular have been widely observed in urban watersheds over the past 15-20 years. Most is related to the buildup of deicing salt in the riparian zone and near surface groundwater, but in Mill Creek a significant portion is discharged by point sources.

The IPS biological effect thresholds (MBI 2015) were used to assess all of the urban related parameters the same way the conventional, demand, and nutrient parameters (Table 7). In addition to conductivity and chloride, total dissolved solids were well in excess of the WWH and MWH IPS thresholds and not returning to those levels until RM 0.05. Sulfates were in excess of the WWH IPS thresholds downstream from the East Fork, but this persisted only through the WWH segment. Bloody Run did not show any issues with these parameters. The heavy metals

copper, lead, and zinc did not exceed any of the IPS thresholds except one value for copper in Bloody Run that only slightly exceeded the MWH threshold.

Sediment Chemistry

Sediment samples were collected from all sites in the 2016 Mill Creek study area in October and analyzed for heavy metals and organic compounds. The results were screened with the MacDonald et al. (2000) consensus-based levels for potential adverse effects to aquatic life. MacDonald et al. (2000) described two values for sediment metal and organic compounds; a threshold effects concentration (TEC) and a probable effects concentration (PEC) the latter being the more conclusive threshold for adverse effects to aquatic life. Sediment chemistry has yet to be incorporated into the IPS, but developing those thresholds is a priority for IPS development in 2017.

Exceedances of TELs for heavy metals were documented for the three metals included in the urban parameters, copper, lead and zinc (Table 8). All of the exceedances occurred in the lower mainstem between RM 2.5 (MC05) and the mouth at RM 0.05 (MC 69) and in Bloody Run. Lead exceedances occurred at all of these sites, copper at four sites, and zinc at a single site (RM 0.3; MC 70). These are presumably from urban runoff and nearby CSOs.

PAH compounds in excess of both TEL and PEL thresholds occurred throughout the Mill Creek mainstem beginning at RM 18.1 (MC 08) and extending to the mouth at RM 0.05 (MC 69; Table 9). This included 10 PAH compounds with PEL exceedances being commonplace for benzo(a)pyrene, benzo(ghi)perylene, chrysene, fluoranthene, phenanthrene, and pyrene. TEL exceedances occurred for benzo(b)fluoranthene, benzo(k)fluoranthene, and indeo(1,2,3-cd)pyrene. Similar exceedances were also documented at the mouth of the West Fork and in Bloody Run that additionally included PEL exceedances for acenapthylene and anthracene. All of the detected PAH compounds are in coal tar, gasoline exhaust, and are products of incomplete combustion and several are known carcinogens. These are common in urban areas with asphalt pavement and heavy automobile traffic and presumably enter streams via runoff from paved surfaces.

Stream Habitat

The habitat assessment is based on the QHEI and its metrics, submetrics, and individual attributes. QHEI scores in 2016 were generally in line with those observed in prior surveys dating back to 1992 (Figure 18). QHEI scores were generally above the threshold for WWH attainability (60) for the mainstem downstream to the site immediately upstream from the concrete channel and the start of the MWH segment. The RM 7.5 site (MC77) was originally part of the MWH segment established by Ohio EPA in 1992 (Ohio EPA 1994), but was recommended for upgrading to WWH in 2011 (MBI 2012) because it was showing sufficient signs of recovery to eventually meet WWH. Now the MWH segment begins at the start of the concrete channel extending to the mouth. The QHEI scores in the WWH segment exhibit some variability which is likely due to the sampling sites being in slightly different locations between years, but also because of the comparatively instability of the channel in localized areas. QHEI

scores were consistently very poor in the concrete channel increasing to fair and some good scores downstream. The predominance of high influence modified attributes would need to be addressed in order for WWH to be a serious consideration.

A QHEI matrix showing both good and poor habitat attributes (after Rankin 1995) was developed for each site in the Mill Creek study area (Table 10). Stream habitat in Mill Creek has been modified to some extent throughout its length as evidenced by the presence of moderate influence modified attributes. Both substrate and channel related issues are evident in the QHEI results. All except 7 of 33 sites had moderate to high silt covering the hard substrates. The silt covering was also accompanied by moderate to extensive embeddedness at 25 of 33 sites. Two of the sites without these modified attributes occurred in the concrete channel where silt covering or embeddedness is not likely due to frequent flushing of the concrete bottom by recurrent high flows. Channel modifications were still apparent in fair to poor development at 22 sites, including all of the sites in the MWH segment. High influence modified attributes were prevalent in the MWH segment and especially so in the concrete channel. The East Fork exhibited signs of legacy modifications high influence attributes at 4 of 5 sites. An extensive restoration project was recently completed just upstream of the upstream most site at RM 1.2 (MC18). The West Fork at RM 0.2 (MC45) exhibited good habitat with no high influence attributes and only 3 moderate influence modified attributes. Bloody Run exhibited attributes characteristic of a highly modified channel which is consistent with the MWH designation.

The IPS biological effect thresholds (MBI 2015) were used to assess the QHEI, the Hydro QHEI[5], and selected QHEI attributes the same way the water chemistry results were assessed (Table 11). The goals were derived from the biological stressor relationships developed to support IPS implementation (MBI 2015). This analysis of the QHEI results could be used to determine

[5] The Hydro QHEI is a subset of the QHEI metrics to include those representative of or influenced by flow.

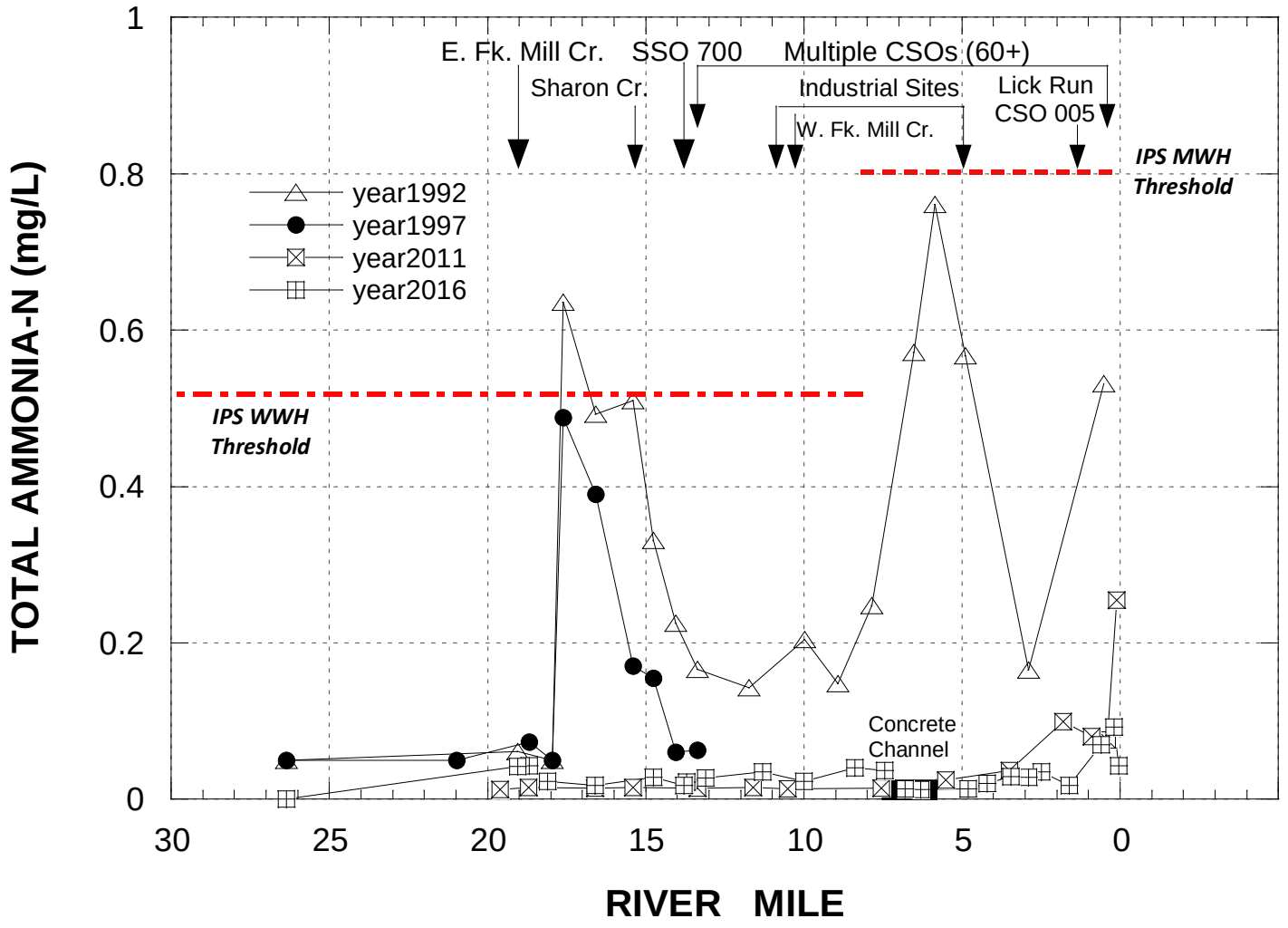

Figure 14. *Mean ammonia-N at Mill Creek mainstem sites in 1992, 1997, 2011, and 2016. The IPS biological effect thresholds for the WWH and MWH uses are shown as red dashed lines.*

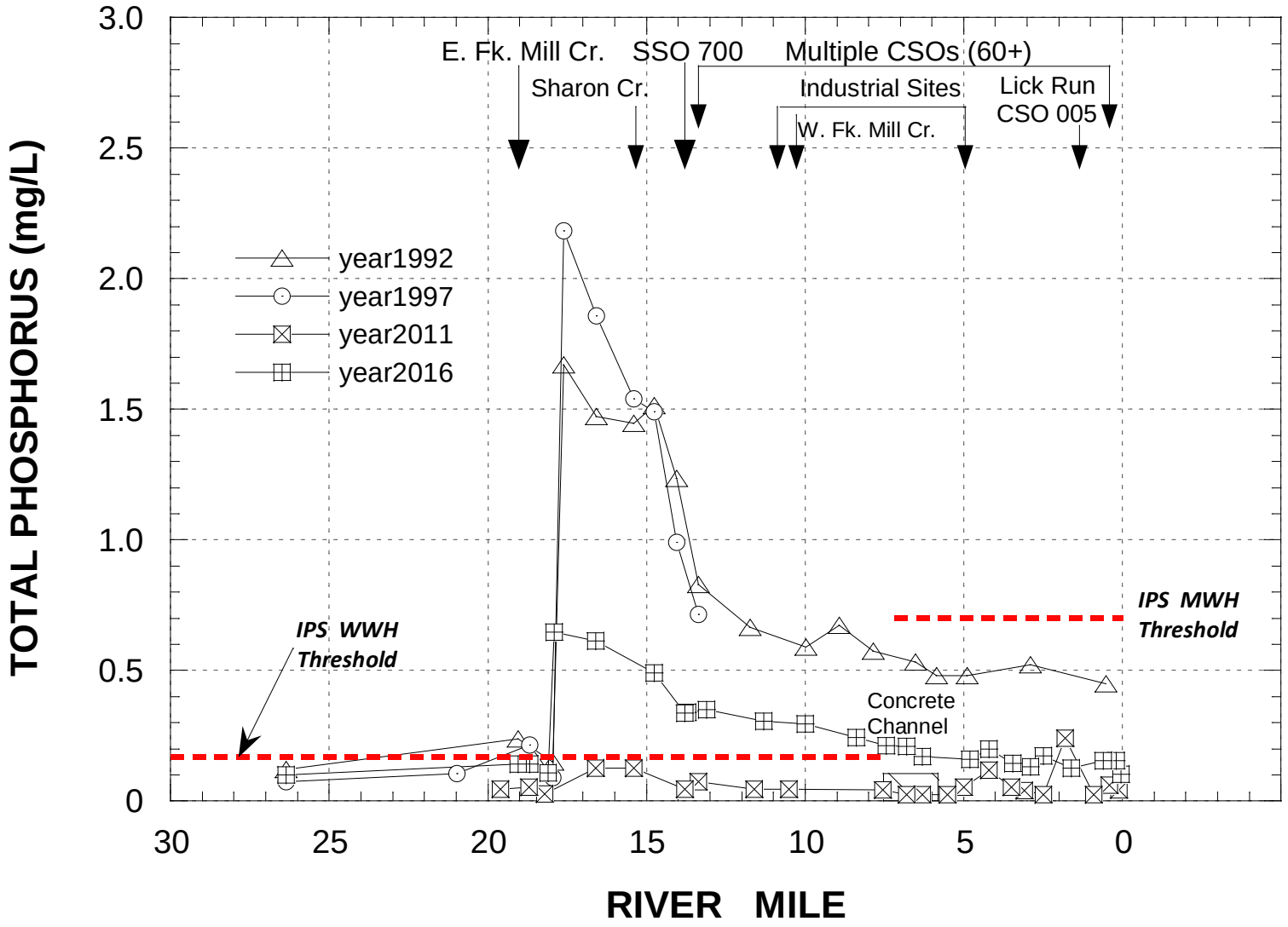

Figure 15. *Mean total phosphorus at Mill Creek mainstem sites in 1992, 1997, 2011, and 2016. The IPS biological effect thresholds for the WWH and MWH uses are shown as red dashed lines.*

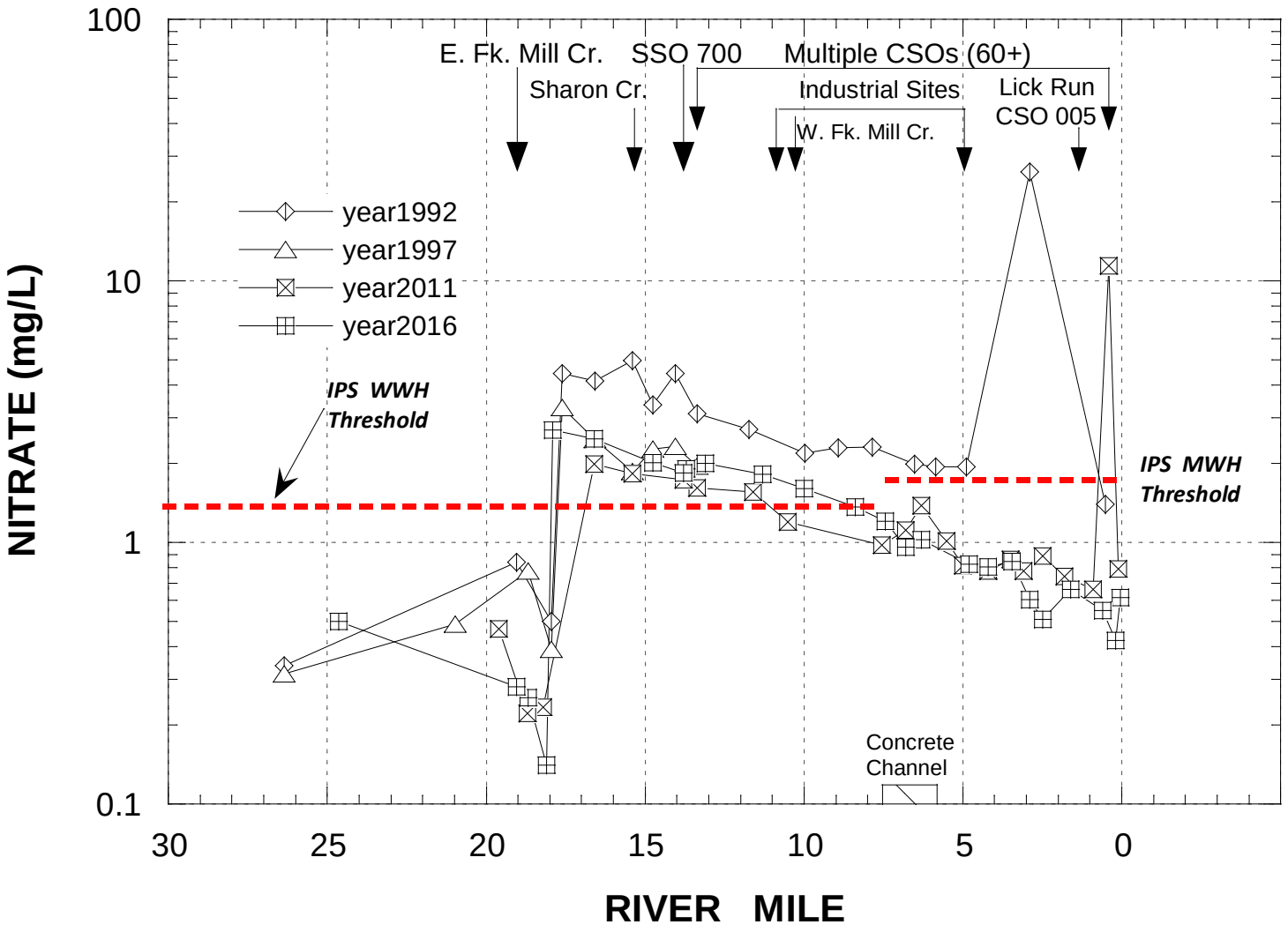

Figure 16. *Mean nitrate-N at Mill Creek mainstem sites in 1992, 1997, 2011, and 2016. The IPS biological effect thresholds for the WWH and MWH uses are shown as red dashed lines.*

***Table 7**. Results for parameters and indicators used in the Stream Nutrient Assessment Procedure (SNAP) to determine the role of the effect of nutrients on aquatic life use attainment in the 2016 Mill Creek study area. SNAP produces a trophic status that is the likelihood of nutrients as a cause of non-attainment.*

Site ID	River Mile	Aq. Life Use	Drain Area (mi^2)	IBI	MIwb	ICI	Attain-ment Status	Total P (mg/l)[b]	Nitrate (mg/L)[b]	Max DO	Min DO[c]	Max. Daily DO Swing	DO Swing Narrative	Benthic Chlr. a	Benthic Chlr. a Narrative	Sestonic Chlr. a	Trophic Status
Mill Creek – WWH Reach																	
MC12	19.05	WWH	20.5	35	7.7	44	**IMPAIRED**	0.14	0.28	6.12	3.83	2.03	Normal-Low	24.7	Low-Moderate	12.5	Not Nutrients
MC10	18.69	WWH	27	33	7.5	46	**IMPAIRED**	0.14	0.26	7.15	4.19	2.96	Normal-Low	69.2	Low- Moderate	8.1	Not Nutrients
MC08	18.1	WWH	32.4	35	7.6	38	**IMPAIRED**	0.11	0.14	9.66	4.2	4.26	Normal-Low	51.9	Low- Moderate	5.1	Not Nutrients
MC101	17.9	WWH	0.8	36	7.4	38	**IMPAIRED**	0.65	2.70	11.03	4.92	6.11	Normal-Low	143	Low- Moderate	6.7	Possible Threat
MC06	16.6	WWH	50.5	27	5.4	38	**IMPAIRED**	0.61	2.50	10.32	1.45	8.87	Wide	167	Low	3.1	Likely Nutrients
MC04	14.75	WWH	64	25	4.8	38	**IMPAIRED**	0.49	2.02	7.52	4.94	2.13	Normal-Low	42.6	Low- Moderate	4.1	Not Nutrients
MC11	13.8	WWH	71	35	7.6	VG	**IMPAIRED**	0.37	1.84	9.04[a]	5.82[a]	-	Normal-Low	10.2	Low- Moderate	4.4	Not Nutrients
MC104	13.7	WWH	71.6	29	6.8	38	**IMPAIRED**	0.34	1.92	9.94	5.78	3.39	Normal-Low	115	Low- Moderate	3.7	Not Nutrients
MC02	13.1	WWH	72.2	27	5.9	42	**IMPAIRED**	0.35	2.00	9.87	5.32	3.95	Normal-Low	148	Low- Moderate	4.1	Not Nutrients
MC01	11.3	WWH	73.9	36	7.0	VG	**IMPAIRED**	0.31	1.82	8.77[a]	7.28[a]	-	Normal-Low	107	Low- Moderate	3.2	Not Nutrients
MC80	10	WWH	115	31	5.6	40	**IMPAIRED**	0.30	1.61	10.83	6.45	4.23	Normal-Low	34.9	Low- Moderate	6.6	Not Nutrients
MC79	8.38	WWH	124	38	8.1	44	ATTAINS	0.24	1.37	8.7	5.88	2.74	Normal-Low	13.7	Low- Moderate	11.3	No Threat
Mill Creek – MWH Reach																	
MC77	7.45	MWH-C	130	29	6.4	G	ATTAINS	0.21	1.20	12.11	5.86	6.01	Normal-Low	47.1	Low- Moderate	12.7	No Threat
MC09	6.8	MWH-C	127	22	5.0	MF	**IMPAIRED**	0.21	0.96	19.9	5.31	14.16	Wide	101	Low	20.4	Likely Nutrients
MC75	4.8	MWH-C	136	30	5.5	34	ATTAINS	0.16	0.83	11.1[a]	5.81[a]	-	Wide	17.1	Low- Moderate	12.5	No Threat
MC74	4.2	MWH-C	141	37	7.7	MG	ATTAINS	0.20	0.81	15.43	4.04	11.13	Wide	22	Low	12.8	Possible Threat
MC73	3.45	MWH-C	139	34	6.3	MG	ATTAINS	0.14	0.85	12.74	2.91	9.32	Wide	14.7	Low	10.4	Possible Threat
MC72	2.9	MWH-C	149	35	6.3	26	ATTAINS	0.13	0.61	12.39	4.39	6.94	Wide	25.8	Low	12.1	Possible Threat
MC05	2.5	MWH-C	154	32	7.6	28	ATTAINS	0.17	0.51	10.49	5.1	4.71	Normal-Low	27.9	Low- Moderate	12.5	No Threat
MC03	1.6	MWH-C	163	25	8.0	24	ATTAINS	0.13	0.66	9.66	4.81	4.42	Normal-Low	0	Low- Moderate	12.2	No Threat
West Fork Mill Creek - WWH																	
MC45	0.15	WWH	36.4	25	7.1	48	**IMPAIRED**	0.13	0.49	7.87	5.74	1.90	Normal-Low	62.2	Low- Moderate	3.6	Not Nutrients
East Fork Mill Creek - WWH																	
MC18	1.2	WWH	9.5	31	na	42	**IMPAIRED**	0.14	0.05	10.56	3.46	6.24	Normal-Low	67.7	Low	1.6	Not Nutrients
MC15	1	WWH	9.1	33	na	34	**IMPAIRED**	0.80	2.96	7.98	6.84	1.14	Normal-Low	151	Low- Moderate	1.9	High Risk[d]
MC16	0.01	WWH	9.4	22	na	48	**IMPAIRED**	0.93	3.01	7.1	4.63	2.32	Normal-Low	238	Low- Moderate	0.9	High Risk[d]

[a] Datasonde data not available, data represent summer max and min values (i.e., no available DO daily swing data)
[b] Color shading for TP and Nitrate based on SNAP risk levels
[c] Red shading indicates value below dissolved oxygen minimum criteria for the applicable aquatic life use.
[d] High risk from nutrients based on combination of elevated TP and nitrate.

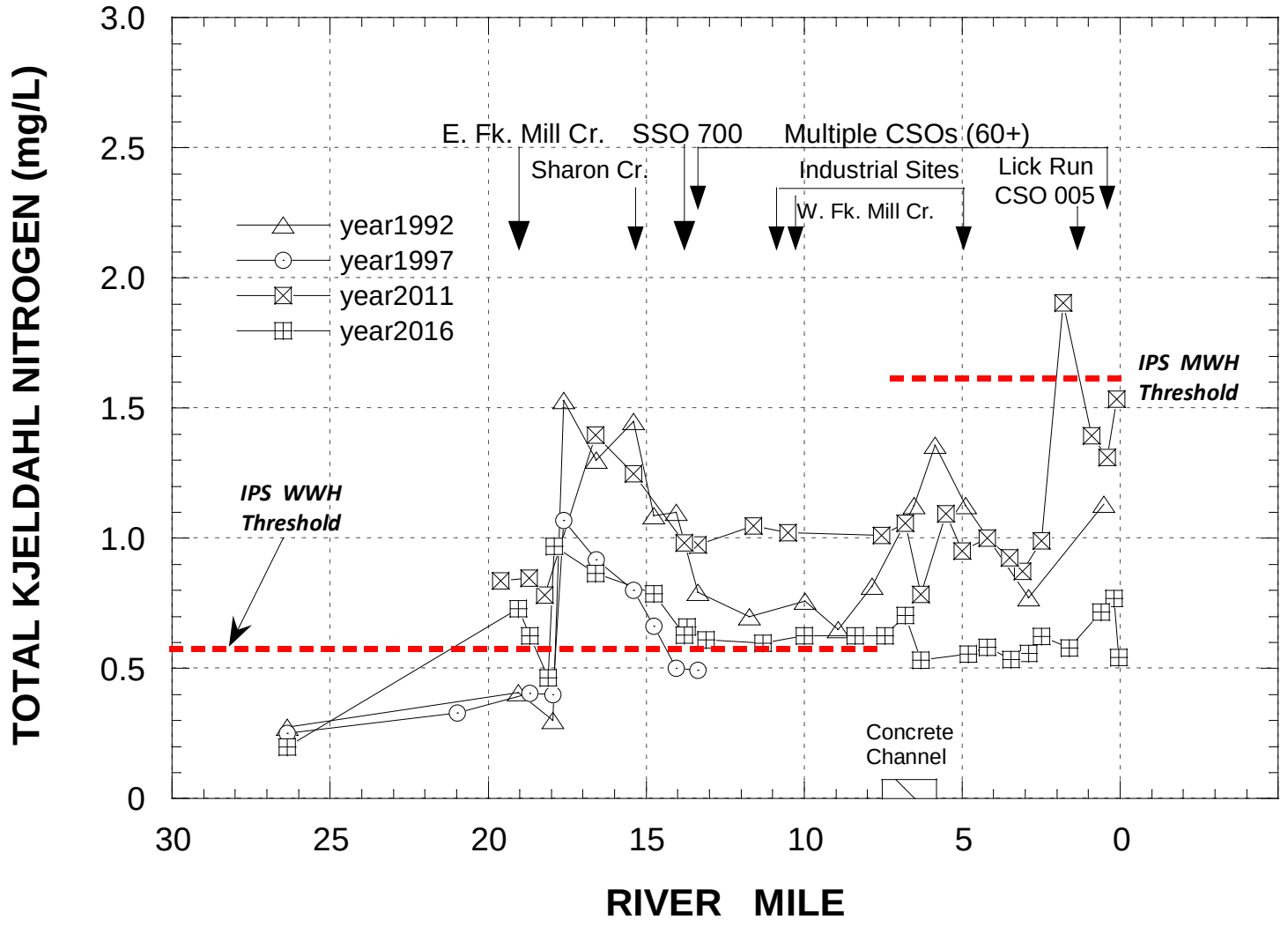

Figure 17. *Mean total Kjedahl nitrogen (TKN) at Mill Creek mainstem sites in 1992, 1997, 2011, and 2016. The IPS biological effect thresholds for the WWH and MWH uses are shown as red dashed lines.*

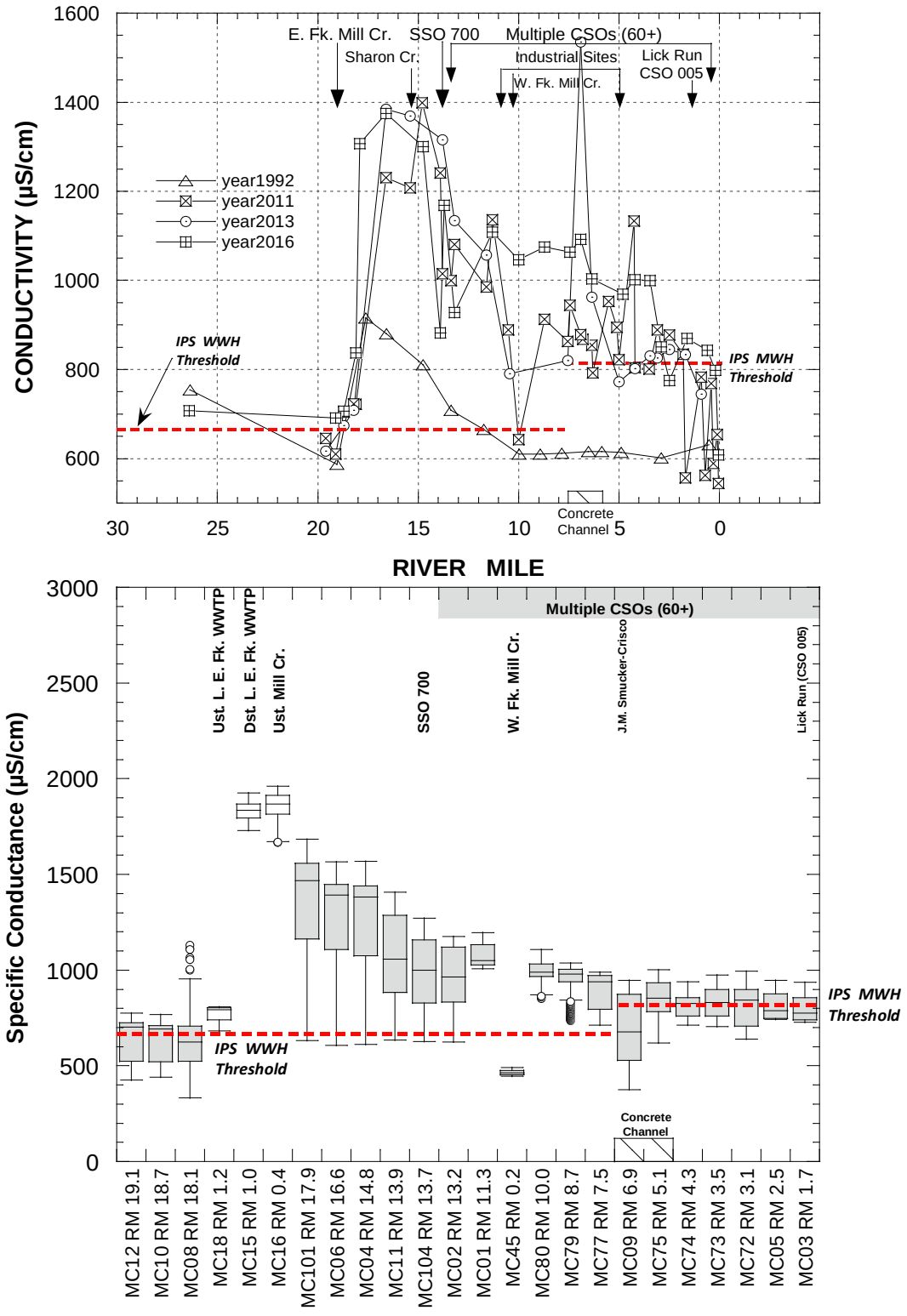

Figure 18. *Mean conductivity values in the mainstem of Mill Creek in 1992, 2011, 2013, and 2016 (Upper). Box-and-whisker plots of continuous temperature from Datasonde continuous recorders at 24 sites in the mainstem of Mill Creek and the lower East Fork during July 11-15 and July 20-22, 2016 (Lower). The WWH average and maximum temperature criteria are indicated by a red dashed and solid black lines. Major discharges and tributaries are indicated across the top.*

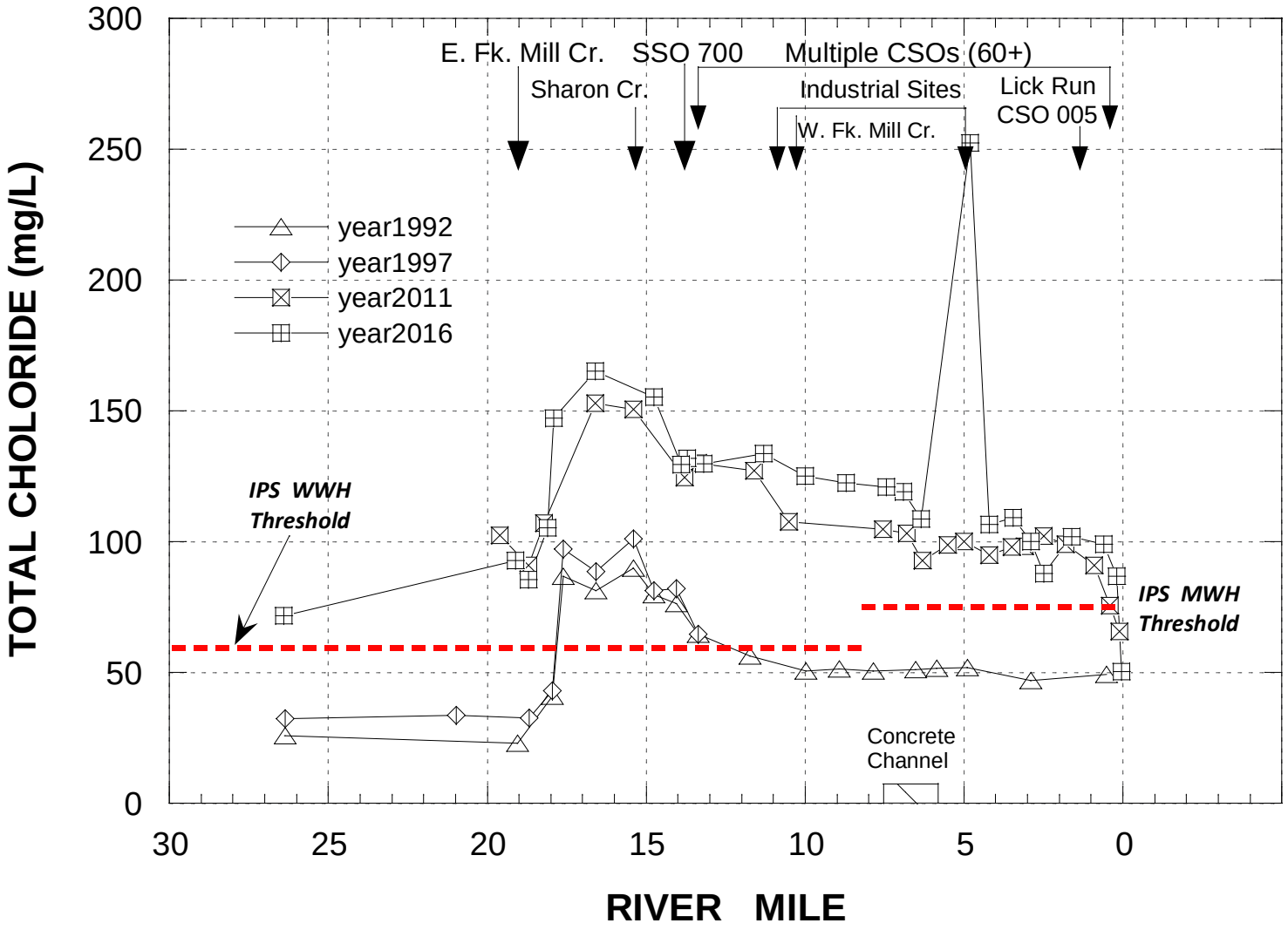

Figure 19. *Mean total chloride at Mill Creek mainstem sites in 1992, 1997, 2011, and 2016. The IPS biological effect thresholds for the WWH and MWH uses are shown as red dashed lines.*

Table 8. *Urban parameters in the 2016 Mill Creek study. Mean ambient values are color coded by their IPS ranges that correspond to tiered uses and narrative quality; blue – EWH (exceptional); green – WWH (good); yellow – MWH (fair); orange – LRW (poor); red – very poor quality. IPS threshold goals for each site are in the column to the right of each value.*

Site ID	River Mile	Year	Aquatic Life Use	Conductivity (µS/cm) Ambient	Conductivity (µS/cm) Goal	TDS (mg/L) Ambient	TDS (mg/L) Goal	Total Chloride (mg/L) Ambient	Total Chloride (mg/L) Goal	Total Sulfate (mg/L) Ambient	Total Sulfate (mg/L) Goal	Total Copper (µg/L) Ambient	Total Copper (µg/L) Goal	Total Lead (µg/L Ambient)	Total Lead (µg/L Ambient)/Goal	Total Zinc (µg/l) Ambient	Total Zinc (µg/l) Ambient/Goal
Mill Creek – WWH Reach																	
MC00	26.4	2016	WWH	707	**703**	478	**364**	72	**53**	72	**118.8**	1.7		5.2		6.2	
MC12	19.1	2016	WWH	691		427		93		41		4		5.2		15.1	
MC10	18.7	2016	WWH	1061		618		122		136		4.4		5.2		18.3	
MC08	18.1	2016	WWH	837		481		105		40		3.1		5.2		11.9	
MC101	17.9	2016	WWH	1307		766		147		210		4.8		5.2		28.8	
MC06	16.6	2016	WWH	1375		786		165		208		3.6		5.2		27	
MC04	14.75	2016	WWH	1300		740		155		187		3.6	**8.9**	5.2	**17.4**	22.5	**39.3**
MC11	13.9	2016	WWH	882	**660**	627	**384**	130	**59**	154	**120**	2.9		5.2		18.6	
MC104	13.7	2016	WWH	1168		649		132		160		5.0		5.2		15.1	
MC02	13.2	2016	WWH	928		626		130		144		3.7		5.2		18.1	
MC01	11.3	2016	WWH	1108		632		134		147		4.6		5.2		18.1	
MC80	10	2016	WWH	1047		581		125		135		4.5		5.2		16.7	
MC79	8.7	2016	WWH	1075		593		122		137		5		5.2		17.9	
MC77	7.45	2016	WWH	1064		597		121		132		3.7		5.2		14.5	
Mill Creek – MWH Reach																	
MC09	6.9	2016	MWH-C	1092		597		119		127		3.6		5.2		12.1	
MC07	6.35	2016	MWH-C	1003		572		109		110		3.5		5.2		9.6	
MC75	4.8	2016	MWH-C	969		530		252		103		4		5.2		21.8	
MC74	4.2	2016	MWH-C	1002		575		107		102		3.7		5.2		13.6	
MC73	3.45	2016	MWH-C	1000		565		109		104		4.6		5.2		16	
MC72	2.9	2016	MWH-C	850	**814**	506	**428**	100	**75**	92	**120**	3.3	**10.4**	5.2	**26.8**	13.7	**50.8**
MC05	2.5	2016	MWH-C	776		455		88		72		4.3		6.1		13.3	
MC03	1.6	2016	MWH-C	870		510		102		92		4.2		5.2		11.3	
MC71	0.6	2016	MWH-C	843		491		99		96		6.1		6.2		16.5	
MC70	0.2	2016	MWH-C	798		439		87		80		5.4		5.2		13.9	
MC69	0.05	2016	MWH-C	608		330		50		73		5.5		5.2		12.7	
West Branch Mill Creek																	
MC45	0.2	2016	WWH	500	**660**	261	**384**	47	**59**	21	**120**	5.2	**8.9**	6.3	**17.4**	10.3	**39.3**
East Fork Mill Creek																	
MC18	1.2	2016	WWH	841		503		91		42		2.2		5.2		4.1	
MC15	1.00	2016	WWH	1748	**660**	1023	**384**	184	**59**	299	**120**	2.8	**8.9**	5.2	**17.4**	35	**39.3**
MC14	0.5	2016	WWH	1653		1039		185		303		2.9		5.2		36.4	
MC16	0.01	2016	WWH	1655		1015		181		287		3		5.2		36.7	
Bloody Run																	
MC102	0.3	2016	MWH-C	501	**703**	279	**364**	40	**53**	42	**118.25**	8.7	**10.4**	5.2	**17.4**	25.9	**39.3**
MC103	0.2	2016	MWH-C	371		228		24		38		10.8		5.2		14.5	

Table 9. *Metals in sediments in the 2016 Mill Creek study area. Yellow shaded values exceed the TEL of MacDonald et al. (2000).*

Site ID	Basin code	Stream Code	RM	Arsenic (mg/kg)	Cadmium (mg/kg)	Calcium (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Magnesium (mg/kg)	Zinc (mg/kg)
Mill Creek Mainstem											
MC00	23	001	26.40	AA	AA	67000	7.9	11000	8.5	7600	26
MC12	23	001	19.10	AA	AA	23000	17	16000	13	6000	65
MC10	23	001	18.70	AA	AA	29000	13	14000	18	6400	52
MC08	23	001	18.10	AA	AA	60000	11	11000	10	14000	49
MC101	23	001	17.90	AA	AA	48000	6.5	7900	8.3	13000	35
MC06	23	001	16.60	AA	AA	13000	8.7	7500	8.6	4200	51
MC04	23	001	14.80	AA	AA	28000	7.9	6900	8.6	7400	38
MC11	23	001	13.90	AA	AA	45000	9.1	9100	26	11000	54
MC104	23	001	13.70	AA	AA	45000	AA	5500	5.0	10000	18
MC02	23	001	13.20	AA	AA	42000	6.6	7000	7.8	9500	31
MC01	23	001	11.30	AA	AA	55000	9.4	8000	9.9	14000	43
MC80	23	001	10.00	AA	AA	12000	8.6	6000	9.9	3800	45
MC79	23	001	8.70	AA	AA	87000	6.6	8600	7.7	15000	32
MC77	23	001	7.45	AA	AA	24000	20	10000	21	6200	89
MC09	23	001	6.90	5.1	AA	24000	11	6800	13	4900	41
MC07	23	001	6.35	AA	AA	33000	26	2700	16	2000	33
MC75	23	001	5.1	AA	AA	34000	30	8700	27	7400	58
MC74	23	001	4.25	AA	AA	29000	27	8200	23	6800	64
MC73	23	001	3.50	AA	AA	21000	21	6100	23	5200	46
MC72	23	001	3.1	AA	AA	22000	19	7100	15	4600	56
MC05	23	001	2.50	AA	AA	34000	26	8600	40	7400	61
MC03	23	001	1.7	AA	AA	93000	33	12000	61	21000	90
MC71	23	001	0.70	AA	AA	22000	24	7100	54	12000	84
MC70	23	001	0.30	AA	AA	56000	50	18000	79	13000	150
MC69	23	001	0.05	AA	AA	46000	68	14000	93	12000	120
West Fork Mill Creek											
MC45	23	004	0.20	AA	AA	50000	10	6400	19	11000	43
MC18	23	006	1.2	AA	AA	62000	11	14000	12	12000	37
MC15	23	006	1.00	AA	AA	47000	12	11000	11	8800	49
MC14	23	006	0.7	AA	AA	81000	8.5	8900	10	13000	36
MC16	23	006	0.10	AA	AA	130000	AA	8100	AA	33000	26
Bloody Run											
MC102	23	017	0.30	AA	AA	14000	49	7900	85	4400	100
MC103	23	017	0.20	AA	AA	55000	27	22000	56	11000	89

***Table 10**. PAH compounds in sediments in the 2016 Mill Creek study area. Yellow shaded values exceed the TEL and orange shaded values exceed the PEL of MacDonald et al. (2000).*

Site ID	Basin code	Stream Code	RM	1,4-Dichlorobenzene (mg/kg)	2-Chloronaphthalene (mg/kg)	Acenaphthene (mg/kg)	Acenaphthylene (mg/kg)	acetophenone (mg/kg)	Anthracene (mg/kg)	Benzo(a)anthracene (mg/kg)	Benzo(a)pyrene (mg/kg)	Benzo(b)fluoranthene (mg/kg)	Benzo(ghi)perylene (mg/kg)	Benzo(k)fluoranthene (mg/kg)	Chrysene (mg/kg)	Dibenzo(a,h)anthracene (mg/kg)	Fluoranthene (mg/kg)	Fluorene (mg/kg)	Indeno(1,2,3-cd)pyrene (mg/kg)	Naphthalene (mg/kg)	Phenanthrene (mg/kg)	Pyrene (mg/kg)
Mill Creek Mainstem																						
MC00	23	001	26.40	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
MC12	23	001	19.10	AA	AA	AA	AA	AA	AA	AA	AA	0.48	AA	AA	AA	AA	0.67	AA	0.22	AA	AA	0.52
MC10	23	001	18.70	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
MC08	23	001	18.10	AA	AA	AA	AA	AA	AA	2.50	2.40	3.70	1.60	1.40	3.30	AA	6.30	AA	1.70	AA	3.30	4.80
MC101	23	001	17.90	AA	AA	AA	AA	AA	AA	0.54	0.54	0.82	0.35	AA	0.74	AA	1.40	AA	0.39	AA	0.69	1.10
MC06	23	001	16.60	AA	AA	AA	AA	AA	AA	0.86	0.99	1.60	0.66	0.57	1.40	AA	2.40	AA	0.74	AA	0.94	1.90
MC04	23	001	14.80	AA	AA	AA	AA	AA	0.43	1.10	1.00	1.60	0.63	0.57	1.60	AA	2.80	AA	0.72	AA	0.97	2.20
MC11	23	001	13.90	AA	AA	AA	AA	AA	AA	0.39	0.40	0.65	AA	AA	0.55	AA	1.00	AA	0.29	AA	0.40	0.79
MC104	23	001	13.70	AA	AA	AA	AA	AA	AA	0.72	0.71	1.10	0.41	0.41	0.96	AA	1.50	AA	0.45	AA	0.60	1.20
MC02	23	001	13.20	AA	AA	AA	AA	AA	AA	1.10	1.10	1.70	0.70	0.64	1.50	AA	3.00	AA	0.78	AA	1.30	2.40
MC01	23	001	11.30	AA	AA	AA	AA	AA	AA	0.37	0.38	0.58	AA	AA	0.54	AA	1.10	AA	0.26	AA	0.44	0.82
MC80	23	001	10.00	AA	AA	AA	AA	AA	AA	0.58	0.71	1.20	0.46	0.44	1.00	AA	2.10	AA	0.50	AA	0.78	1.70
MC79	23	001	8.70	AA	AA	AA	AA	AA	AA	AA	0.34	0.52	AA	AA	0.42	AA	0.92	AA	0.24	AA	0.35	0.73
MC77	23	001	7.45	AA	AA	AA	AA	AA	AA	0.53	0.65	1.00	0.43	0.39	0.81	AA	1.60	AA	0.46	AA	0.62	1.30
MC09	23	001	6.90	AA	AA	AA	AA	AA	AA	AA	0.35	0.56	AA	AA	0.42	AA	0.84	AA	0.27	AA	AA	0.67
MC07	23	001	6.35	AA	AA	AA	AA	AA	AA	0.83	0.96	1.50	0.63	0.57	1.30	AA	2.60	AA	0.69	AA	1.10	2.10
MC75	23	001	5.1	AA	AA	AA	AA	AA	AA	0.94	1.00	1.50	0.60	0.60	1.30	AA	2.80	AA	0.67	AA	1.20	2.30
MC74	23	001	4.25	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	0.45	AA	AA	AA	AA	0.36
MC73	23	001	3.50	AA	AA	AA	AA	AA	AA	0.46	0.56	0.84	0.35	AA	0.63	AA	1.20	AA	0.37	AA	0.39	1.00
MC72	23	001	3.1	AA	AA	AA	AA	AA	AA	0.41	0.49	0.85	0.38	AA	0.69	AA	1.10	AA	0.41	AA	0.50	0.81
MC05	23	001	2.50	AA	AA	AA	AA	AA	AA	1.00	1.20	1.90	0.83	0.65	1.50	AA	2.90	AA	0.89	AA	1.10	2.20
MC03	23	001	1.7	AA	AA	AA	AA	AA	AA	1.30	1.30	2.00	0.90	0.72	1.70	AA	3.40	AA	1.00	AA	1.40	2.60
MC71	23	001	0.70	AA	AA	AA	AA	AA	AA	1.60	1.60	2.50	1.10	0.91	2.10	AA	4.10	AA	1.20	AA	1.60	3.20
MC70	23	001	0.30	AA	AA	AA	AA	AA	AA	1.40	1.30	1.90	0.89	0.73	1.70	AA	3.20	AA	0.99	AA	1.40	2.40
MC69	23	001	0.05	AA	AA	AA	AA	AA	AA	2.00	1.90	2.90	1.30	1.00	2.40	AA	4.60	AA	1.40	AA	1.80	3.50
West Fork Mill Creek																						
MC45	23	004	0.20	AA	AA	AA	AA	AA	AA	1.20	1.30	1.90	0.76	0.72	1.70	AA	3.20	AA	0.84	AA	1.50	2.40
East Fork Mill Creek																						
MC18	23	006	1.2	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
MC15	23	006	1.00	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
MC14	23	006	0.7	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
MC16	23	006	0.10	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Bloody Run																						
MC102	23	017	0.30	AA	AA	AA	0.48	AA	1.60	6.30	7.40	10.00	5.10	4.20	8.60	1.20	21.00	0.53	5.50	AA	9.60	17.00
MC103	23	017	0.20	AA	AA	AA	AA	AA	0.45	2.10	2.40	3.80	1.70	1.30	3.10	0.39	3.90	AA	1.90	AA	3.00	3.20

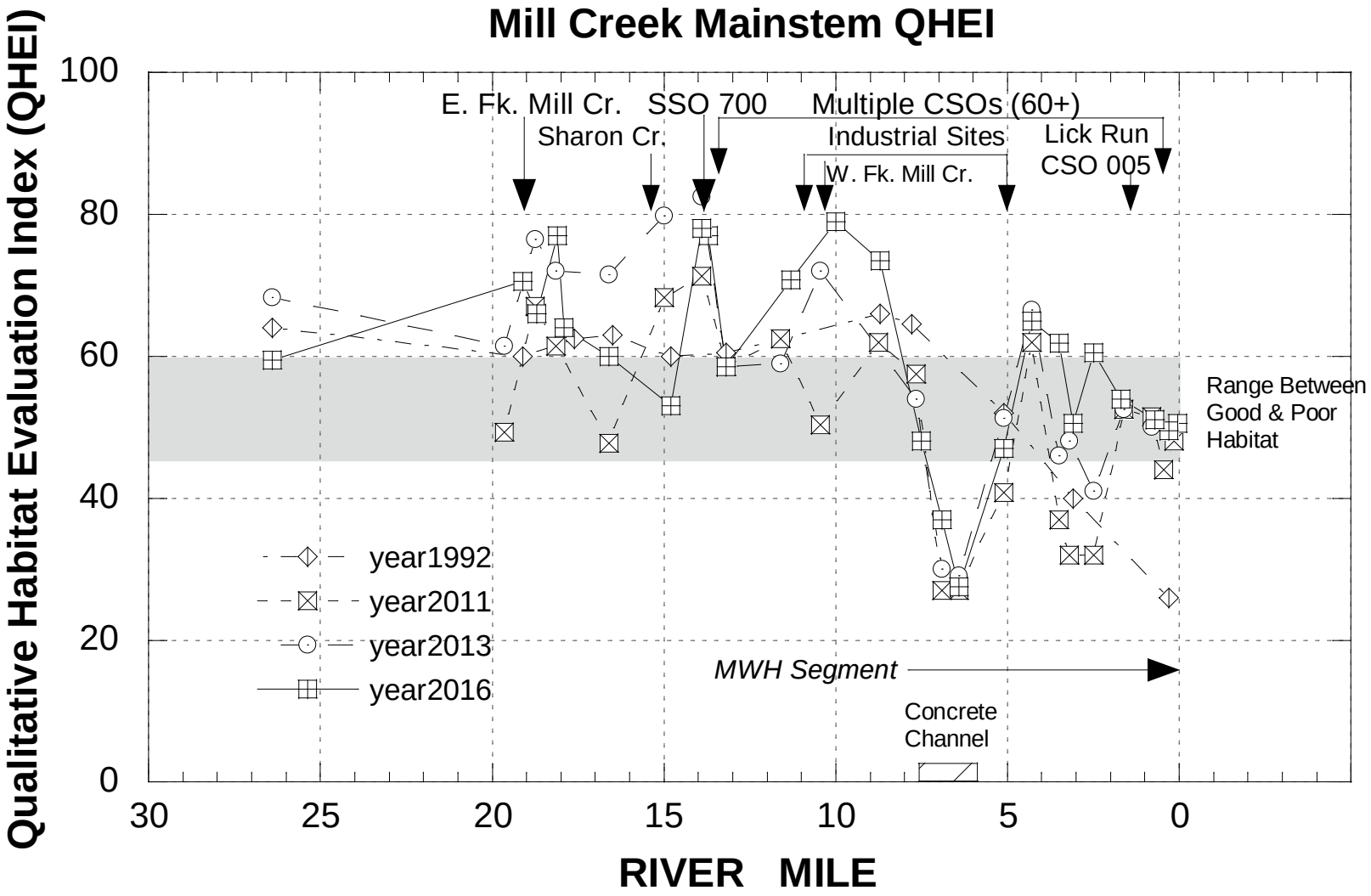

Figure 20. *QHEI values in the mainstem of Mill Creek in 1992, 2011, 2013, and 2016. The range between good and poor habitat is indicated by the shaded area.*

Table 11. *Qualitative Habitat Evaluation Index (QHEI) scores showing Good and Modified Habitat attributes at sites in the 2016 Mill Creek study.*

			Good Habitat Attributes												High Influence Modified Attr.						Moderate Influence Modified Attributes													Ratios	
Site ID	River Mile	QHEI	No Channelization	Boulder, Cobble, Gravel	Silt Free	Good-Excellent Development	Moderate-High Sinuosity	Moderate-Extensive Cover	Fast Flow w Eddies	Little to No Embeddedness	Max Depth >40 cm	No Riffle Embeddedness	Good Habitat Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse No Cover	Max Depths <40 cm	High Influence Poor Attributes	Recovering from Channelization	Mod-High Silt Cover	Sand Substrates (Boat sites)	Hardpan Origin	Fair- Poor Development	Low Sinuosity	≤2 Cover Types	Intermittent Flow or Pools <20 cm	No Fast Current Types	Mod-Extensive Embeddedness	Mod-Extensive Riffle Embeddedness	No Riffle	Total Modified Attributes	Modified (High) to Good	Modified (All) to Good
Mill Creek																																		
MC00	26.4	**59.5**		■		■		■	■		■	■	6						0	●	●				●				●			4	0	0.7
MC12	19.1	**70.5**		■		■		■	■		■	■	6						0	●	●				●				●	●		5	0	0.8
MC10	18.7	**66**					■	■	■		■		4						0	●	●			●					●	●		5	0	1.2
MC08	18.1	**77**	■	■		■	■	■	■		■	■	8						0		●								●			2	0	0.3
MC101	17.9	**64**		■				■	■		■	■	5	●		●			2		●			●					●			5	0.4	1.0
MC06	16.6	**60**						■		■	■		3						0	●				●	●			●		●		5	0	1.7
MC04	14.8	**53**						■			■		2			●			1	●	●			●				●	●		●	6	0.5	3.0
MC11	13.9	**78**		■		■	■	■	■	■	■	■	8						0	●										●		2	0	0.3
MC104	13.7	**77**		■		■		■	■	■	■	■	7						0	●	●				●				●			4	0	0.6
MC02	13.2	**58.5**		■				■		■	■		4	●		●			2		●			●				●	●		●	7	0.5	1.7
MC01	11.3	**70.8**		■		■		■	■		■	■	6			●			1	●	●								●			3	0.1	0.5
MC80	10.0	**79**		■		■		■	■	■	■	■	7						0	●					●							2	0	0.3
MC79	8.7	**73.5**		■		■		■	■		■	■	6						0	●	●				●				●			4	0	0.7
MC77	7.5	**48**		■					■	■		■	4	●		●	●	●	4					●		●						6	1.0	1.5
MC09	6.9	**37**		■					■	■		■	4	●			●	●	3					●	●	●						6	0.7	1.5
MC07	6.4	**27.5**							■			■	2	●			●	●	3		●			●	●	●			●			8	1.5	4.0
MC75	5.1	**47**						■			■		2	●	●	●	●		4		●			●				●	●		●	9	2.0	4.5
MC74	4.3	**65**		■		■		■	■		■		5						0	●	●			●	●				●	●		6	0	1.2
MC73	3.5	**61.8**		■		■		■	■		■		5			●	●		2	●	●			●	●				●	●		8	0.4	1.6
MC72	3.1	**50.5**		■							■		2	●		●	●		3		●			●		●		●	●	●		9	1.5	4.5
MC05	2.5	**60.5**						■	■		■	■	4	●		●			2		●			●		●						6	0.5	1.5
MC03	1.7	**54**						■			■		2				●		1	●	●			●	●			●	●	●		8	0.5	4.0
MC71	0.7	**51**						■			■		2	●		●			2		●			●				●	●		●	7	1.0	3.5
MC70	0.3	**49.5**						■			■		2	●		●			2		●			●				●	●		●	7	1.0	3.5
MC69	0.05	**50.5**	■					■			■		3				●		1		●			●	●			●	●		●	7	0.3	2.3
West Fork Mill Creek																																		
MC45	0.2	**68.5**		■		■		■	■	■	■	■	7						0	●	●				●							3	0	0.4
East Fork of Mill Creek																																		
MC18	1.2	**57**						■			■	■	3			●	●		2	●	●			●				●	●			7	0.7	2.3
MC15	1.0	**73**		■		■		■	■	■	■	■	7						0	●					●							2	0	0.3
MC14	0.7	**58.5**						■	■		■		3			●			1	●	●			●					●	●		6	0.3	2.0
MC17	0.4	**53.8**				■		■	■		■		4	●		●	●		3		●			●					●	●		7	0.8	1.7
MC16a	0.1	**65.5**	■	■		■	■	■			■	■	7						0		●							●	●			3	0.4	0.4
Bloody Run																																		
MC102	0.3	**44.5**		■			■			■			3				●	●	2	●				●				●		●		6	0.7	2.0
MC103	0.2	**40.5**		■			■	■			■	■	5				●		1	●	●			●				●	●			6	0.2	1.2

Table 12. *QHEI and Hydro QHEI scores and selected attributes in the 2016 Mill Creek study area. Selected values are color coded by their IPS ranges that correspond to tiered uses and narrative quality; blue – EWH (exceptional); green – WWH (good); yellow – MWH (fair); orange – LRW (poor); red – very poor quality. IPS threshold goals for each site are in the column to the right of each value.*

Site ID	River Mile	QHEI		Hydro-QHEI		QHEI Metrics								Gradient (ft./mi.)	
						Substrate		Channel		Riparian	Cover	Pool	Riffle	Value	Score
Mill Creek – WWH Reach															
MC00	26.4	59.5	**59.8**	9	**9.7**	14	**11.3**	13	**11.8**	5.5	12	7	4	50.1	4
MC12	19.1	70.5		14		16		12		4.5	15	9	4	16.7	10
MC10	18.7	66		17		13		10.5		3	16	11	2.5	16.4	10
MC08	18.1	77		20		14		14		8	13	10	8	15.4	10
MC101	17.9	64		19		14		8		4	15	9	6	14.8	8
MC06	16.6	60		9		15		8		4	16	8	1	12.8	8
MC04	14.8	53	**60.4**	8	**11.3**	9	**11.5**	7	**11.8**	4	15	8	0	10.2	10
MC11	13.9	78		22		16		15		3.5	15	12	6.5	9.2	10
MC104	13.7	77		22		15		14.5		3.5	15	12	7	9.0	10
MC02	13.2	58.5		10		15		5		3.5	16	9	0	8.5	10
MC01	11.3	70.75		22		15		11		4.8	13	12	7	7. 5	8
MC80	10	79		22		18		12		6	13	12	8	7.4	10
MC79	8.7	73.5		22		14		12		4	14	12	7.5	7.8	10
Mill Creek – MWH Reach															
MC77	7.5	48		8		17		7		3.5	4	2	4.5	7.3	10
MC09	6.9	37		5		8		7		3	2	4	3	7.4	10
MC07	6.4	27.5		5		-1.5		7		3	2	4	3	7.6	10
MC75	5.1	47		8		7		6		5	11	8	0	7.0	10
MC74	4.3	65		15		14		11		5.5	12	10	2.5	6.8	10
MC73	3.5	61.75	**31.6**	15	**1.0**	13	**No Minimum Score**	10.5	**3.6**	4.8	11	10	2.5	6.7	10
MC72	3.1	50.5		6		12		8		5.5	5	8	2	6. 9	10
MC05	2.5	60.5		19		11		8		4.5	10	9	8	6.8	10
MC03	1.7	54		11		9		8		5	12	9	1	6.4	10
MC71	0.7	51		8		9		6		5	15	6	0	6.5	10
MC70	0.3	49.5		8		11		5		3.5	14	6	0	6.4	10
MC69	0.05	50.5		8		11		10		3.5	10	6	0	6.4	10
West Fork Mill Creek - WWH															
MC45	0.2	68.5	**60.4**	13	**11.3**	15	**11.5**	13	**11.8**	3	14	9	6.5	19.2	8
East Fork Mill Creek - WWH															
MC18	1.2	57		11		13		9		6	11	10	4	50.7	4
MC15	1.0	73		20		16		14		5	16	11	7	49.5	4
MC14	0.7	58.5	**60.4**	22	**11.3**	11	**11.5**	8	**11.8**	4	14	12	5.5	47.6	4
MC17	0.4	53.75		20		11		8		2.3	12	11	5.5	46.1	4
MC16a	0.1	65.5		12		14		15		6.5	12	9	5	45.2	4
Bloody Run – MWH Existing															
MC102	0.3	44.5	**59.4**	1	**1.0**	15.5	**No Min.**	12	**3.6**	4	6	2	1	47.7	4
MC103	0.2	40.5		3		5.5		12		4	8	4	3	47.7	4

design criteria for habitat restoration where the QHEI and/or selected metrics are below the thresholds needed to meet the applicable aquatic life use. In the WWH reach of the Mill Creek the deficiencies included the Hydro QHEI at 4 sites, substrate at one site, and channel condition at 6 sites. In the MWH reach deficiencies were judged against the MWH use which is inherently modified thus only one site in the concrete channel (RM 6.4; MC07) revealed any deficiencies below MWH goals. The East Fork revealed deficiencies below the WWH IPS thresholds for Hydro QHEI (1 site), substrate (2 sites), and channel condition (3 sites). Bloody Run showed a single deficiency below the MWH IPS thresholds for the Hydro QHEI at one site, which is related to its highly urbanized watershed.

Biological Assemblages

Fish were sampled at 33 sites and macroinvertebrates at 29 sites in 2016 following standardized procedures specified by the 2011 Plan (MBI 2011) and consistent with Level 3 specifications and the Ohio WQS.

Fish Assemblage Results

Key fish assemblage results are depicted in Table 12. Excepting Bloody Run, which had no fish collected, overall narrative fish assemblage condition ranged from very poor to good. Of the 33 sites with fish assemblage data 13 failed to attain the WWH IBI biocriteria threshold and another 7 failed MWH which is 61% of all sites down from 75% in 2011. The composition of the fish assemblage was compared between 2001 and 2016 and for the WWH and MWH reaches (Tables 13 and 14). In the WWH reach white sucker, northern hog sucker, and orangethroat darter increased in numbers from 2011 to 2016. Nine species not collected in 2011 were collected in 2016 and included smallmouth bass for the first time. Other notable new species were rainbow darter, golden redhorse, logperch, and greenside darter. Four species collected in 2011 were not collected in 2016, but each was in low numbers in 2011. Tolerant species such as green sunfish and bluntnose minnow were reduced in abundance while intermediate and sensitive species increased in numbers between 2011 and 2016. In the MWH reach species with significant increases in 2016 included channel catfish (9.8 vs. 75.2), northern hog sucker, and white sucker. There were nine new species in 2016 and four species collected in 2011 were absent in 2016. The 2016 assemblage included several large river species which presumably entered Mill Creek via the Ohio River as water quality conditions have improved.

Prior to the urban development in the Mill Creek watershed the fish fauna also included the highly intolerant bigeye chub, rosyface shiner, brook silverside, and sand darter and one record of alligator gar at the mouth of Mill Creek (Trautman 1981). Species of intermediate tolerance (e.g., striped shiner, silverjaw minnow, sand shiner, and orangethroat darter) have now been documented in Mill Creek as the heavily polluted conditions of the 1980s and 1990s have been abated. Sensitive fish species still occur in low numbers and restoring the assemblage to WWH expectations will require dealing with non-pollutant stressors such as habitat.

Macroinvertebrate Assemblage Results

Excepting the very poor results in Bloody Run, macroinvertebrate assemblages in the Mill Creek study area ranged from fair to exceptional quality which is a significant improvement over the 2011 results.

***Table 13**. Selected fish and macroinvertebrate assemblage attributes for sites sampled in the 2016 Mill Creek study area. Biological index scores are shaded by their narrative quality rating: blue - exceptional (EWH); green – good (WWH); yellow – fair (MWH); orange – poor (LRW); red - very poor. VG – very good; G – good; MG – marginally good; MF – marginally fair; VP – very poor.*

				Fish Assemblage (mean or cumulative for 2 passes)									**Macroinvertebrate Assemblage**				**Aquatic**
Site ID	**River Mile**	**Drainage Area mi.²**	**QHEI**	**Mean # Fish Species**	**#Sensitive Fish Sp.**	**% Sens. Fish Sp.**	**Intolerant Sp.**	**% Tol. Fish**	**Rel. No.**	**DELT Anom.**	**MIwb**	**IBI**	**ICI**	**Narr. Rating**	**Qual. EPT**	**#Sensitive Taxa**	**Life Use**
Mill Creek – WWH Reach																	
MC00	26.40	4.4	59.5	13	1	0.4	0	48.9	608	1.2	na	41	52		12	9	WWH
MC12	19.10	26.7	70.5	17	3	8.6	0	46.2	234.5	1.4	7.7	35	44		6	3	WWH
MC10	18.70	27.0	66.0	12.5	2	1.4	0	56.4	242.5	0.2	7.5	33	46		8	4	WWH
MC08	18.10	32.4	77.0	12	2	2.5	0	60.5	241.5	0.5	7.6	35	38		7	3	WWH
MC101	17.90	42.2	64.0	15	2	8.3	0	50.0	256	1.5	7.4	36	38		6	3	WWH
MC06	16.60	50.5	60.0	8	1	1.7	0	86.3	74	2.6	5.4	27	38		8	3	WWH
MC04	14.80	61.3	53.0	7.5	0	0	0	86.3	59	3.6	4.8	25	38		8	6	WWH
MC11	13.90	68.8	78.0	15.5	3	12.3	0	22.8	445	1.5	7.6	35	-	VG	9	4	WWH
MC104	13.70	71.6	77.0	13.5	2	11.9	0	15.3	404	1.3	6.8	29	38		9	6	WWH
MC02	13.20	72.3	58.5	11	1	10.4	0	80.5	67	3.3	5.9	27	42		7	6	WWH
MC01	11.30	73.9	70.8	20	6	24.4	0	38.6	152.5	2.6	7.0	36	-	VG	8	2	WWH
MC80	10.00	115	79.0	8	4	39.7	0	20.5	62	5.0	5.6	31	40		8	5	WWH
MC79	8.70	120	73.5	16	5	48.4	0	25.4	218	1.0	8.1	38	44		7	5	WWH
MC77	7.50	126	48.0	14.5	5	17.4	0	52.7	232.5	0.6	6.4	29	-	G	9	2	WWH
Mill Creek – MWH Reach																	
MC09	6.90	128	37.0	8	2	6.8	0	21.7	95	1.0	5.0	22	-	MF	4	3	MWH
MC07	6.40	135	27.5	6.5	3	21.2	0	40.0	74.5	0	4.9	21	24		6	3	MWH
MC75	5.10	139	47.0	9.5	2	15.6	0	63.5	79.5	6.8	5.5	30	34		10	4	MWH
MC74	4.30	141	65.0	17.5	6	5.7	0	36.9	302	0	7.7	37	-	MG	7	2	MWH
MC73	3.50	144	61.8	15.5	6	9.1	1	2.6	538.5	0.4	6.3	34	-	MG	7	3	MWH
MC72	3.10	154	50.5	16.5	6	7.3	1	2.5	472	0	6.3	35	26		7	3	MWH
MC05	2.50	154	60.5	14.5	6	4.5	1	4.4	942	0.3	7.6	32	28		8	4	MWH
MC03	1.70	163	54.0	11.5	3	1.2	1	4.7	244	1.9	8.0	25	24		5	4	MWH
MC71	0.70	164	51.0	8	1	1.0	0	7.2	195	2.1	7.6	23	Not Sampled – Ohio R. Backwater				MWH
MC70	0.30	164	49.5	13	4	10.3	1	6.8	149	3.6	8.1	27					MWH
MC69	0.05	164	50.5	10.5	3	12.5	2	15.6	85.5	6.5	7.0	27					MWH
E. Fork Mill Creek																	
MC18	1.20	9.3	57.0	9	1	0.7	0	47.4	78	1.0	na	31	42		8	7	WWH
MC15	1.00	9.3	73.0	11.5	1	1.3	0	46.7	369	0.4	na	33	34		6	3	WWH
MC14	0.70	9.5	58.5	9.5	1	12.1	0	61.2	80	1.9	na	28	40		7	3	WWH
MC16	0.40	9.6	53.8	9	1	10.2	0	68.2	148	1.1	na	36	No sample				WWH
MC16A	0.10	9.6	65.5	9	1	5.1	0	84.0	114	5.1	na	22	48		11	6	WWH
W. Fork Mill Creek																	
MC45	0.20	36.5	68.5	10.5	2	22.3	0	58.7	259	0/0	7.1	25	48		9		WWH
Bloody Run																	
MC102	0.30	3.9	44.5	0	0	0	0	0	0	0	na	12	-	VP	0	0	MWH
MC103	0.20	3.9	40.5	0	0	0	0	0	0	0	na	12	-	VP	0	1	MWH

***Table 14**. Fish species (excluding hybrids) collected in the WWH reach of the Mill Creek mainstem in 2016 showing catch-per-unit-effort (CPUE) and percent by numbers compared to 2011.*

Species (rank in 2011)	**2016**		**2011**	
	CPUE	**%numbers**	**CPUE**	**%numbers**
1. Central stoneroller (2)	75.9	21.3%	53.4	13.03%
2. Green sunfish (1)	44.5	12.5%	168.2	41.03%
3. White sucker (10)	40.9	11.47%	4.0	0.98%
4. Bluegill (3)	37.4	10.47%	47.8	11.67%
5. Spotfin shiner (4)	24.2	6.80%	38.2	9.33%
6. Northern hog sucker (19)	22.0	6.18%	1.5	0.37%
7. Bluntnose minnow (5)	18.7	5.24%	30.8	7.51%
8. Gizzard shad (11)	13.8	3.87%	3.5	0.86%
9. Largemouth bass (8)	12.2	3.43%	7.6	1.85%
10. Orangethroat darter (18)	12.0	3.37%	1.9	0.47%
11. Sand shiner (15)	11.3	3.17%	2.9	0.70%
12. Johnny darter (12)	7.0	1.97%	3.5	0.86%
13. Common carp (7)	6.4	1.81%	9.8	2.40%
14. Yellow bullhead (6)	5.9	1.66%	12.0	2.93%
15. Pumpkinseed sunfish (13)	4.1	1.15%	3.3	0.80%
16. Creek chub (9)	3.3	0.91%	5.0	1.23%
17. Striped shiner (14)	3.2	0.89%	3.1	0.76%
18. Black bullhead (29)	2.5	0.70%	0.1	0.02%
19. Longear sunfish (16)	1.6	0.46%	2.6	0.64%
20. Spotted bass (21)	1.6	0.44%	1.2	0.29%
21. Smallmouth bass (none)	1.4	0.39%	-	-
22. Channel catfish (20)	1.2	0.34%	1.4	0.35%
23. Rainbow darter (none)	1.0	0.28%	-	-
24. Fantail darter (17)	0.7	0.20%	2.2	0.55%
25. Black crappie (38)	0.5	0.15%	-	-
26. Golden redhorse (28)	0.4	0.10%	-	-
27. Goldfish (26)	0.3	0.08%	0.2	0.04%
28. Logperch (none)	0.2	0.07%	-	-
29. Blacknose dace (22)	0.2	0.05%	0.6	0.14%
30. Flathead catfish (30)	0.2	0.05%	0.1	0.02%
31. Greenside darter (none)	0.2	0.05%	-	-
32. Quillback carpsucker (none)	0.1	0.03%	-	-
33. Emerald shiner (27)	0.1	0.03%	0.2	0.04%
34. Suckermouth minnow (none)	0.1	0.02%	-	-
35. Sauger (none)	0.1	0.02%	-	-
2011 species not collected: Silverjaw minnow, Orangespotted sunfish, White crappie, Western mosquitofish				

***Table 15**. Fish species (excluding hybrids) collected in the MWH reach of the Mill Creek mainstem in 2016 showing catch-per-unit-effort (CPUE) and percent by numbers compared to 2011.*

Species (rank in 2011)	**2016**		**2011**	
	CPUE	**%numbers**	**CPUE**	**%numbers**
1. Emerald Shiner (1)	282.8	42.57%	109.8	34.85%
2. Gizzard Shad (2)	91.4	13.76%	44.9	14.24%
3. Channel Catfish (6)	75.2	11.32%	9.8	3.11%
4. Bluegill Sunfish (5)	23.4	3.52%	28.0	8.89%
5. Central Stoneroller (15)	6.1	3.05%	1.9	0.61%
6. River Carpsucker (13)	15.0	2.25%	10.0	0.95%
7. White Sucker (23)	4.4	2.21%	0.5	0.15%
8. Spotfin Shiner (4)	4.3	2.14%	29.3	9.30%
9. Common Carp (9)	12.3	1.85%	5.1	1.61%
10. Largemouth Bass (12)	12.3	1.85%	3.3	1.03%
11. Northern Hog Sucker (26)	3.6	1.78%	0.3	0.08%
12. Channel Shiner (none)	11.1	1.67%	-	-
13. Longear Sunfish (8)	3.0	1.48%	8.3	2.64%
14. Freshwater Drum (16)	2.9	1.43%	1.7	0.54%
15. Green Sunfish (3)	9.2	1.39%	35.2	11.16%
16. Sand Shiner (7)	2.4	1.17%	9.0	2.85%
17. Smallmouth Buffalo (19)	6.6	0.99%	3.5	0.34%
18. Bluntnose Minnow (10)	2.0	0.99%	5.0	1.59%
19. Quillback Carpsucker (25)	4.7	0.70%	1.0	0.10%
20. Spotted Bass (17)	3.3	0.49%	1.7	0.53%
21. Smallmouth Redhorse (none)	0.9	0.42%	-	-
22. Pumpkinseed Sunfish (11)	0.9	0.42%	4.2	1.34%
23. White Crappie (18)	1.9	0.28%	5.0	0.47%
24. White Bass (27)	1.7	0.26%	0.7	0.07%
25. Flathead Catfish (30)	0.4	0.21%	0.3	0.03%
26. Longnose Gar (35)	1.3	0.19%	0.0	0.01%
27. Black Crappie (37)	1.3	0.19%	0.2	0.01%
28. Golden Redhorse (29)	0.9	0.14%	0.6	0.06%
29. Smallmouth Bass (31)	0.3	0.14%	0.3	0.03%
30. Yellow Bullhead (14)	0.2	0.12%	2.8	0.88%
31. Sauger (none)	0.8	0.12%	-	-
32. Creek Chub (21)	0.2	0.09%	0.8	0.27%
33. Logperch (none)	0.6	0.09%	-	-
34. Johnny Darter (34)	0.2	0.09%	0.1	0.03%
35. Striped Bass (none)	0.3	0.05%	-	-
Goldfish, Warmouth, Orangespotted Sunfish, Striped Shiner	1.9	0.44%	1.4	0.17%
Black Redhorse, River Shiner, Rainbow Darter, Silver Chub	-	-	0.6	0.08%
2011 species not collected: Skipjack herring.				

The ICI criterion of 30 was met or surpassed at 24 of the 29 sites (83%) sampled in 2016 and included meeting the WWH criterion at all sites in the WWH reach (Table 12). Qualitative EPT taxa ranged from 6-12 in the WWH reach and 4-10 in the MWH reach. Sensitive taxa were present at all sites except one site in Bloody Run mostly ranging from 2-6 taxa in the WWH reach with 9 taxa at the upstream most site (RM 26.4; MC00) and at the mouth of the West Fork. There were 2-4 sensitive taxa in the MWH reach. The East Fork had 6-11 Qualitative EPT taxa and 3-7 sensitive taxa. Bloody Run had no qualitative EPT taxa and only one sensitive taxa, a reflection of the heavily polluted conditions described in the water quality results. These results represent an overall improvement over the 2011 results.

Comparing 2016 to Prior Results

The prior sampling conducted by Ohio EPA in 1992 (Ohio EPA 1994) and MSD/MBI in 2011 (MBI 2012) and 2013 offers an opportunity to examine changes through time for the mainstem of Mill Creek and the East Fork. Results for the IBI, MIwb, and %DELT anomalies were used to assess any changes in the fish assemblages and the ICI were used to assess changes in the macroinvertebrate assemblage. Such analyses offer the opportunity to determine not only the magnitude of any changes, but to determine the incremental changes that have taken place through time. It also provides a way to visualize the degree to which the biocriteria indices either exceed or fail to attain their respective biological criteria.

The overall results show that increases in the quality of both the fish and macroinvertebrate assemblages have taken place along the length of the commonly assessed reaches of the mainstem over a distance of approximately 26 miles (Figure 19 upper). The increases in the IBI between 1992 and 2011 were insufficient to attain the WWH biocriterion, but the narrative quality improved form consistently poor in 1992 to mostly fair in 2011. The IBI improved further in 2016 showing incremental increases below the WWH biocriterion (Figure 19 upper). The increases observed in the MWH segment were sufficient to attain and exceed the IBI MWH biocriterion in 2011 and 2016. The results in 2013 and from on Ohio EPA survey of the upper mainstem in 2014 were included in Figure 19 (lower) to illustrate the consistency with the 2011 and 2016 results. The 2014 IBI at the upstream most site was in the very good range and was comparable to the 2016 result in terms of WWH attainment.

The MIwb showed comparatively little change between 1992 and 2011 in the WWH designated reach, but increased in 2016 attaining the WWH biocriterion at four sites in the WWH reach and five sites in the MWH reach (Figure 20 upper). This is not necessarily a contradiction of the IBI results, but rather shows the usual recovery process where fish abundance and biomass can increase across tolerant and moderately tolerant species in the initial stages of recovery, whereas the IBI needs to have compositional changes among intermediate and sensitive species in order to attain WWH. The MIwb continued to show a marked increase from 1992 in the MWH designated reach which suggests a lessening of legacy toxic impacts. DELT anomalies markedly declined between 1992 and 2011 suggesting diminished legacy toxic impacts, but remained elevated above normal levels (Figure 20 lower). While the 2016 results were slightly lower than 2011, rates were above the range of normal to elevated incidence at eight sites in 2016. However, the 2016 results were well within that expected for an urbanized watershed

with the level of impacts that remain in Mill Creek. This will be a key indicator of lingering stress going forward.

The macroinvertebrate ICI showed the most marked improvement among the biological assemblage results in 2016 attaining the WWH biocriterion in the entirety of the WWH and MWH reaches (Figure 21). In 2011 the ICI declined to non-attainment in the Ohio R. backwater affected section of the mainstem and this segment was not sampled in 2016 given the difficulties of interpreting ICI results.

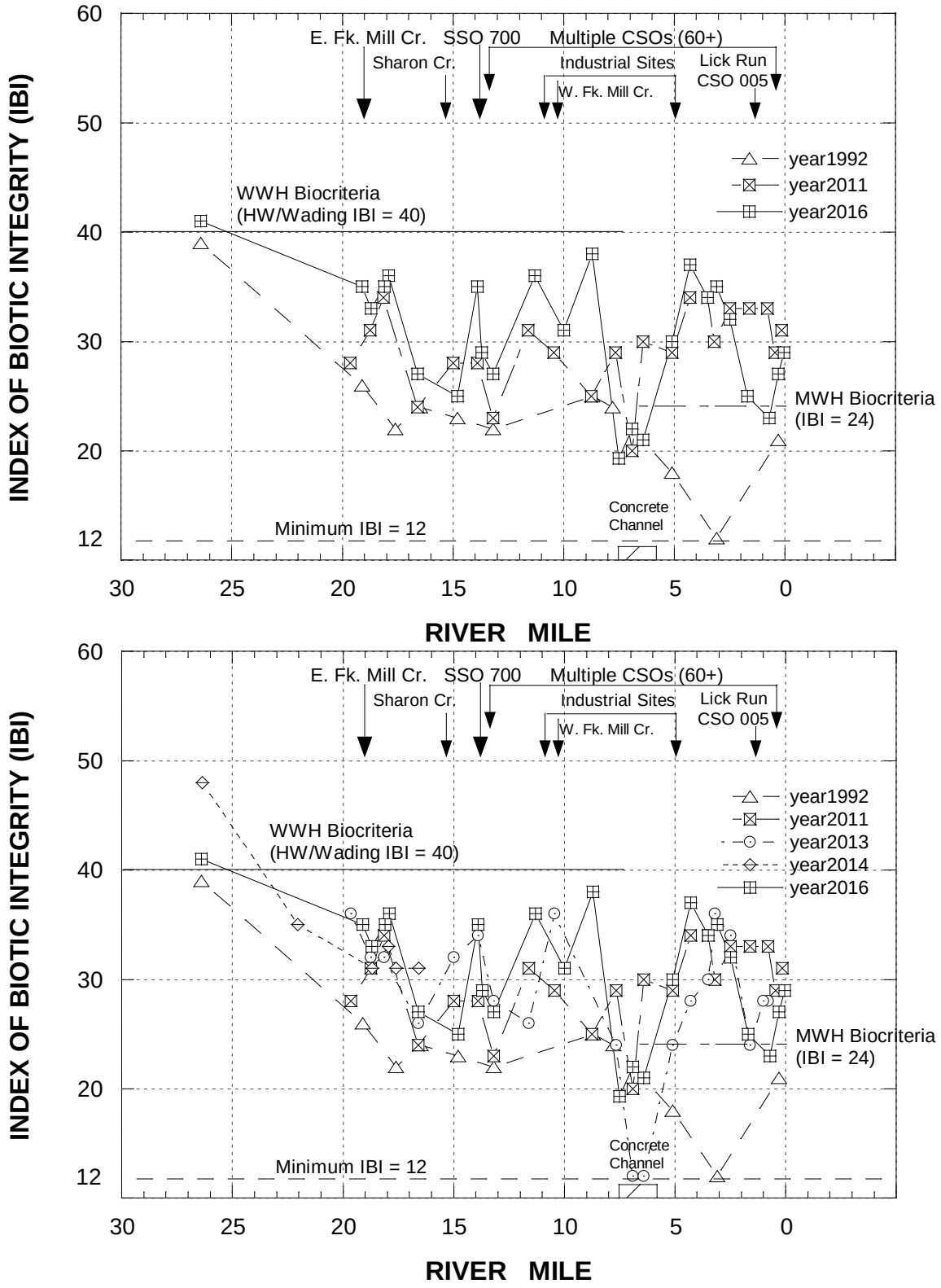

Figure 21. *Index of biotic integrity (IBI) results for the Mill Creek mainstem in 1992, 2011, and 2016 (upper) and adding 2013 and 2014 (Ohio EPA) results (lower). WWH and MWH IBI biocriteria are depicted with major pollution sources and tributaries along the top of each graph.*

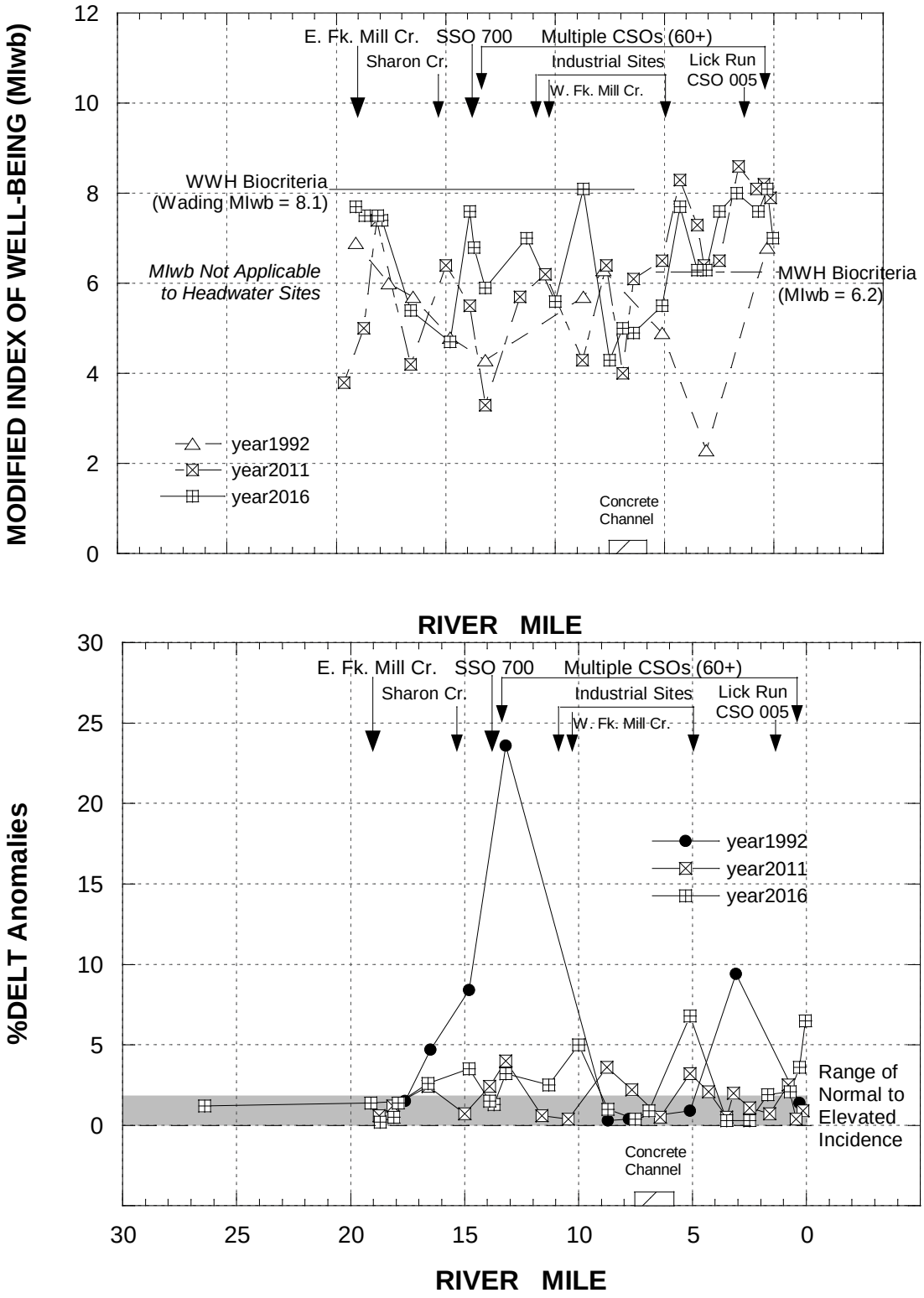

Figure 22. *Modified Index of Well-Being (MIwb) and percentage of fish with DELT anomalies in the mainstem of Mill Creek during 1992, 2011, and 2016. MIwb WWH and MWH biocriteria and the range of %DELT from normal to elevated incidence are depicted with major pollution sources and tributaries along the top of each graph.*

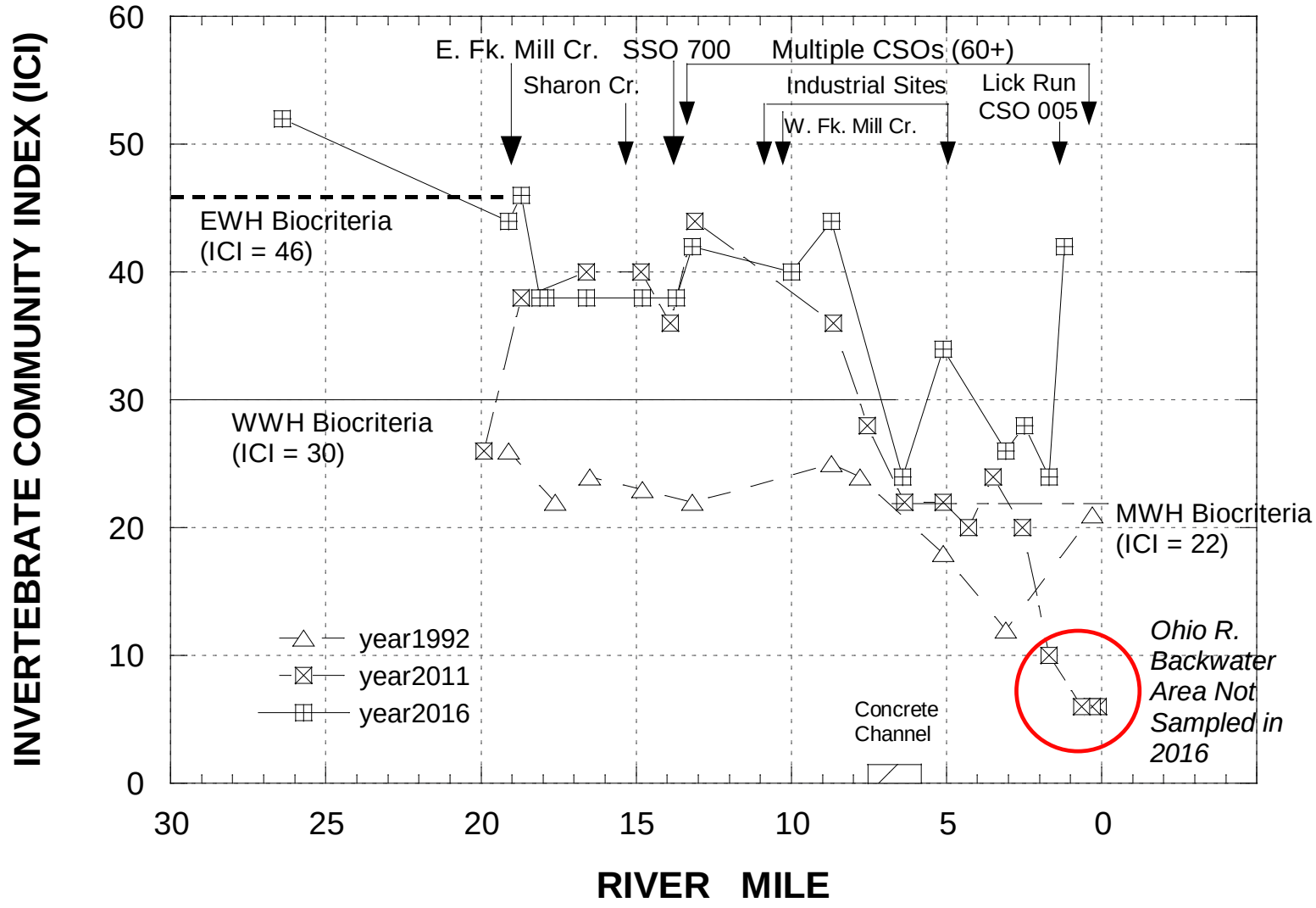

Figure 23. *Invertebrate Community Index (ICI) results for the Mill Creek mainstem in 1992, 2011, and 2016. WWH and MWH ICI biocriteria are depicted with major pollution sources and tributaries along the top.*

REFERENCES

DeShon, J. D. 1995. Development and application of the invertebrate community index (ICI), pages 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Dufour, A.P. 1977. *Escherichia coli*: The fecal coliform. American Society for Testing and Materials Spec. Publ. 635: 45-58.

Gammon, J. R., A. Spacie, A., J. L. Hamelink, and R. L. Kaesler. 1981. Role of electrofishing in assessing environmental quality of the Wabash River, in Ecological assessments of effluent impacts on communities of indigenous aquatic organisms, in Bates, J. M. and Weber, C. I., Eds., ASTM STP 730, 307 pp.

Gammon, J. R. 1973. The effect of thermal inputs on the populations of fish and macroinvertebrates in the Wabash River. Purdue University Water Resources Research Center Technical Report 32. 106 pp.

Karr, J.R. and C.O. Yoder. 2004. Biological assessment and criteria improve TMDL planning and decision-making. Journal of Environmental Engineering 130(6): 594-604.

Karr, J. R. 1991**.** Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1(1): 66-84.

Karr, J. R., K. D. Fausch, P. L. Angermier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5: 28 pp.

MacDonald, R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 2000. Development and evaluation of sediment guidelines for Florida coastal waters. Ecotoxicology 5: 253-278.

Metropolitan Sewer District of Greater Cincinnati (MSDGC). 2011a. Lower Mill Creek fact sheet: Project Groundwork. MSDGC, Cincinnati, OH. 3 pp. www.msdgc.org.

Metropolitan Sewer District of Greater Cincinnati (MSDGC). 2011b. 2010 Sustainability Report: Redefining the Future. MSDGC, Cincinnati, OH. 51 pp. www.msdgc.org.

Metropolitan Sewer District of Greater Cincinnati (MSDGC). 2011c. Metropolitan Sewer District Of Greater Cincinnati, Division of Industrial Waste Laboratory Section Chemistry Quality Assurance Program For Chemical Analysis. SOP 001 (10/01/01) Revision No. 2 (06/01/11).

Midwest Biodiversity Institute (MBI). 2015. Integrated Prioritization System (IPS) Documentation and Atlas of Biological Stressor Relationships for Southwest Ohio.

Technical Report MBI/2015-12-15. MSD Project Number 10180900. Columbus, OH 43221-0561. 32 pp. + appendices. http://www.msdgc.org/initiatives/water_quality/index.html.

Midwest Biodiversity Institute (MBI). 2012. 2011 Biological and Water Quality Study of Mill Creek and Tributaries Hamilton County, Ohio. Technical Report MBI/2012-6-10. MSD Project Number 10180900. Columbus, OH. 117 pp. + appendices. http://www.msdgc.org/initiatives/water_quality/index.html.

Midwest Biodiversity Institute (MBI). 2011. Watershed Monitoring and Bioassessment Plan for the MSD Greater Cincinnati Service Area, Hamilton County, Ohio. Technical Report MBI/2011-6-3. Columbus, OH. 30 pp. + appendices. http://www.msdgc.org/initiatives/water_quality/index.html.

Ohio Department of Natural Resources. 1960. Gazetteer of Ohio Streams. Division of Water, Columbus, Ohio. Ohio Water Plan Inventory Rept. No. 12. 179 pp.

Ohio Environmental Protection Agency. 2016. Biological and Water Quality Study of the Southwest Ohio Tributaries 2014. Butler, Hamilton, Brown, and Clermont Counties, Ohio. Ohio EPA Technical Report EAS/2016-06-01. Division of Surface Water, Columbus, Ohio. 119 pp.

Ohio Environmental Protection Agency. 2015a. Biological criteria for the protection of aquatic life (revised June 26, 2015). Volume III: Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Tech. Rept. EAS/2015-06-01. Division of Surface Water, Ecological Assessment Section, Columbus, Ohio. 66 pp.

Ohio Environmental Protection Agency. 2015b. Surface Water Field Sampling Manual for water quality parameters and flows. Final Manual July 31, 2015. Version 5.0. Division of Surface Water, Columbus, Ohio. 45 pp.

Ohio Environmental Protection Agency. 2015c. Surface Water Field Sampling Manual - Appendix III sediment sampling. Final Manual July 31, 2015. Version 5.0. Division of Surface Water, Columbus, Ohio. 52 pp.

Ohio Environmental Protection Agency. 2015d. Proposed Stream Nutrient Assessment Procedure. Ohio EPA Nutrients Technical Advisory Group – Assessment Procedure Subgroup. Division of Surface Water, Columbus, OH. 17 pp. http://epa.ohio.gov/dsw/wqs/NutrientReduction/NutrientTAG.aspx.

Ohio Environmental Protection Agency (Ohio EPA) 2012. Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams Version 3.0. Division of Surface Water, Columbus, Ohio. 117pp.

Ohio Environmental Protection Agency. 2006. Methods for assessing habitat in flowing waters: using the qualitative habitat evaluation index (QHEI). Division of Surface Water, Ecological Assessment Section, Columbus, OH. 23 pp.

Ohio EPA. 1999. Association between nutrients, habitat, and the aquatic biota in Ohio Rivers and streams. Ohio EPA Technical Bulletin MAS/1999-1-1. Jan. 7, 1999.

Ohio Environmental Protection Agency. 1994. Biological and water quality study of Mill Creek. Ohio EPA Tech. Rept. SWS/1993-12-9. Division of Surface Water, Water Quality and Ecological Assessment Sections, Columbus, Ohio. 86 pp.

Ohio Environmental Protection Agency. 1989a. Biological criteria for the protection of aquatic life. volume III: standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities, Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to biological criteria for the protection of aquatic life. volume II: users manual for biological field assessment of Ohio surface waters, Division of Water Quality Planning and Assessment, Surface Water Section, Columbus, Ohio.

Ohio EPA. 1987a. Biological criteria for the protection of aquatic life. Volume I. The role of biological data in water quality assessments. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Ohio EPA. 1987b. Biological criteria for the protection of aquatic life. Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77(1): 118-125.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pages 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E.T. 1989. The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application. Ohio EPA, Division of Water Quality Planning and Assessment, Ecological Analysis Section, Columbus, Ohio.

Trautman, M. B. 1981. The fishes of Ohio. The Ohio State Univ. Press, Columbus, OH. 782 pp.

U.S. Environmental Protection Agency. 1995a. Environmental indicators of water quality in the United States. EPA 841-R-96-002. Office of Water, Washington, DC 20460. 25 pp.

U.S. Environmental Protection Agency. 1995b. A conceptual framework to support development and use of environmental information in decision-making. EPA 239-R-95-012. Office of Policy, Planning, and Evaluation, Washington, DC 20460. 43 pp.

Woods, A., J.M. Omernik, C.S. Brockman, T.D. Gerber, W.D. Hosteter, and S.H. Azevedo. 1995. Ecoregions of Ohio and Indiana. U.S. EPA, Corvallis, OR. 2 pp.

Yoder, C.O. and E.T. Rankin. 2008. Evaluating options for documenting incremental improvement of impaired waters under the TMDL program. MBI Technical Report MBI/2008-11-1. EPA Contract No. 68-C-04-006, Work Assignment 4-68. U.S. EPA, Office of Wetlands, Oceans, and Watersheds, Washington, D.C. 44 pp. + appendices.

Yoder, C.O. and 9 others. 2005. Changes in fish assemblage status in Ohio's non-wadeable rivers and streams over two decades, pp. 399-429. *in* R. Hughes and J. Rinne (eds.). Historical changes in fish assemblages of large rivers in the America's. American Fisheries Society Symposium Series.

Yoder, C. O., and DeShon, J. E. 2003. Using biological response signatures within a framework of multiple indicators to assess and diagnose causes and sources of impairments to aquatic assemblages in selected Ohio rivers and streams. Biological response signatures: indicator patterns using aquatic communities, T. P. Simon, ed., CRC Press, Boca Raton, FL., 23–81.

Yoder, C. O. and M. A Smith. 1999. Using fish assemblages in a state biological assessment and criteria program: essential concepts and considerations, pages 17-56. *in* T.P. Simon (ed.), Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1998. The role of biological indicators in a state water quality management process. J. Env. Mon. Assess. 51(1-2): 61-88.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pages 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1991. The integrated biosurvey as an approach for the evaluation of aquatic life use attainment and diagnosis of impairment for Ohio surface waters. Biocriteria Symposium on Research and Regulation, U.S. EPA, Offc. Water, Criteria and Stds. Div., Washington, D.C. EPA-440/5-91-005. pp. 110-122.

APPENDIX A

Mill Creek 2016 Raw Chemical Data

(Contact Chris Hall, MSDGC at Chris.Hall@cincinnati-oh.gov for Excel files)

APPENDIX B

Mill Creek 2016 Fish Assemblage Data

B-1: Index of Biotic Integrity (IBI) Metrics and Scores, Modified Index of Well-Being (MIwb) Scores

B-2: Fish Species Grand (WWH and MWH Reaches - all sites combined)

B-3: Fish Species by Sampling Event

Appendix Table B-1. Boatable IBI scores and metrics for site sampled in the boatable reach of Mill Creek during 2016.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Minnow species	Headwater species	Sensitive species	Darter & Sculpin species	Simple Lithophils	Percent of Individuals: Tolerant fishes	Omni-vores	Pioneering fishes	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI
Mill Creek - (23-001)																
Year: 2016																
1.70	P	07/20/2016	163.0	11(3)	0(0)	0(0)	1(1)	0(0)	2(1)	5(5)	78(1)	1(0)	8(1)	3.2(1)	180(1) *	22
1.70	P	10/14/2016	163.0	12(3)	2(0)	0(0)	2(1)	1(0)	1(1)	3(5)	79(1)	1(0)	16(1)	0.6(5)	308(3)	28
0.70	P	07/20/2016	165.0	8(1)	0(0)	0(0)	0(1)	0(0)	0(1)	9(5)	78(1)	0(0)	15(1)	3.4(1)	160(1) *	20
0.70	P	10/14/2016	165.0	8(1)	1(0)	0(0)	1(1)	0(0)	1(1)	4(5)	68(1)	0(0)	30(3)	0.8(5)	230(3)	26
0.30	P	07/20/2016	166.0	12(3)	0(0)	0(0)	2(1)	0(0)	0(1)	4(5)	64(1)	0(0)	22(1)	4.0(1)	114(1) *	24
0.30	P	10/14/2016	166.0	14(3)	2(0)	0(0)	3(1)	0(0)	2(1)	4(5)	29(1)	0(0)	54(5)	3.1(1)	184(1) *	30
0.05	P	07/20/2016	165.0	9(1)	1(0)	0(0)	3(3)	0(0)	2(1)	17(3)	39(1)	0(0)	48(3)	13.0(1)	54(1) *	24
0.05	P	10/14/2016	165.0	12(3)	2(0)	0(0)	2(1)	0(0)	0(1)	0(5)	20(3)	0(0)	71(5)	0.0(5)	117(1) *	34

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table B-1. Wadeable IBI scores and metrics for site sampled in the wadeable reach of Mill Creek during 2016.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Darter species	Percent of Individuals: Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)		IBI	Modified Iwb
Mill Creek - (23001)																		
Year: 2016																		
18.70	D	07/26/2016	27.0	12(3)	2(3)	2(3)	0(1)	1(1)	8(1)	28(5)	31(3)	5.7(5)	61(5)	0.0(5)	285(3)		38	7.5
18.70	D	10/03/2016	27.0	13(3)	3(3)	2(3)	0(1)	1(1)	11(1)	42(3)	35(1)	4.0(3)	59(5)	0.4(3)	200(1)		28	7.5
19.10	D	07/26/2016	26.5	18(5)	3(3)	2(3)	0(1)	2(3)	18(3)	34(3)	21(3)	12.6(5)	46(3)	0.6(3)	308(3)		38	8.4
19.10	D	10/03/2016	26.5	16(3)	3(3)	2(3)	0(1)	1(1)	15(1)	41(3)	18(5)	6.1(5)	69(5)	2.2(1)	161(1)		32	7.0
16.60	D	08/02/2016	50.5	8(1)	2(3)	2(3)	0(1)	1(1)	21(3)	59(1)	33(3)	5.3(5)	61(5)	2.6(1)	71(1)	*	28	5.7
16.60	D	10/05/2016	50.5	8(1)	3(3)	2(3)	0(1)	0(1)	11(1)	57(1)	17(5)	3.4(3)	80(5)	2.5(1)	77(1)	*	26	5.1
18.10	D	08/01/2016	32.4	14(3)	3(3)	1(1)	0(1)	2(1)	7(1)	21(5)	27(3)	11.0(5)	60(5)	0.6(3)	237(3)		34	7.3
18.10	D	10/04/2016	32.4	10(3)	2(3)	2(3)	0(1)	1(1)	11(1)	33(3)	28(3)	12.6(5)	58(5)	0.4(5)	246(3)		36	7.7
17.90	D	08/01/2016	42.2	16(3)	3(3)	2(3)	0(1)	2(1)	19(3)	31(3)	14(5)	7.5(5)	58(5)	0.4(3)	266(3)		38	7.1
17.90	D	10/05/2016	42.2	14(3)	3(3)	2(3)	0(1)	2(1)	19(3)	32(3)	10(5)	2.1(3)	76(5)	2.5(1)	246(3)		34	7.7
14.80	D	08/02/2016	68.8	8(1)	4(5)	1(1)	0(1)	1(1)	5(1)	74(1)	14(5)	6.4(5)	80(5)	4.1(1)	58(1)		28	4.1
14.80	D	10/05/2016	68.8	7(1)	3(3)	1(1)	0(1)	0(1)	3(1)	71(1)	20(3)	2.9(3)	75(5)	3.0(1)	60(1)		22	5.4
13.90	D	07/27/2016	68.8	17(3)	4(5)	3(3)	0(1)	2(1)	20(3)	18(5)	14(5)	1.1(3)	25(1)	0.5(3)	473(3)		36	7.7
13.90	D	10/10/2016	68.8	14(3)	3(3)	3(3)	0(1)	3(3)	23(3)	22(5)	14(5)	0.0(1)	33(3)	2.5(1)	417(3)		34	7.6
13.70	D	07/27/2016	71.6	14(3)	2(3)	2(3)	0(1)	2(1)	14(1)	14(5)	10(5)	0.6(1)	17(1)	0.6(3)	617(3)		30	7.2
13.70	D	10/10/2016	71.6	13(3)	1(1)	2(3)	0(1)	2(1)	29(3)	18(5)	14(5)	1.3(3)	23(1)	1.9(1)	191(1)		28	6.4
13.20	D	07/27/2016	72.2	12(3)	4(5)	2(3)	0(1)	1(1)	43(5)	61(1)	39(1)	1.5(3)	59(5)	4.6(1)	77(1)	*	30	5.8
13.20	D	10/10/2016	72.2	10(1)	3(3)	2(3)	0(1)	1(1)	57(5)	65(1)	48(1)	1.8(3)	49(3)	1.9(1)	57(1)	*	24	6.1
11.30	D	07/27/2016	73.9	22(5)	4(5)	4(5)	0(1)	4(3)	26(3)	29(3)	40(1)	6.2(5)	37(3)	3.4(1)	191(1)		36	7.6

na - Qualitative data, Modified Iwb not applicable.

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table B-1. Wadeable IBI scores and metrics for site sampled in the wadeable reach of Mill Creek during 2016.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Darter species	Percent of Individuals: Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)		IBI	Modified Iwb
11.30	D	10/06/2016	73.9	18(3)	4(5)	2(3)	0(1)	1(1)	22(3)	39(3)	12(5)	3.2(3)	78(5)	1.6(3)	114(1)	*	36	6.4
10.00	E	07/25/2016	115.0	8(1)	1(1)	3(3)	0(1)	0(1)	29(3)	29(3)	24(3)	12.2(5)	41(3)	7.3(1)	58(1)	*	26	5.4
10.00	E	10/06/2016	115.0	8(1)	1(1)	2(1)	0(1)	1(1)	46(5)	11(5)	5(5)	10.8(5)	62(5)	2.7(5)	66(1)	*	36	5.7
8.70	E	07/26/2016	124.0	18(3)	5(5)	3(3)	0(1)	1(1)	22(3)	30(3)	30(3)	14.3(5)	55(5)	1.1(3)	246(3)		38	8.7
8.70	E	10/06/2016	124.0	14(3)	3(3)	2(1)	0(1)	1(1)	51(5)	15(5)	14(5)	8.9(5)	76(5)	0.9(3)	190(1)		38	7.4
7.50	D	07/25/2016	126.0	14(3)	1(1)	2(1)	0(1)	2(1)	28(3)	67(1)	60(1)	2.8(3)	34(3)	0.7(3)	210(3)		24	6.3
7.50	D	10/06/2016	126.0	15(3)	2(3)	2(1)	0(1)	3(3)	21(3)	26(3)	15(5)	0.9(1)	36(3)	0.4(5)	255(3)		34	6.6
6.90	D	07/22/2016	127.0	7(1)	0(1)	2(1)	0(1)	0(1)	54(5)	46(1)	43(1)	0.0(1)	28(3)	1.9(3)	44(1)	*	20	4.9
6.90	D	10/07/2016	127.0	9(1)	0(1)	2(1)	0(1)	0(1)	7(1)	9(5)	8(5)	0.0(1)	6(1)	0.0(5)	146(1)	*	24	5.1
6.40	D	07/22/2016	135.0	9(1)	0(1)	2(1)	0(1)	1(1)	25(3)	31(3)	30(3)	0.8(1)	46(3)	0.0(5)	129(1)	*	24	5.8
6.40	D	10/07/2016	135.0	4(1)	0(1)	2(1)	0(1)	0(1)	34(3)	68(1)	68(1)	0.0(1)	5(1)	0.0(5)	20(1)	*	18	3.9
5.10	D	07/21/2016	136.0	13(3)	5(5)	2(1)	0(1)	1(1)	16(1)	33(3)	23(3)	16.7(5)	58(5)	13.6(1)	132(1)	*	30	6.3
5.10	D	10/11/2016	136.0	6(1)	3(3)	0(1)	0(1)	0(1)	0(1)	49(1)	0(5)	8.6(5)	91(5)	0.0(5)	27(1)	*	30	4.7
4.30	D	07/22/2016	141.0	21(3)	6(5)	3(3)	0(1)	1(1)	2(1)	11(5)	7(5)	12.4(5)	77(5)	0.0(5)	434(3)		42	8.0
4.30	D	10/11/2016	141.0	17(3)	5(5)	3(3)	0(1)	1(1)	3(1)	16(5)	51(1)	4.5(3)	28(3)	0.0(5)	170(1)		32	7.3
3.50	D	07/21/2016	154.0	18(3)	1(1)	4(3)	1(1)	1(1)	6(1)	3(5)	21(3)	3.0(3)	74(5)	0.0(5)	633(3)		34	6.9
3.50	D	10/07/2016	154.0	13(3)	3(3)	1(1)	1(1)	1(1)	6(1)	1(5)	1(5)	1.0(3)	97(5)	0.7(3)	444(3)		34	5.7
3.10	D	07/21/2016	155.0	21(3)	3(3)	4(3)	1(1)	1(1)	5(1)	2(5)	21(3)	3.0(3)	75(5)	0.0(5)	441(3)		36	7.0
3.10	D	10/07/2016	155.0	12(3)	1(1)	3(3)	1(1)	0(1)	4(1)	2(5)	2(5)	0.9(1)	97(5)	0.0(5)	503(3)		34	5.5
2.50	D	10/11/2016	154.0	15(3)	1(1)	4(3)	1(1)	0(1)	1(1)	0(5)	6(5)	0.1(1)	45(3)	0.2(3)	1422(5)		32	8.2
2.50	D	07/21/2016	154.0	14(3)	2(3)	2(1)	1(1)	0(1)	1(1)	1(5)	20(3)	1.3(3)	76(5)	0.3(3)	462(3)		32	7.0

na - Qualitative data, Modified Iwb not applicable.

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table B-1. Wadeable IBI scores and metrics for site sampled in the wadeable reach of Mill Creek during 2016.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Darter species	Percent of Individuals: Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)		IBI	Modified Iwb
1.70	P	07/20/2016	163.0	11(3)	1(1)	4(3)	0(1)	0(0)	2(1)	5(5)	78(1)	9.5(3)	8(1)	3.2(1)	180(1)	*	22	8.1
1.70	P	10/14/2016	163.0	12(3)	2(3)	3(3)	1(1)	1(0)	1(1)	3(5)	79(1)	1.3(1)	16(1)	0.6(5)	308(3)		28	8.0
0.70	P	07/20/2016	165.0	8(1)	2(3)	3(3)	0(1)	0(0)	0(1)	9(5)	78(1)	1.1(1)	15(1)	3.4(1)	160(1)	*	20	7.9
0.70	P	10/14/2016	165.0	8(1)	2(3)	2(1)	0(1)	0(0)	1(1)	4(5)	68(1)	0.8(1)	30(3)	0.8(5)	230(3)		26	7.2
0.30	P	07/20/2016	166.0	12(3)	3(3)	3(3)	0(1)	0(0)	0(1)	4(5)	64(1)	10.0(3)	22(1)	4.0(1)	114(1)	*	24	7.9
0.30	P	10/14/2016	166.0	14(3)	2(3)	3(3)	1(1)	0(0)	4(1)	4(5)	29(1)	13.5(5)	54(5)	3.1(1)	184(1)	*	30	8.3
0.05	P	07/20/2016	165.0	9(1)	2(3)	3(3)	2(3)	0(0)	13(1)	17(3)	39(1)	8.7(3)	48(3)	13.0(1)	54(1)	*	24	7.0
0.05	P	10/14/2016	165.0	12(3)	3(3)	3(3)	1(1)	0(0)	0(1)	0(5)	20(3)	9.8(3)	71(5)	0.0(5)	117(1)	*	34	7.0
West Fork Mill Creek (Mill Cr. RM 11.57) - (23004)																		
Year: 2016																		
0.20	E	07/25/2016	36.4	10(3)	1(1)	2(3)	0(1)	1(1)	16(1)	58(1)	45(1)	0.0(1)	28(3)	0.0(5)	300(3)		24	7.2
0.20	E	10/05/2016	36.4	11(3)	2(3)	2(3)	0(1)	1(1)	12(1)	60(1)	37(1)	0.4(1)	35(3)	0.0(5)	218(3)		26	7.0

na - Qualitative data, Modified Iwb not applicable.

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table B-1. Headwater IBI scores and metrics for site sampled in the headwater reach of Mill Creek during 2016.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Minnow species	Headwater species	Sensitive species	Darter & Sculpin species	Simple Lithophils	Percent of Individuals: Tolerant fishes	Omni-vores	Pioneering fishes	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI
Mill Creek - (23-001)																
Year: 2016																
26.40	F	08/02/2016	4.10	13(5)	4(3)	1(1)	1(1)	2(3)	5(5)	28(5)	16(3)	43(3)	57(5)	0.7(3)	624(5)	42
26.40	E	10/03/2016	4.10	13(5)	3(3)	0(1)	1(1)	2(3)	4(3)	28(5)	11(5)	36(3)	69(5)	1.7(1)	592(5)	40
East Fork Mill Creek - (23-006)																
Year: 2016																
1.20	E	07/29/2016	9.50	10(3)	4(3)	0(1)	1(1)	2(3)	4(3)	31(5)	17(3)	37(3)	27(3)	1.9(5)	72(1) *	34
1.20	E	10/04/2016	9.50	8(3)	2(1)	0(1)	0(1)	1(1)	2(1)	51(3)	5(5)	55(1)	64(5)	0.0(5)	84(1) *	28
1.00	D	07/29/2016	9.10	12(3)	4(3)	0(1)	1(1)	2(3)	4(3)	42(3)	33(1)	14(5)	16(1)	0.2(5)	508(3)	32
1.00	D	10/04/2016	9.10	11(3)	3(1)	0(1)	1(1)	2(3)	4(3)	39(3)	28(3)	12(5)	31(3)	0.5(5)	230(3)	34
0.70	E	07/29/2016	9.50	11(3)	2(1)	1(1)	1(1)	3(3)	4(3)	39(3)	20(3)	32(3)	68(5)	0.0(5)	102(1) *	32
0.70	E	10/03/2016	9.50	8(3)	2(1)	0(1)	1(1)	0(1)	3(3)	64(1)	25(3)	37(3)	70(5)	3.7(1)	58(1) *	24
0.40	D	07/29/2016	9.50	9(3)	1(1)	0(1)	1(1)	2(3)	3(3)	33(5)	8(5)	32(3)	83(5)	1.1(5)	148(1)	36
0.10	E	10/04/2016	9.40	9(3)	2(1)	0(1)	1(1)	1(1)	2(1)	63(1)	17(3)	44(3)	74(5)	5.1(1)	114(1)	22
Bloody Run - (23-017)																
Year: 2016																
0.30	F	08/02/2016	3.20	1(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0.0(1)	0(1) * *	12
0.30	F	10/05/2016	3.20	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0.0(1)	0(1) * *	12
0.20	F	08/02/2016	3.20	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0.0(1)	0(1) * *	12
0.20	F	10/05/2016	3.20	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0.0(1)	0(1) * *	12

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix B-2: Midwest Biodiversity Institute
Fish Species List - Grand Totals

Rivers: *Mill Creek - WWH Reach*

Years: 2016

Number of Samples: 28 Data Sources: 99 Data Types: D; E; F

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
43-044	CENTRAL STONEROLLER	H		N	N	1308	75.9	21.28	281	3.10	3.7
77-008	GREEN SUNFISH	I	T	C	S	768	44.5	12.49	820	9.05	18.4
40-016	WHITE SUCKER	O	T	S	W	705	40.9	11.47	1128	12.44	27.6
77-009	BLUEGILL SUNFISH	I	P	C	S	644	37.4	10.47	527	5.81	14.1
43-032	SPOTFIN SHINER	I		M	N	418	24.2	6.80	129	1.43	5.3
40-015	NORTHERN HOG SUCKER	I	M	S	R	380	22.0	6.18	877	9.67	39.7
43-043	BLUNTNOSE MINNOW	O	T	C	N	322	18.7	5.24	32	0.35	1.7
20-003	GIZZARD SHAD	O		M		238	13.8	3.87	766	8.44	55.5
77-006	LARGEMOUTH BASS	C		C	F	211	12.2	3.43	303	3.34	24.7
80-023	ORANGETHROAT DARTER	I		S	D	207	12.0	3.37	1	0.02	0.1
43-034	SAND SHINER	I	M	M	N	195	11.3	3.17	29	0.33	2.6
80-014	JOHNNY DARTER	I		C	D	121	7.0	1.97	5	0.06	0.8
43-001	COMMON CARP	O	T	M	G	111	6.4	1.81	2666	29.39	414.2
47-004	YELLOW BULLHEAD	I	T	C		102	5.9	1.66	422	4.66	71.4
77-013	PUMPKINSEED SUNFISH	I	P	C	S	71	4.1	1.15	64	0.71	15.6
43-013	CREEK CHUB	G	T	N	N	56	3.3	0.91	30	0.34	9.5
43-025	STRIPED SHINER	I		S	N	55	3.2	0.89	28	0.32	8.9
47-006	BLACK BULLHEAD	I	P	C		43	2.5	0.70	3	0.04	1.4
77-011	LONGEAR SUNFISH	I	M	C	S	28	1.6	0.46	50	0.55	30.9
77-005	SPOTTED BASS	C		C	F	27	1.6	0.44	77	0.86	49.6
77-004	SMALLMOUTH BASS	C	M	C	F	24	1.4	0.39	65	0.72	47.0
47-002	CHANNEL CATFISH			C	F	21	1.2	0.34	207	2.29	170.4
77-015	GREEN SF X BLUEGILL SF					21	1.2	0.34	37	0.41	30.3
80-022	RAINBOW DARTER	I	M	S	D	17	1.0	0.28	2	0.03	2.4
80-024	FANTAIL DARTER	I		C	D	12	0.7	0.20	1	0.01	1.9
77-002	BLACK CRAPPIE	I		C	S	9	0.5	0.15	15	0.17	28.8
40-010	GOLDEN REDHORSE	I	M	S	R	6	0.4	0.10	174	1.92	501.6
43-002	GOLDFISH	O	T	M	G	5	0.3	0.08	80	0.89	279.0
77-016	GREEN SF X PUMPKINSEED					4	0.2	0.07	8	0.09	35.0
80-011	LOGPERCH	I	M	S	D	4	0.2	0.07	4	0.04	17.5
43-011	WESTERN BLACKNOSE DACE	G	T	S	N	3	0.2	0.05	0	0.00	1.0
47-007	FLATHEAD CATFISH	P		C	F	3	0.2	0.05	140	1.55	806.6
80-015	GREENSIDE DARTER	I	M	S	D	3	0.2	0.05	0	0.01	4.0
40-005	QUILLBACK CARPSUCKER	O		M	C	2	0.1	0.03	70	0.78	607.5
43-020	EMERALD SHINER	I		M	N	2	0.1	0.03	0	0.00	2.0
43-015	SUCKERMOUTH MINNOW	I		S	N	1	0.1	0.02	0	0.00	6.0
80-001	SAUGER	P		S	F	1	0.1	0.02	15	0.17	265.0

No Species: 37 **Nat. Species:** 33 **Hybrids:** 2 **Total Counted:** 6148 **Total Rel. Wt. :** 9072

Appendix B-2: Midwest Biodiversity Institute
Fish Species List - Grand Totals

Rivers: *Mill Creek - MWH Reach*

Years: 2016

Number of Samples: 22 Data Sources: 99 Data Types: D; P

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
43-020	EMERALD SHINER	I		M	N	1813	282.8	42.57	53	0.16	0.1
20-003	GIZZARD SHAD	O		M		586	91.4	13.76	2988	8.91	32.7
47-002	CHANNEL CATFISH			C	F	482	75.2	11.32	2652	7.90	35.2
77-009	BLUEGILL SUNFISH	I	P	C	S	150	23.4	3.52	497	1.48	21.2
43-044	CENTRAL STONEROLLER	H		N	N	130	6.1	3.05	48	0.48	7.9
40-006	RIVER CARPSUCKER	O		M	C	96	15.0	2.25	3865	11.52	258.1
40-016	WHITE SUCKER	O	T	S	W	94	4.4	2.21	68	0.68	15.5
43-032	SPOTFIN SHINER	I		M	N	91	4.3	2.14	16	0.16	3.7
43-001	COMMON CARP	O	T	M	G	79	12.3	1.85	8803	26.23	714.3
77-006	LARGEMOUTH BASS	C		C	F	79	12.3	1.85	585	1.74	47.4
40-015	NORTHERN HOG SUCKER	I	M	S	R	76	3.6	1.78	206	2.05	57.8
43-063	CHANNEL SHINER	I	I	M	N	71	11.1	1.67	12	0.04	1.1
77-011	LONGEAR SUNFISH	I	M	C	S	63	3.0	1.48	84	0.84	28.6
85-001	FRESHWATER DRUM		P	M		61	2.9	1.43	522	5.17	182.3
77-008	GREEN SUNFISH	I	T	C	S	59	9.2	1.39	186	0.56	20.2
43-034	SAND SHINER	I	M	M	N	50	2.4	1.17	5	0.06	2.4
40-004	SMALLMOUTH BUFFALO	I		M	C	42	6.6	0.99	5188	15.46	791.9
43-043	BLUNTNOSE MINNOW	O	T	C	N	42	2.0	0.99	8	0.08	4.0
40-005	QUILLBACK CARPSUCKER	O		M	C	30	4.7	0.70	1102	3.29	235.6
77-005	SPOTTED BASS	C		C	F	21	3.3	0.49	300	0.89	91.6
40-023	SMALLMOUTH REDHORSE	I	M	S	R	18	0.9	0.42	13	0.14	16.5
77-013	PUMPKINSEED SUNFISH	I	P	C	S	18	0.9	0.42	7	0.08	9.1
74-005	STR. BASS X WH. BASS				E	14	2.2	0.33	1616	4.82	740.0
77-001	WHITE CRAPPIE	I		C	S	12	1.9	0.28	225	0.67	120.4
74-001	WHITE BASS	P		M	F	11	1.7	0.26	226	0.68	132.2
47-007	FLATHEAD CATFISH	P		C	F	9	0.4	0.21	166	1.65	393.4
10-004	LONGNOSE GAR	P		M		8	1.3	0.19	337	1.01	270.6
77-002	BLACK CRAPPIE	I		C	S	8	1.3	0.19	112	0.33	90.0
40-010	GOLDEN REDHORSE	I	M	S	R	6	0.9	0.14	88	0.26	95.0
77-004	SMALLMOUTH BASS	C	M	C	F	6	0.3	0.14	16	0.17	59.1
47-004	YELLOW BULLHEAD	I	T	C		5	0.2	0.12	24	0.24	104.6
80-001	SAUGER	P		S	F	5	0.8	0.12	269	0.80	345.0
43-013	CREEK CHUB	G	T	N	N	4	0.2	0.09	2	0.02	11.0
80-011	LOGPERCH	I	M	S	D	4	0.6	0.09	10	0.03	17.5
80-014	JOHNNY DARTER	I		C	D	4	0.2	0.09	0	0.00	1.2
74-002	STRIPED BASS	P		M	E	2	0.3	0.05	351	1.05	1125.0
77-015	GREEN SF X BLUEGILL SF					2	0.1	0.05	3	0.04	40.0
40-009	BLACK REDHORSE	I	I	S	R	1	0.2	0.02	0	0.00	2.0
43-002	GOLDFISH	O	T	M	G	1	0.2	0.02	101	0.30	650.0
43-006	SILVER CHUB	I		M	N	1	0.1	0.02	0	0.00	8.0

Appendix B-2: Midwest Biodiversity Institute
Fish Species List - Grand Totals

Rivers: *Mill Creek - MWH Reach*

Years: 2016

Number of Samples: 22 Data Sources: 99 Data Types: D; P

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
43-025	STRIPED SHINER	I		S	N	1	0.1	0.02	0	0.00	1.0
43-027	RIVER SHINER	I		S	N	1	0.1	0.02	0	0.00	3.0
77-007	WARMOUTH SUNFISH	C		C	S	1	0.1	0.02	2	0.02	50.0
77-010	ORANGESPOTTED SUNFISH	I		C	S	1	0.1	0.02	0	0.00	3.0
80-022	RAINBOW DARTER	I	M	S	D	1	0.1	0.02	0	0.00	2.0

No Species: 45 **Nat. Species:** 40 **Hybrids:** 2 **Total Counted:** 4259 **Total Rel. Wt. :** 30777

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 0.05 Date: 07/20/2016

Time Fished: 1067 Distance: 0.350 Drainge (sq mi): 165.0 Depth: 0

Location: Dst. W. 8th St. bridge Lat: 39.10441 Long: -84.54497

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		4	11.4	17.39	571	1.09	50.0
40-004	SMALLMOUTH BUFFALO	I		M	C	4	11.4	17.39	21427	40.94	1875.0
40-005	QUILLBACK CARPSUCKER	O		M	C	1	2.9	4.35	2571	4.91	900.0
40-009	BLACK REDHORSE	I	I	S	R	1	2.9	4.35	5	0.01	2.0
43-001	COMMON CARP	O	T	M	G	4	11.4	17.39	23284	44.49	2037.5
43-063	CHANNEL SHINER	I	I	M	N	2	5.7	8.70	8	0.02	1.5
47-002	CHANNEL CATFISH			C	F	1	2.9	4.35	1028	1.97	360.0
77-002	BLACK CRAPPIE	I		C	S	1	2.9	4.35	371	0.71	130.0
77-011	LONGEAR SUNFISH	I	M	C	S	3	8.6	13.04	128	0.25	15.0
80-001	SAUGER	P		S	F	2	5.7	8.70	2942	5.62	515.0

No Species: 10 **Nat. Species:** 9 **Hybrids:** 0 **Total Counted:** 23 **Total Rel. Wt. :** 52340

IBI: 24.0 **MIwb:** 7.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 0.05 Date: 10/14/2016

Time Fished: 715 Distance: 0.350 Drainge (sq mi): 165.0 Depth: 0

Location: Dst. W. 8th St. bridge Lat: 39.10441 Long: -84.54497

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		6	17.1	14.63	1085	4.23	63.3
40-004	SMALLMOUTH BUFFALO	I		M	C	3	8.6	7.32	19256	75.04	2246.6
40-005	QUILLBACK CARPSUCKER	O		M	C	1	2.9	2.44	85	0.33	30.0
40-006	RIVER CARPSUCKER	O		M	C	1	2.9	2.44	2885	11.24	1010.0
43-020	EMERALD SHINER	I		M	N	14	40.0	34.15	57	0.22	1.4
43-063	CHANNEL SHINER	I	I	M	N	1	2.9	2.44	5	0.02	2.0
74-001	WHITE BASS	P		M	F	1	2.9	2.44	100	0.39	35.0
77-002	BLACK CRAPPIE	I		C	S	4	11.4	9.76	1514	5.90	132.5
77-005	SPOTTED BASS	C		C	F	2	5.7	4.88	142	0.56	25.0
77-006	LARGEMOUTH BASS	C		C	F	1	2.9	2.44	85	0.33	30.0
77-009	BLUEGILL SUNFISH	I	P	C	S	6	17.1	14.63	399	1.56	23.3
77-011	LONGEAR SUNFISH	I	M	C	S	1	2.9	2.44	42	0.17	15.0

No Species: 12 **Nat. Species:** 12 **Hybrids:** 0 **Total Counted:** 41 **Total Rel. Wt. :** 25661

IBI: 34.0 **MIwb:** 7.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 0.30 Date: 07/20/2016

Time Fished: 1459 Distance: 0.420 Drainge (sq mi): 166.0 Depth: 0

Location: Ust. Mill Creek WWTP Lat: 39.10901 Long: -84.54453

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		6	14.3	12.00	2190	2.27	153.3
40-004	SMALLMOUTH BUFFALO	I		M	C	7	16.7	14.00	19309	20.03	1158.5
40-005	QUILLBACK CARPSUCKER	O		M	C	1	2.4	2.00	2857	2.96	1200.0
40-006	RIVER CARPSUCKER	O		M	C	23	54.8	46.00	51429	53.35	939.1
43-001	COMMON CARP	O	T	M	G	2	4.8	4.00	10714	11.11	2250.0
47-002	CHANNEL CATFISH			C	F	2	4.8	4.00	7023	7.29	1475.0
47-007	FLATHEAD CATFISH	P		C	F	1	2.4	2.00	595	0.62	250.0
74-001	WHITE BASS	P		M	F	2	4.8	4.00	666	0.69	140.0
77-001	WHITE CRAPPIE	I		C	S	2	4.8	4.00	833	0.86	175.0
77-004	SMALLMOUTH BASS	C	M	C	F	1	2.4	2.00	119	0.12	50.0
77-006	LARGEMOUTH BASS	C		C	F	1	2.4	2.00	428	0.44	180.0
77-009	BLUEGILL SUNFISH	I	P	C	S	1	2.4	2.00	166	0.17	70.0
77-011	LONGEAR SUNFISH	I	M	C	S	1	2.4	2.00	71	0.07	30.0

No Species: 13 **Nat. Species:** 12 **Hybrids:** 0 **Total Counted:** 50 **Total Rel. Wt. :** 96406

IBI: 24.0 **MIwb:** 7.9

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 0.30 Date: 10/14/2016

Time Fished: 1313 Distance: 0.500 Drainge (sq mi): 166.0 Depth: 0

Location: Ust. Mill Creek WWTP Lat: 39.10901 Long: -84.54453

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		20	40.0	20.83	4220	6.82	105.5
40-004	SMALLMOUTH BUFFALO	I		M	C	2	4.0	2.08	7280	11.76	1820.0
40-006	RIVER CARPSUCKER	O		M	C	4	8.0	4.17	7940	12.82	992.5
40-023	SMALLMOUTH REDHORSE	I	M	S	R	3	6.0	3.13	200	0.32	33.3
43-001	COMMON CARP	O	T	M	G	4	8.0	4.17	26460	42.73	3307.5
43-020	EMERALD SHINER	I		M	N	36	72.0	37.50	60	0.10	0.8
43-063	CHANNEL SHINER	I	I	M	N	7	14.0	7.29	12	0.02	0.8
47-002	CHANNEL CATFISH			C	F	1	2.0	1.04	2000	3.23	1000.0
74-001	WHITE BASS	P		M	F	1	2.0	1.04	1040	1.68	520.0
74-002	STRIPED BASS	P		M	E	2	4.0	2.08	4500	7.27	1125.0
77-005	SPOTTED BASS	C		C	F	3	6.0	3.13	1540	2.49	256.6
77-006	LARGEMOUTH BASS	C		C	F	6	12.0	6.25	880	1.42	73.3
77-009	BLUEGILL SUNFISH	I	P	C	S	1	2.0	1.04	10	0.02	5.0
77-011	LONGEAR SUNFISH	I	M	C	S	3	6.0	3.13	110	0.18	18.3
80-001	SAUGER	P		S	F	1	2.0	1.04	230	0.37	115.0
85-001	FRESHWATER DRUM		P	M		2	4.0	2.08	5440	8.79	1360.0

No Species: 16 **Nat. Species:** 14 **Hybrids:** 0 **Total Counted:** 96 **Total Rel. Wt. :** 61922

IBI: 30.0 **MIwb:** 8.3

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 0.70 Date: 07/20/2016

Time Fished: 1960 Distance: 0.500 Drainge (sq mi): 165.0 Depth: 0

Location: UST. Gest St. bridge Lat: 39.11440 Long: -84.54518

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		33	66.0	37.50	9780	7.56	148.1
40-004	SMALLMOUTH BUFFALO	I		M	C	5	10.0	5.68	8500	6.57	850.0
40-005	QUILLBACK CARPSUCKER	O		M	C	2	4.0	2.27	1400	1.08	350.0
40-006	RIVER CARPSUCKER	O		M	C	26	52.0	29.55	57200	44.21	1100.0
43-001	COMMON CARP	O	T	M	G	8	16.0	9.09	37300	28.83	2331.2
47-002	CHANNEL CATFISH			C	F	5	10.0	5.68	12510	9.67	1251.0
47-007	FLATHEAD CATFISH	P		C	F	1	2.0	1.14	670	0.52	335.0
77-001	WHITE CRAPPIE	I		C	S	6	12.0	6.82	1890	1.46	157.5
77-009	BLUEGILL SUNFISH	I	P	C	S	2	4.0	2.27	140	0.11	35.0

No Species: 9 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 88 **Total Rel. Wt. :** 129390

IBI: 20.0 **MIwb:** 7.9

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 0.70 Date: 10/14/2016

Time Fished: 1188 Distance: 0.500 Drainge (sq mi): 165.0 Depth: 0

Location: UST. Gest St. bridge Lat: 39.11440 Long: -84.54518

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		66	132.0	55.00	16160	23.59	122.4
40-005	QUILLBACK CARPSUCKER	O		M	C	2	4.0	1.67	3040	4.44	760.0
40-006	RIVER CARPSUCKER	O		M	C	9	18.0	7.50	17960	26.21	997.7
43-001	COMMON CARP	O	T	M	G	5	10.0	4.17	29120	42.50	2912.0
43-020	EMERALD SHINER	I		M	N	33	66.0	27.50	100	0.15	1.5
47-002	CHANNEL CATFISH			C	F	1	2.0	0.83	1400	2.04	700.0
77-001	WHITE CRAPPIE	I		C	S	1	2.0	0.83	440	0.64	220.0
77-011	LONGEAR SUNFISH	I	M	C	S	2	4.0	1.67	14	0.02	3.5
80-001	SAUGER	P		S	F	1	2.0	0.83	280	0.41	140.0

No Species: 9 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 120 **Total Rel. Wt. :** 68514

IBI: 26.0 **MIwb:** 7.2

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 1.70 Date: 07/20/2016

Time Fished: 1619 Distance: 0.500 Drainge (sq mi): 163.0 Depth: 0

Location: Dst. Lick Run CSO Lat: 39.12486 Long: -84.54319

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
10-004	LONGNOSE GAR	P		M		1	2.0	1.05	1500	1.75	750.0
20-003	GIZZARD SHAD	O		M		57	114.0	60.00	10400	12.13	91.2
40-004	SMALLMOUTH BUFFALO	I		M	C	6	12.0	6.32	19380	22.61	1615.0
40-005	QUILLBACK CARPSUCKER	O		M	C	1	2.0	1.05	2200	2.57	1100.0
40-006	RIVER CARPSUCKER	O		M	C	12	24.0	12.63	26450	30.86	1102.0
40-010	GOLDEN REDHORSE	I	M	S	R	1	2.0	1.05	160	0.19	80.0
43-001	COMMON CARP	O	T	M	G	3	6.0	3.16	14200	16.57	2366.6
43-002	GOLDFISH	O	T	M	G	1	2.0	1.05	1300	1.52	650.0
47-002	CHANNEL CATFISH			C	F	4	8.0	4.21	6820	7.96	852.5
74-001	WHITE BASS	P		M	F	4	8.0	4.21	950	1.11	118.7
77-006	LARGEMOUTH BASS	C		C	F	3	6.0	3.16	1420	1.66	236.6
77-008	GREEN SUNFISH	I	T	C	S	1	2.0	1.05	60	0.07	30.0
80-001	SAUGER	P		S	F	1	2.0	1.05	880	1.03	440.0

No Species: 13 **Nat. Species:** 11 **Hybrids:** 0 **Total Counted:** 95 **Total Rel. Wt. :** 85720

IBI: 22.0 **MIwb:** 8.1

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 1.70 Date: 10/14/2016

Time Fished: 1367 Distance: 0.500 Drainge (sq mi): 163.0 Depth: 0

Location: Dst. Lick Run CSO Lat: 39.12486 Long: -84.54319

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		98	196.0	61.64	19840	16.60	101.2
40-004	SMALLMOUTH BUFFALO	I		M	C	3	6.0	1.89	12000	10.04	2000.0
40-005	QUILLBACK CARPSUCKER	O		M	C	2	4.0	1.26	2200	1.84	550.0
40-006	RIVER CARPSUCKER	O		M	C	21	42.0	13.21	40180	33.63	956.6
43-001	COMMON CARP	O	T	M	G	4	8.0	2.52	25940	21.71	3242.5
43-020	EMERALD SHINER	I		M	N	17	34.0	10.69	50	0.04	1.4
43-063	CHANNEL SHINER	I	I	M	N	1	2.0	0.63	4	0.00	2.0
47-002	CHANNEL CATFISH			C	F	6	12.0	3.77	8940	7.48	745.0
74-001	WHITE BASS	P		M	F	1	2.0	0.63	370	0.31	185.0
74-005	STR. BASS X WH. BASS				E	1	2.0	0.63	9540	7.98	4770.0
77-005	SPOTTED BASS	C		C	F	1	2.0	0.63	270	0.23	135.0
77-008	GREEN SUNFISH	I	T	C	S	1	2.0	0.63	30	0.03	15.0
77-009	BLUEGILL SUNFISH	I	P	C	S	2	4.0	1.26	100	0.08	25.0
80-011	LOGPERCH	I	M	S	D	1	2.0	0.63	30	0.03	15.0

No Species: 13 **Nat. Species:** 12 **Hybrids:** 1 **Total Counted:** 159 **Total Rel. Wt. :** 119494

IBI: 28.0 **MIwb:** 8.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 2.50 Date: 07/21/2016

Time Fished: 1507 Distance: 0.200 Drainge (sq mi): 154.0 Depth: 0

Location: Dst. Hopple St. bridge Lat: 39.13501 Long: -84.54555

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
10-004	LONGNOSE GAR	P		M		2	3.0	0.65	2025	7.16	675.0
20-003	GIZZARD SHAD	O		M		61	91.5	19.68	6319	22.35	69.0
40-004	SMALLMOUTH BUFFALO	I		M	C	3	4.5	0.97	9600	33.95	2133.3
40-023	SMALLMOUTH REDHORSE	I	M	S	R	2	3.0	0.65	60	0.21	20.0
43-001	COMMON CARP	O	T	M	G	1	1.5	0.32	2475	8.75	1650.0
43-020	EMERALD SHINER	I		M	N	203	304.5	65.48	102	0.36	0.3
43-032	SPOTFIN SHINER	I		M	N	8	12.0	2.58	45	0.16	3.7
43-034	SAND SHINER	I	M	M	N	3	4.5	0.97	6	0.02	1.3
43-063	CHANNEL SHINER	I	I	M	N	13	19.5	4.19	22	0.08	1.1
47-002	CHANNEL CATFISH			C	F	2	3.0	0.65	363	1.28	121.0
47-007	FLATHEAD CATFISH	P		C	F	1	1.5	0.32	1	0.01	1.0
74-005	STR. BASS X WH. BASS				E	2	3.0	0.65	6975	24.67	2325.0
77-004	SMALLMOUTH BASS	C	M	C	F	1	1.5	0.32	60	0.21	40.0
77-008	GREEN SUNFISH	I	T	C	S	1	1.5	0.32	3	0.01	2.0
77-011	LONGEAR SUNFISH	I	M	C	S	2	3.0	0.65	195	0.69	65.0
85-001	FRESHWATER DRUM		P	M		5	7.5	1.61	21	0.07	2.8

No Species: 15 **Nat. Species:** 14 **Hybrids:** 1 **Total Counted:** 310 **Total Rel. Wt. :** 28273

IBI: 32.0 **MIwb:** 7.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 2.50 Date: 10/11/2016

Time Fished: 1435 Distance: 0.200 Drainge (sq mi): 154.0 Depth: 0

Location: Dst. Hopple St. bridge Lat: 39.13501 Long: -84.54555

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		36	54.0	3.79	3255	8.81	60.2
40-004	SMALLMOUTH BUFFALO	I		M	C	6	9.0	0.63	16275	44.03	1808.3
40-005	QUILLBACK CARPSUCKER	O		M	C	17	25.5	1.79	600	1.62	23.5
40-015	NORTHERN HOG SUCKER	I	M	S	R	4	6.0	0.42	120	0.32	20.0
40-023	SMALLMOUTH REDHORSE	I	M	S	R	5	7.5	0.53	180	0.49	24.0
43-006	SILVER CHUB	I		M	N	1	1.5	0.11	12	0.03	8.0
43-020	EMERALD SHINER	I		M	N	387	580.5	40.78	532	1.44	0.9
43-034	SAND SHINER	I	M	M	N	2	3.0	0.21	3	0.01	1.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	1	1.5	0.11	6	0.02	4.0
43-044	CENTRAL STONEROLLER	H		N	N	2	3.0	0.21	45	0.12	15.0
43-063	CHANNEL SHINER	I	I	M	N	18	27.0	1.90	34	0.09	1.2
47-002	CHANNEL CATFISH			C	F	415	622.5	43.73	4365	11.81	7.0
74-001	WHITE BASS	P		M	F	1	1.5	0.11	240	0.65	160.0
74-005	STR. BASS X WH. BASS				E	1	1.5	0.11	135	0.37	90.0
77-011	LONGEAR SUNFISH	I	M	C	S	6	9.0	0.63	345	0.93	38.3
85-001	FRESHWATER DRUM		P	M		47	70.5	4.95	10815	29.26	153.4

No Species: 15 **Nat. Species:** 15 **Hybrids:** 1 **Total Counted:** 949 **Total Rel. Wt. :** 36963

IBI: 32.0 **MIwb:** 8.2

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 3.10 Date: 07/21/2016

Time Fished: 1314 Distance: 0.200 Drainge (sq mi): 155.0 Depth: 0

Location: Dst. Mill Creek bridge Lat: 39.14429 Long: -84.54813

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
10-004	LONGNOSE GAR	P		M		2	3.0	0.66	82	0.56	27.5
20-003	GIZZARD SHAD	O		M		58	87.0	19.27	3390	23.10	38.9
40-004	SMALLMOUTH BUFFALO	I		M	C	3	4.5	1.00	8850	60.30	1966.6
40-015	NORTHERN HOG SUCKER	I	M	S	R	12	18.0	3.99	1611	10.98	89.5
40-016	WHITE SUCKER	O	T	S	W	2	3.0	0.66	10	0.07	3.5
40-023	SMALLMOUTH REDHORSE	I	M	S	R	1	1.5	0.33	3	0.02	2.0
43-020	EMERALD SHINER	I		M	N	185	277.5	61.46	108	0.74	0.3
43-025	STRIPED SHINER	I		S	N	1	1.5	0.33	1	0.01	1.0
43-032	SPOTFIN SHINER	I		M	N	9	13.5	2.99	31	0.21	2.3
43-034	SAND SHINER	I	M	M	N	3	4.5	1.00	4	0.03	1.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	4	6.0	1.33	7	0.05	1.2
43-063	CHANNEL SHINER	I	I	M	N	3	4.5	1.00	4	0.03	1.0
47-002	CHANNEL CATFISH			C	F	2	3.0	0.66	42	0.29	14.0
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.33	60	0.41	40.0
77-004	SMALLMOUTH BASS	C	M	C	F	2	3.0	0.66	37	0.26	12.5
77-005	SPOTTED BASS	C		C	F	1	1.5	0.33	45	0.31	30.0
77-006	LARGEMOUTH BASS	C		C	F	4	6.0	1.33	142	0.97	23.7
77-009	BLUEGILL SUNFISH	I	P	C	S	3	4.5	1.00	75	0.51	16.6
77-010	ORANGESPOTTED SUNFISH	I		C	S	1	1.5	0.33	4	0.03	3.0
77-011	LONGEAR SUNFISH	I	M	C	S	3	4.5	1.00	165	1.12	36.6
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.33	1	0.01	1.0

No Species: 21 **Nat. Species:** 21 **Hybrids:** 0 **Total Counted:** 301 **Total Rel. Wt. :** 14677

IBI: 36.0 **MIwb:** 7.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 3.10 Date: 10/07/2016

Time Fished: 734 Distance: 0.200 Drainge (sq mi): 155.0 Depth: 0

Location: Dst. Mill Creek bridge Lat: 39.14429 Long: -84.54813

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	8	12.0	2.35	450	39.42	37.5
40-016	WHITE SUCKER	O	T	S	W	1	1.5	0.29	45	3.94	30.0
40-023	SMALLMOUTH REDHORSE	I	M	S	R	6	9.0	1.76	180	15.77	20.0
43-020	EMERALD SHINER	I		M	N	300	450.0	87.98	187	16.43	0.4
43-032	SPOTFIN SHINER	I		M	N	8	12.0	2.35	30	2.63	2.5
43-043	BLUNTNOSE MINNOW	O	T	C	N	5	7.5	1.47	30	2.63	4.0
43-063	CHANNEL SHINER	I	I	M	N	8	12.0	2.35	9	0.79	0.7
47-002	CHANNEL CATFISH			C	F	1	1.5	0.29	7	0.66	5.0
47-007	FLATHEAD CATFISH	P		C	F	1	1.5	0.29	7	0.66	5.0
77-005	SPOTTED BASS	C		C	F	1	1.5	0.29	165	14.45	110.0
77-006	LARGEMOUTH BASS	C		C	F	1	1.5	0.29	18	1.58	12.0
77-011	LONGEAR SUNFISH	I	M	C	S	1	1.5	0.29	12	1.05	8.0

No Species: 12 **Nat. Species:** 12 **Hybrids:** 0 **Total Counted:** 341 **Total Rel. Wt. :** 1141

IBI: 34.0 **MIwb:** 5.5

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 3.50 Date: 07/21/2016

Time Fished: 1694 Distance: 0.200 Drainge (sq mi): 154.0 Depth: 0

Location: Ust. Mill Creek Rd. bridge Lat: 39.14913 Long: -84.54626

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
10-004	LONGNOSE GAR	P		M		2	3.0	0.46	52	0.21	17.5
20-003	GIZZARD SHAD	O		M		81	121.5	18.62	5167	20.76	42.5
40-010	GOLDEN REDHORSE	I	M	S	R	3	4.5	0.69	330	1.33	73.3
40-015	NORTHERN HOG SUCKER	I	M	S	R	19	28.5	4.37	2535	10.18	88.9
40-016	WHITE SUCKER	O	T	S	W	1	1.5	0.23	75	0.30	50.0
40-023	SMALLMOUTH REDHORSE	I	M	S	R	1	1.5	0.23	52	0.21	35.0
43-001	COMMON CARP	O	T	M	G	6	9.0	1.38	15525	62.36	1725.0
43-020	EMERALD SHINER	I		M	N	271	406.5	62.30	192	0.77	0.4
43-032	SPOTFIN SHINER	I		M	N	11	16.5	2.53	40	0.16	2.4
43-034	SAND SHINER	I	M	M	N	6	9.0	1.38	6	0.02	0.6
43-043	BLUNTNOSE MINNOW	O	T	C	N	5	7.5	1.15	3	0.01	0.4
43-063	CHANNEL SHINER	I	I	M	N	9	13.5	2.07	16	0.07	1.2
47-002	CHANNEL CATFISH			C	F	5	7.5	1.15	40	0.16	5.4
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.23	4	0.02	3.0
74-001	WHITE BASS	P		M	F	1	1.5	0.23	7	0.03	5.0
77-005	SPOTTED BASS	C		C	F	4	6.0	0.92	705	2.83	117.5
77-006	LARGEMOUTH BASS	C		C	F	6	9.0	1.38	60	0.24	6.6
77-011	LONGEAR SUNFISH	I	M	C	S	2	3.0	0.46	82	0.33	27.5
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.23	1	0.01	1.0

No Species: 19 **Nat. Species:** 18 **Hybrids:** 0 **Total Counted:** 435 **Total Rel. Wt. :** 24897

IBI: 34.0 **MIwb:** 6.9

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 3.50 Date: 10/07/2016

Time Fished: 953 Distance: 0.200 Drainge (sq mi): 154.0 Depth: 0

Location: Ust. Mill Creek Rd. bridge Lat: 39.14913 Long: -84.54626

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	17	25.5	5.67	4305	32.16	168.8
43-001	COMMON CARP	O	T	M	G	2	3.0	0.67	8325	62.18	2775.0
43-020	EMERALD SHINER	I		M	N	240	360.0	80.00	240	1.79	0.6
43-032	SPOTFIN SHINER	I		M	N	21	31.5	7.00	67	0.50	2.1
43-063	CHANNEL SHINER	I	I	M	N	9	13.5	3.00	12	0.09	0.8
47-002	CHANNEL CATFISH			C	F	2	3.0	0.67	37	0.28	12.5
47-007	FLATHEAD CATFISH	P		C	F	1	1.5	0.33	75	0.56	50.0
77-005	SPOTTED BASS	C		C	F	1	1.5	0.33	37	0.28	25.0
77-006	LARGEMOUTH BASS	C		C	F	1	1.5	0.33	75	0.56	50.0
77-008	GREEN SUNFISH	I	T	C	S	2	3.0	0.67	30	0.22	10.0
77-009	BLUEGILL SUNFISH	I	P	C	S	1	1.5	0.33	15	0.11	10.0
77-011	LONGEAR SUNFISH	I	M	C	S	1	1.5	0.33	105	0.78	70.0
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.33	3	0.02	2.0
85-001	FRESHWATER DRUM		P	M		1	1.5	0.33	60	0.45	40.0

No Species: 14 **Nat. Species:** 13 **Hybrids:** 0 **Total Counted:** 300 **Total Rel. Wt. :** 13387

IBI: 34.0 **MIwb:** 5.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 4.30 Date: 07/22/2016

Time Fished: 2130 Distance: 0.200 Drainge (sq mi): 141.0 Depth: 0

Location: Ust. S. Ludlow Ave. bridge Lat: 39.15729 Long: -84.53770

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		10	15.0	3.09	1425	2.62	95.0
40-010	GOLDEN REDHORSE	I	M	S	R	1	1.5	0.31	255	0.47	170.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	3.0	0.62	285	0.52	95.0
40-016	WHITE SUCKER	O	T	S	W	1	1.5	0.31	6	0.01	4.0
43-001	COMMON CARP	O	T	M	G	13	19.5	4.01	35010	64.49	1795.3
43-020	EMERALD SHINER	I		M	N	119	178.5	36.73	45	0.08	0.2
43-027	RIVER SHINER	I		S	N	1	1.5	0.31	4	0.01	3.0
43-032	SPOTFIN SHINER	I		M	N	1	1.5	0.31	3	0.01	2.0
43-034	SAND SHINER	I	M	M	N	2	3.0	0.62	3	0.01	1.0
47-002	CHANNEL CATFISH			C	F	6	9.0	1.85	870	1.60	96.6
47-007	FLATHEAD CATFISH	P		C	F	3	4.5	0.93	5055	9.31	1123.3
77-001	WHITE CRAPPIE	I		C	S	3	4.5	0.93	1170	2.16	260.0
77-004	SMALLMOUTH BASS	C	M	C	F	1	1.5	0.31	75	0.14	50.0
77-005	SPOTTED BASS	C		C	F	5	7.5	1.54	300	0.55	40.0
77-006	LARGEMOUTH BASS	C		C	F	30	45.0	9.26	2749	5.06	61.1
77-007	WARMOUTH SUNFISH	C		C	S	1	1.5	0.31	75	0.14	50.0
77-008	GREEN SUNFISH	I	T	C	S	21	31.5	6.48	585	1.08	18.5
77-009	BLUEGILL SUNFISH	I	P	C	S	69	103.5	21.30	3690	6.80	35.6
77-011	LONGEAR SUNFISH	I	M	C	S	12	18.0	3.70	735	1.35	40.8
77-013	PUMPKINSEED SUNFISH	I	P	C	S	16	24.0	4.94	192	0.35	8.0
80-011	LOGPERCH	I	M	S	D	1	1.5	0.31	45	0.08	30.0
85-001	FRESHWATER DRUM		P	M		6	9.0	1.85	1710	3.15	190.0

No Species: 22 **Nat. Species:** 21 **Hybrids:** 0 **Total Counted:** 324 **Total Rel. Wt. :** 54288

IBI: 42.0 **MIwb:** 8.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 4.30 Date: 10/11/2016

Time Fished: 1428 Distance: 0.200 Drainge (sq mi): 141.0 Depth: 0

Location: Ust. S. Ludlow Ave. bridge Lat: 39.15729 Long: -84.53770

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
10-004	LONGNOSE GAR	P		M		1	1.5	0.75	0	0.00	0.0
20-003	GIZZARD SHAD	O		M		45	67.5	33.58	8107	7.91	120.1
40-005	QUILLBACK CARPSUCKER	O		M	C	3	4.5	2.24	2190	2.14	486.6
40-010	GOLDEN REDHORSE	I	M	S	R	1	1.5	0.75	225	0.22	150.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	1	1.5	0.75	180	0.18	120.0
43-001	COMMON CARP	O	T	M	G	20	30.0	14.93	54000	52.68	1800.0
43-020	EMERALD SHINER	I		M	N	7	10.5	5.22	18	0.02	1.7
47-002	CHANNEL CATFISH			C	F	13	19.5	9.70	14175	13.83	726.9
47-007	FLATHEAD CATFISH	P		C	F	1	1.5	0.75	2550	2.49	1700.0
74-005	STR. BASS X WH. BASS				E	10	15.0	7.46	18067	17.63	1204.5
77-002	BLACK CRAPPIE	I		C	S	1	1.5	0.75	240	0.23	160.0
77-004	SMALLMOUTH BASS	C	M	C	F	1	1.5	0.75	285	0.28	190.0
77-005	SPOTTED BASS	C		C	F	1	1.5	0.75	127	0.12	85.0
77-006	LARGEMOUTH BASS	C		C	F	2	3.0	1.49	765	0.75	255.0
77-008	GREEN SUNFISH	I	T	C	S	1	1.5	0.75	7	0.01	5.0
77-009	BLUEGILL SUNFISH	I	P	C	S	21	31.5	15.67	1410	1.38	44.7
77-011	LONGEAR SUNFISH	I	M	C	S	2	3.0	1.49	75	0.07	25.0
77-013	PUMPKINSEED SUNFISH	I	P	C	S	1	1.5	0.75	37	0.04	25.0
80-011	LOGPERCH	I	M	S	D	2	3.0	1.49	37	0.04	12.5

No Species: 18 **Nat. Species:** 17 **Hybrids:** 1 **Total Counted:** 134 **Total Rel. Wt. :** 102498

IBI: 32.0 **MIwb:** 7.3

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 5.10 Date: 07/21/2016

Time Fished: 1882 Distance: 0.200 Drainge (sq mi): 136.0 Depth: 0

Location: Adj. Salway Park Lat: 39.16230 Long: -84.52330

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		5	7.5	3.79	345	1.51	46.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	3.0	1.52	352	1.54	117.5
40-016	WHITE SUCKER	O	T	S	W	19	28.5	14.39	5070	22.15	177.8
43-001	COMMON CARP	O	T	M	G	5	7.5	3.79	13050	57.02	1740.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	2	3.0	1.52	4	0.02	1.5
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.76	135	0.59	90.0
77-002	BLACK CRAPPIE	I		C	S	2	3.0	1.52	90	0.39	30.0
77-005	SPOTTED BASS	C		C	F	1	1.5	0.76	30	0.13	20.0
77-006	LARGEMOUTH BASS	C		C	F	21	31.5	15.91	1177	5.14	37.3
77-008	GREEN SUNFISH	I	T	C	S	17	25.5	12.88	922	4.03	36.1
77-009	BLUEGILL SUNFISH	I	P	C	S	39	58.5	29.55	1185	5.18	20.2
77-011	LONGEAR SUNFISH	I	M	C	S	14	21.0	10.61	360	1.57	17.1
77-013	PUMPKINSEED SUNFISH	I	P	C	S	1	1.5	0.76	45	0.20	30.0
77-015	GREEN SF X BLUEGILL SF					2	3.0	1.52	120	0.52	40.0
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.76	1	0.01	1.0

No Species: 14 **Nat. Species:** 13 **Hybrids:** 1 **Total Counted:** 132 **Total Rel. Wt. :** 22888

IBI: 30.0 **MIwb:** 6.3

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 5.10 Date: 10/11/2016

Time Fished: 910 Distance: 0.200 Drainge (sq mi): 136.0 Depth: 0

Location: Adj. Salway Park Lat: 39.16230 Long: -84.52330

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
47-004	YELLOW BULLHEAD	I	T	C		2	3.0	5.71	585	27.66	195.0
77-005	SPOTTED BASS	C		C	F	1	1.5	2.86	120	5.67	80.0
77-006	LARGEMOUTH BASS	C		C	F	2	3.0	5.71	45	2.13	15.0
77-008	GREEN SUNFISH	I	T	C	S	15	22.5	42.86	555	26.24	24.6
77-009	BLUEGILL SUNFISH	I	P	C	S	5	7.5	14.29	315	14.89	42.0
77-011	LONGEAR SUNFISH	I	M	C	S	10	15.0	28.57	495	23.40	33.0

No Species: 6 **Nat. Species:** 6 **Hybrids:** 0 **Total Counted:** 35 **Total Rel. Wt. :** 2115

IBI: 30.0 **MIwb:** 4.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 6.40 Date: 07/22/2016

Time Fished: 1230 Distance: 0.200 Drainge (sq mi): 135.0 Depth: 0

Location: at RR tressel dst. Springgrove Ave. Lat: 39.16927 Long: -84.50570

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	3.0	1.61	15	1.38	5.0
40-016	WHITE SUCKER	O	T	S	W	28	42.0	22.58	367	33.79	8.7
43-001	COMMON CARP	O	T	M	G	1	1.5	0.81	15	1.38	10.0
43-013	CREEK CHUB	G	T	N	N	1	1.5	0.81	3	0.28	2.0
43-032	SPOTFIN SHINER	I		M	N	24	36.0	19.35	225	20.69	6.2
43-034	SAND SHINER	I	M	M	N	30	45.0	24.19	150	13.79	3.3
43-043	BLUNTNOSE MINNOW	O	T	C	N	8	12.0	6.45	75	6.90	6.2
43-044	CENTRAL STONEROLLER	H		N	N	28	42.0	22.58	225	20.69	5.3
77-006	LARGEMOUTH BASS	C		C	F	1	1.5	0.81	9	0.83	6.0
80-022	RAINBOW DARTER	I	M	S	D	1	1.5	0.81	3	0.28	2.0

No Species: 10 **Nat. Species:** 9 **Hybrids:** 0 **Total Counted:** 124 **Total Rel. Wt. :** 1087

IBI: 24.0 **MIwb:** 5.8

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 6.40 Date: 10/07/2016

Time Fished: 400 Distance: 0.200 Drainge (sq mi): 135.0 Depth: 0

Location: at RR tressel dst. Springgrove Ave. Lat: 39.16927 Long: -84.50570

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	3.0	4.88	75	8.40	25.0
40-016	WHITE SUCKER	O	T	S	W	12	18.0	29.27	480	53.78	26.6
43-043	BLUNTNOSE MINNOW	O	T	C	N	16	24.0	39.02	127	14.29	5.3
43-044	CENTRAL STONEROLLER	H		N	N	11	16.5	26.83	210	23.53	12.7

No Species: 4 **Nat. Species:** 4 **Hybrids:** 0 **Total Counted:** 41 **Total Rel. Wt. :** 892

IBI: 18.0 **MIwb:** 3.9

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 6.90 Date: 07/22/2016

Time Fished: 0 Distance: 0.200 Drainge (sq mi): 127.0 Depth: 0

Location: Dst. outfall river left looking upstream Lat: 39.17570 Long: -84.50562

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	6	9.0	11.11	450	48.47	50.0
40-016	WHITE SUCKER	O	T	S	W	23	34.5	42.59	225	24.23	6.5
43-013	CREEK CHUB	G	T	N	N	2	3.0	3.70	60	6.46	20.0
43-032	SPOTFIN SHINER	I		M	N	7	10.5	12.96	90	9.69	8.5
43-034	SAND SHINER	I	M	M	N	2	3.0	3.70	6	0.65	2.0
43-044	CENTRAL STONEROLLER	H		N	N	12	18.0	22.22	90	9.69	5.0
47-002	CHANNEL CATFISH			C	F	2	3.0	3.70	7	0.81	2.5

No Species: 7 **Nat. Species:** 7 **Hybrids:** 0 **Total Counted:** 54 **Total Rel. Wt. :** 928

IBI: 20.0 **MIwb:** 4.9

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 6.90 Date: 10/07/2016

Time Fished: 544 Distance: 0.200 Drainge (sq mi): 127.0 Depth: 0

Location: Dst. outfall river left looking upstream Lat: 39.17570 Long: -84.50562

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	1	1.5	0.93	97	4.66	65.0
40-016	WHITE SUCKER	O	T	S	W	7	10.5	6.54	465	22.21	44.2
43-001	COMMON CARP	O	T	M	G	1	1.5	0.93	262	12.54	175.0
43-013	CREEK CHUB	G	T	N	N	1	1.5	0.93	3	0.14	2.0
43-020	EMERALD SHINER	I		M	N	1	1.5	0.93	3	0.14	2.0
43-032	SPOTFIN SHINER	I		M	N	2	3.0	1.87	7	0.36	2.5
43-034	SAND SHINER	I	M	M	N	2	3.0	1.87	4	0.21	1.5
43-043	BLUNTNOSE MINNOW	O	T	C	N	1	1.5	0.93	6	0.29	4.0
43-044	CENTRAL STONEROLLER	H		N	N	77	115.5	71.96	975	46.56	8.4
47-002	CHANNEL CATFISH			C	F	14	21.0	13.08	270	12.89	12.8

No Species: 10 **Nat. Species:** 9 **Hybrids:** 0 **Total Counted:** 107 **Total Rel. Wt. :** 2094

IBI: 24.0 **MIwb:** 5.1

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 7.50 Date: 07/25/2016

Time Fished: 1449 Distance: 0.200 Drainge (sq mi): 126.0 Depth: 0

Location: RR Trestle Winton Place Lat: 0.00000 Long: 0.00000

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	10	15.0	2.35	90	2.57	6.0
40-016	WHITE SUCKER	O	T	S	W	107	160.5	25.18	1147	32.78	7.1
43-013	CREEK CHUB	G	T	N	N	6	9.0	1.41	60	1.71	6.6
43-015	SUCKERMOUTH MINNOW	I		S	N	1	1.5	0.24	9	0.26	6.0
43-020	EMERALD SHINER	I		M	N	2	3.0	0.47	6	0.17	2.0
43-032	SPOTFIN SHINER	I		M	N	23	34.5	5.41	150	4.28	4.3
43-034	SAND SHINER	I	M	M	N	79	118.5	18.59	330	9.43	2.7
43-043	BLUNTNOSE MINNOW	O	T	C	N	150	225.0	35.29	1155	32.99	5.1
47-002	CHANNEL CATFISH			C	F	6	9.0	1.41	45	1.29	5.0
47-004	YELLOW BULLHEAD	I	T	C		14	21.0	3.29	112	3.21	5.3
77-006	LARGEMOUTH BASS	C		C	F	12	18.0	2.82	150	4.28	8.3
77-008	GREEN SUNFISH	I	T	C	S	8	12.0	1.88	232	6.64	19.3
80-014	JOHNNY DARTER	I		C	D	6	9.0	1.41	10	0.30	1.1
80-022	RAINBOW DARTER	I	M	S	D	1	1.5	0.24	3	0.09	2.0

No Species: 14 **Nat. Species:** 14 **Hybrids:** 0 **Total Counted:** 425 **Total Rel. Wt. :** 3501

IBI: 24.0 **MIwb:** 6.3

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 7.50 Date: 10/06/2016

Time Fished: 1262 Distance: 0.200 Drainge (sq mi): 126.0 Depth: 0

Location: RR Trestle Winton Place Lat: 0.00000 Long: 0.00000

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	4	6.0	1.73	75	2.04	12.5
40-016	WHITE SUCKER	O	T	S	W	25	37.5	10.82	885	24.12	23.6
43-013	CREEK CHUB	G	T	N	N	4	6.0	1.73	97	2.66	16.2
43-025	STRIPED SHINER	I		S	N	1	1.5	0.43	12	0.33	8.0
43-032	SPOTFIN SHINER	I		M	N	33	49.5	14.29	157	4.29	3.1
43-043	BLUNTNOSE MINNOW	O	T	C	N	10	15.0	4.33	60	1.64	4.0
43-044	CENTRAL STONEROLLER	H		N	N	104	156.0	45.02	1920	52.33	12.3
47-002	CHANNEL CATFISH			C	F	3	4.5	1.30	45	1.23	10.0
47-004	YELLOW BULLHEAD	I	T	C		3	4.5	1.30	67	1.84	15.0
77-006	LARGEMOUTH BASS	C		C	F	2	3.0	0.87	45	1.23	15.0
77-008	GREEN SUNFISH	I	T	C	S	19	28.5	8.23	210	5.72	7.3
77-011	LONGEAR SUNFISH	I	M	C	S	2	3.0	0.87	15	0.41	5.0
80-014	JOHNNY DARTER	I		C	D	3	4.5	1.30	7	0.20	1.6
80-015	GREENSIDE DARTER	I	M	S	D	2	3.0	0.87	12	0.33	4.0
80-022	RAINBOW DARTER	I	M	S	D	16	24.0	6.93	60	1.64	2.5

No Species: 15 **Nat. Species:** 15 **Hybrids:** 0 **Total Counted:** 231 **Total Rel. Wt. :** 3669

IBI: 34.0 **MIwb:** 6.6

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 8.70 Date: 07/26/2016

Time Fished: 1576 Distance: 0.150 Drainge (sq mi): 124.0 Depth: 0

Location: Ust. Este Ave. bridge Lat: 39.19578 Long: -84.48957

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		5	10.0	2.86	1730	10.27	173.0
40-005	QUILLBACK CARPSUCKER	O		M	C	1	2.0	0.57	1630	9.68	815.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	30	60.0	17.14	4310	25.60	71.8
40-016	WHITE SUCKER	O	T	S	W	9	18.0	5.14	1110	6.59	61.6
43-001	COMMON CARP	O	T	M	G	1	2.0	0.57	2200	13.07	1100.0
43-032	SPOTFIN SHINER	I		M	N	11	22.0	6.29	110	0.65	5.0
43-034	SAND SHINER	I	M	M	N	35	70.0	20.00	150	0.89	2.1
43-043	BLUNTNOSE MINNOW	O	T	C	N	37	74.0	21.14	170	1.01	2.2
47-002	CHANNEL CATFISH			C	F	1	2.0	0.57	1220	7.25	610.0
47-004	YELLOW BULLHEAD	I	T	C		2	4.0	1.14	710	4.22	177.5
77-002	BLACK CRAPPIE	I		C	S	1	2.0	0.57	100	0.59	50.0
77-004	SMALLMOUTH BASS	C	M	C	F	11	22.0	6.29	1000	5.94	45.4
77-005	SPOTTED BASS	C		C	F	12	24.0	6.86	1060	6.30	44.1
77-006	LARGEMOUTH BASS	C		C	F	2	4.0	1.14	280	1.66	70.0
77-008	GREEN SUNFISH	I	T	C	S	3	6.0	1.71	480	2.85	80.0
77-009	BLUEGILL SUNFISH	I	P	C	S	1	2.0	0.57	8	0.05	4.0
77-011	LONGEAR SUNFISH	I	M	C	S	7	14.0	4.00	480	2.85	34.2
77-013	PUMPKINSEED SUNFISH	I	P	C	S	2	4.0	1.14	80	0.48	20.0
80-014	JOHNNY DARTER	I		C	D	4	8.0	2.29	10	0.06	1.2

No Species: 19 **Nat. Species:** 18 **Hybrids:** 0 **Total Counted:** 175 **Total Rel. Wt. :** 16838

IBI: 38.0 **MIwb:** 8.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 8.70 Date: 10/06/2016

Time Fished: 989 Distance: 0.150 Drainge (sq mi): 124.0 Depth: 0

Location: Ust. Este Ave. bridge Lat: 39.19578 Long: -84.48957

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		6	12.0	5.36	2120	16.74	176.6
40-015	NORTHERN HOG SUCKER	I	M	S	R	46	92.0	41.07	5520	43.60	60.0
40-016	WHITE SUCKER	O	T	S	W	9	18.0	8.04	1440	11.37	80.0
43-032	SPOTFIN SHINER	I		M	N	22	44.0	19.64	120	0.95	2.7
43-043	BLUNTNOSE MINNOW	O	T	C	N	1	2.0	0.89	6	0.05	3.0
47-004	YELLOW BULLHEAD	I	T	C		3	6.0	2.68	820	6.48	136.6
77-004	SMALLMOUTH BASS	C	M	C	F	1	2.0	0.89	80	0.63	40.0
77-005	SPOTTED BASS	C		C	F	7	14.0	6.25	940	7.42	67.1
77-006	LARGEMOUTH BASS	C		C	F	1	2.0	0.89	20	0.16	10.0
77-008	GREEN SUNFISH	I	T	C	S	4	8.0	3.57	300	2.37	37.5
77-011	LONGEAR SUNFISH	I	M	C	S	8	16.0	7.14	690	5.45	43.1
77-013	PUMPKINSEED SUNFISH	I	P	C	S	1	2.0	0.89	30	0.24	15.0
77-015	GREEN SF X BLUEGILL SF					1	2.0	0.89	6	0.05	3.0
80-001	SAUGER	P		S	F	1	2.0	0.89	530	4.19	265.0
80-011	LOGPERCH	I	M	S	D	1	2.0	0.89	40	0.32	20.0

No Species: 14 **Nat. Species:** 14 **Hybrids:** 1 **Total Counted:** 112 **Total Rel. Wt. :** 12662

IBI: 38.0 **MIwb:** 7.4

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 10.00 Date: 07/25/2016

Time Fished: 1232 Distance: 0.150 Drainge (sq mi): 115.0 Depth: 0

Location: Lat: 39.20207 Long: -84.47134

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-010	GOLDEN REDHORSE	I	M	S	R	1	2.0	2.44	1600	3.75	800.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	9	18.0	21.95	2970	6.95	165.0
40-016	WHITE SUCKER	O	T	S	W	2	4.0	4.88	400	0.94	100.0
43-001	COMMON CARP	O	T	M	G	8	16.0	19.51	36700	85.91	2293.7
43-032	SPOTFIN SHINER	I		M	N	5	10.0	12.20	90	0.21	9.0
43-044	CENTRAL STONEROLLER	H		N	N	9	18.0	21.95	300	0.70	16.6
77-004	SMALLMOUTH BASS	C	M	C	F	2	4.0	4.88	200	0.47	50.0
77-005	SPOTTED BASS	C		C	F	3	6.0	7.32	240	0.56	40.0
77-008	GREEN SUNFISH	I	T	C	S	2	4.0	4.88	220	0.51	55.0

No Species: 9 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 41 **Total Rel. Wt. :** 42720

IBI: 26.0 **MIwb:** 5.4

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 10.00 Date: 10/06/2016

Time Fished: 1673 Distance: 0.150 Drainge (sq mi): 115.0 Depth: 0

Location: Lat: 39.20207 Long: -84.47134

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	15	30.0	40.54	5420	45.55	180.6
40-016	WHITE SUCKER	O	T	S	W	1	2.0	2.70	30	0.25	15.0
43-001	COMMON CARP	O	T	M	G	1	2.0	2.70	5600	47.06	2800.0
43-032	SPOTFIN SHINER	I		M	N	5	10.0	13.51	20	0.17	2.0
43-044	CENTRAL STONEROLLER	H		N	N	8	16.0	21.62	260	2.18	16.2
77-004	SMALLMOUTH BASS	C	M	C	F	3	6.0	8.11	380	3.19	63.3
77-005	SPOTTED BASS	C		C	F	1	2.0	2.70	100	0.84	50.0
77-008	GREEN SUNFISH	I	T	C	S	2	4.0	5.41	60	0.50	15.0
80-011	LOGPERCH	I	M	S	D	1	2.0	2.70	30	0.25	15.0

No Species: 9 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 37 **Total Rel. Wt. :** 11900

IBI: 36.0 **MIwb:** 5.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 11.30 Date: 07/27/2016

Time Fished: 2115 Distance: 0.200 Drainge (sq mi): 73.9 Depth: 0

Location: Lat: 39.21122 Long: -84.45616

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		22	33.0	12.36	4050	5.44	122.7
40-005	QUILLBACK CARPSUCKER	O		M	C	1	1.5	0.56	600	0.81	400.0
40-010	GOLDEN REDHORSE	I	M	S	R	1	1.5	0.56	915	1.23	610.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	30	45.0	16.85	5062	6.80	112.5
40-016	WHITE SUCKER	O	T	S	W	6	9.0	3.37	1477	1.98	164.1
43-001	COMMON CARP	O	T	M	G	30	45.0	16.85	55575	74.64	1235.0
43-025	STRIPED SHINER	I		S	N	6	9.0	3.37	93	0.12	10.3
43-032	SPOTFIN SHINER	I		M	N	7	10.5	3.93	45	0.06	4.2
43-043	BLUNTNOSE MINNOW	O	T	C	N	13	19.5	7.30	45	0.06	2.3
43-044	CENTRAL STONEROLLER	H		N	N	27	40.5	15.17	127	0.17	3.1
47-002	CHANNEL CATFISH			C	F	3	4.5	1.69	4950	6.65	1100.0
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.56	150	0.20	100.0
77-004	SMALLMOUTH BASS	C	M	C	F	6	9.0	3.37	667	0.90	74.1
77-005	SPOTTED BASS	C		C	F	3	4.5	1.69	135	0.18	30.0
77-006	LARGEMOUTH BASS	C		C	F	2	3.0	1.12	24	0.03	8.0
77-008	GREEN SUNFISH	I	T	C	S	1	1.5	0.56	52	0.07	35.0
77-009	BLUEGILL SUNFISH	I	P	C	S	2	3.0	1.12	187	0.25	62.5
77-011	LONGEAR SUNFISH	I	M	C	S	4	6.0	2.25	150	0.20	25.0
77-013	PUMPKINSEED SUNFISH	I	P	C	S	3	4.5	1.69	75	0.10	16.6
80-011	LOGPERCH	I	M	S	D	2	3.0	1.12	52	0.07	17.5
80-014	JOHNNY DARTER	I		C	D	6	9.0	3.37	9	0.01	1.0
80-015	GREENSIDE DARTER	I	M	S	D	1	1.5	0.56	6	0.01	4.0
80-023	ORANGETHROAT DARTER	I		S	D	1	1.5	0.56	3	0.00	2.0

No Species: 23 **Nat. Species:** 22 **Hybrids:** 0 **Total Counted:** 178 **Total Rel. Wt. :** 74452

IBI: 36.0 **MIwb:** 7.6

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 11.30 Date: 10/06/2016

Time Fished: 2065 Distance: 0.200 Drainge (sq mi): 73.9 Depth: 0

Location: Lat: 39.21122 Long: -84.45616

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		1	1.5	0.80	120	0.35	80.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	23	34.5	18.40	3420	9.96	99.1
40-016	WHITE SUCKER	O	T	S	W	1	1.5	0.80	225	0.66	150.0
43-001	COMMON CARP	O	T	M	G	12	18.0	9.60	27300	79.52	1516.6
43-025	STRIPED SHINER	I		S	N	3	4.5	2.40	75	0.22	16.6
43-032	SPOTFIN SHINER	I		M	N	12	18.0	9.60	52	0.15	2.9
43-043	BLUNTNOSE MINNOW	O	T	C	N	1	1.5	0.80	6	0.02	4.0
43-044	CENTRAL STONEROLLER	H		N	N	7	10.5	5.60	90	0.26	8.5
47-002	CHANNEL CATFISH			C	F	1	1.5	0.80	127	0.37	85.0
47-004	YELLOW BULLHEAD	I	T	C		3	4.5	2.40	195	0.57	43.3
47-007	FLATHEAD CATFISH	P		C	F	1	1.5	0.80	810	2.36	540.0
77-004	SMALLMOUTH BASS	C	M	C	F	1	1.5	0.80	315	0.92	210.0
77-005	SPOTTED BASS	C		C	F	1	1.5	0.80	120	0.35	80.0
77-006	LARGEMOUTH BASS	C		C	F	1	1.5	0.80	15	0.04	10.0
77-008	GREEN SUNFISH	I	T	C	S	32	48.0	25.60	1080	3.15	22.5
77-009	BLUEGILL SUNFISH	I	P	C	S	3	4.5	2.40	7	0.02	1.6
77-011	LONGEAR SUNFISH	I	M	C	S	6	9.0	4.80	255	0.74	28.3
77-013	PUMPKINSEED SUNFISH	I	P	C	S	9	13.5	7.20	105	0.31	7.7
80-014	JOHNNY DARTER	I		C	D	7	10.5	5.60	10	0.03	1.0

No Species: 19 **Nat. Species:** 18 **Hybrids:** 0 **Total Counted:** 125 **Total Rel. Wt. :** 34329

IBI: 36.0 **MIwb:** 6.4

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 13.20 Date: 07/27/2016

Time Fished: 1274 Distance: 0.200 Drainge (sq mi): 72.2 Depth: 0

Location: dst. W. Columbia Rd. Lat: 39.22937 Long: -84.44625

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	11	16.5	8.40	1995	4.89	120.9
40-016	WHITE SUCKER	O	T	S	W	45	67.5	34.35	10230	25.05	151.5
43-001	COMMON CARP	O	T	M	G	6	9.0	4.58	25800	63.18	2866.6
43-032	SPOTFIN SHINER	I		M	N	8	12.0	6.11	30	0.07	2.5
47-002	CHANNEL CATFISH			C	F	1	1.5	0.76	52	0.13	35.0
47-004	YELLOW BULLHEAD	I	T	C		4	6.0	3.05	787	1.93	131.2
47-007	FLATHEAD CATFISH	P		C	F	1	1.5	0.76	75	0.18	50.0
77-002	BLACK CRAPPIE	I		C	S	1	1.5	0.76	30	0.07	20.0
77-006	LARGEMOUTH BASS	C		C	F	1	1.5	0.76	127	0.31	85.0
77-008	GREEN SUNFISH	I	T	C	S	25	37.5	19.08	1140	2.79	30.4
77-009	BLUEGILL SUNFISH	I	P	C	S	11	16.5	8.40	360	0.88	21.8
77-013	PUMPKINSEED SUNFISH	I	P	C	S	11	16.5	8.40	195	0.48	11.8
80-014	JOHNNY DARTER	I		C	D	6	9.0	4.58	12	0.03	1.3

No Species: 13 **Nat. Species:** 12 **Hybrids:** 0 **Total Counted:** 131 **Total Rel. Wt. :** 40834

IBI: 30.0 **MIwb:** 5.8

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 13.20 Date: 10/10/2016

Time Fished: 1369 Distance: 0.200 Drainge (sq mi): 72.2 Depth: 0

Location: dst. W. Columbia Rd. Lat: 39.22937 Long: -84.44625

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	14	21.0	12.73	2220	8.29	105.7
40-016	WHITE SUCKER	O	T	S	W	49	73.5	44.55	8160	30.48	111.0
43-001	COMMON CARP	O	T	M	G	4	6.0	3.64	11835	44.21	1972.5
47-002	CHANNEL CATFISH			C	F	1	1.5	0.91	165	0.62	110.0
47-004	YELLOW BULLHEAD	I	T	C		8	12.0	7.27	840	3.14	70.0
47-007	FLATHEAD CATFISH	P		C	F	1	1.5	0.91	2745	10.25	1830.0
77-006	LARGEMOUTH BASS	C		C	F	1	1.5	0.91	22	0.08	15.0
77-008	GREEN SUNFISH	I	T	C	S	11	16.5	10.00	360	1.34	21.8
77-009	BLUEGILL SUNFISH	I	P	C	S	4	6.0	3.64	60	0.22	10.0
77-013	PUMPKINSEED SUNFISH	I	P	C	S	16	24.0	14.55	360	1.34	15.0
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.91	3	0.01	2.0

No Species: 11 **Nat. Species:** 10 **Hybrids:** 0 **Total Counted:** 110 **Total Rel. Wt. :** 26770

IBI: 24.0 **MIwb:** 6.1

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 13.70 Date: 07/27/2016

Time Fished: 1815 Distance: 0.200 Drainge (sq mi): 71.6 Depth: 0

Location: Immediately dst. CSO700 outfall Lat: 0.00000 Long: 0.00000

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	25	37.5	5.24	3075	22.42	82.0
40-016	WHITE SUCKER	O	T	S	W	41	61.5	8.60	2280	16.62	37.0
43-001	COMMON CARP	O	T	M	G	1	1.5	0.21	3000	21.87	2000.0
43-013	CREEK CHUB	G	T	N	N	6	9.0	1.26	157	1.15	17.5
43-025	STRIPED SHINER	I		S	N	1	1.5	0.21	3	0.02	2.0
43-032	SPOTFIN SHINER	I		M	N	12	18.0	2.52	120	0.87	6.6
43-034	SAND SHINER	I	M	M	N	22	33.0	4.61	82	0.60	2.5
43-043	BLUNTNOSE MINNOW	O	T	C	N	7	10.5	1.47	45	0.33	4.2
43-044	CENTRAL STONEROLLER	H		N	N	336	504.0	70.44	3787	27.61	7.5
47-004	YELLOW BULLHEAD	I	T	C		3	4.5	0.63	367	2.68	81.6
77-006	LARGEMOUTH BASS	C		C	F	3	4.5	0.63	244	1.78	54.3
77-008	GREEN SUNFISH	I	T	C	S	8	12.0	1.68	427	3.12	35.6
77-013	PUMPKINSEED SUNFISH	I	P	C	S	3	4.5	0.63	105	0.77	23.3
80-014	JOHNNY DARTER	I		C	D	6	9.0	1.26	15	0.11	1.6
80-024	FANTAIL DARTER	I		C	D	3	4.5	0.63	6	0.04	1.3

No Species: 15 **Nat. Species:** 14 **Hybrids:** 0 **Total Counted:** 477 **Total Rel. Wt. :** 13716

IBI: 30.0 **MIwb:** 7.2

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 13.70 Date: 10/10/2016

Time Fished: 1603 Distance: 0.200 Drainge (sq mi): 71.6 Depth: 0

Location: Immediately dst. CSO700 outfall Lat: 0.00000 Long: 0.00000

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	25	37.5	16.13	5775	36.30	154.0
40-016	WHITE SUCKER	O	T	S	W	16	24.0	10.32	1650	10.37	68.7
43-001	COMMON CARP	O	T	M	G	2	3.0	1.29	6645	41.77	2215.0
43-011	WESTERN BLACKNOSE DACE	G	T	S	N	2	3.0	1.29	4	0.03	1.5
43-013	CREEK CHUB	G	T	N	N	1	1.5	0.65	67	0.42	45.0
43-032	SPOTFIN SHINER	I		M	N	1	1.5	0.65	15	0.09	10.0
43-034	SAND SHINER	I	M	M	N	3	4.5	1.94	9	0.06	2.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	4	6.0	2.58	10	0.07	1.7
43-044	CENTRAL STONEROLLER	H		N	N	93	139.5	60.00	1290	8.11	9.2
47-004	YELLOW BULLHEAD	I	T	C		2	3.0	1.29	127	0.80	42.5
77-006	LARGEMOUTH BASS	C		C	F	2	3.0	1.29	255	1.60	85.0
77-008	GREEN SUNFISH	I	T	C	S	1	1.5	0.65	52	0.33	35.0
80-023	ORANGETHROAT DARTER	I		S	D	2	3.0	1.29	4	0.03	1.5
80-024	FANTAIL DARTER	I		C	D	1	1.5	0.65	3	0.02	2.0

No Species: 14 **Nat. Species:** 13 **Hybrids:** 0 **Total Counted:** 155 **Total Rel. Wt. :** 15909

IBI: 28.0 **MIwb:** 6.4

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 13.90 Date: 07/27/2016

Time Fished: 1822 Distance: 0.200 Drainge (sq mi): 68.8 Depth: 0

Location: behind asphalt company on Cavett Dr. Lat: 39.23729 Long: -84.43925

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-010	GOLDEN REDHORSE	I	M	S	R	3	4.5	0.79	3525	8.66	783.3
40-015	NORTHERN HOG SUCKER	I	M	S	R	35	52.5	9.16	7200	17.69	137.1
40-016	WHITE SUCKER	O	T	S	W	40	60.0	10.47	3142	7.72	52.3
43-001	COMMON CARP	O	T	M	G	7	10.5	1.83	19950	49.02	1900.0
43-013	CREEK CHUB	G	T	N	N	2	3.0	0.52	6	0.01	2.0
43-032	SPOTFIN SHINER	I		M	N	23	34.5	6.02	180	0.44	5.2
43-034	SAND SHINER	I	M	M	N	3	4.5	0.79	9	0.02	2.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	5	7.5	1.31	30	0.07	4.0
43-044	CENTRAL STONEROLLER	H		N	N	229	343.5	59.95	2572	6.32	7.4
47-002	CHANNEL CATFISH			C	F	1	1.5	0.26	1500	3.69	1000.0
47-004	YELLOW BULLHEAD	I	T	C		4	6.0	1.05	1297	3.19	216.2
77-002	BLACK CRAPPIE	I		C	S	1	1.5	0.26	60	0.15	40.0
77-006	LARGEMOUTH BASS	C		C	F	4	6.0	1.05	367	0.90	61.2
77-008	GREEN SUNFISH	I	T	C	S	9	13.5	2.36	540	1.33	40.0
77-009	BLUEGILL SUNFISH	I	P	C	S	2	3.0	0.52	150	0.37	50.0
77-013	PUMPKINSEED SUNFISH	I	P	C	S	5	7.5	1.31	150	0.37	20.0
80-014	JOHNNY DARTER	I		C	D	5	7.5	1.31	12	0.03	1.6
80-024	FANTAIL DARTER	I		C	D	4	6.0	1.05	9	0.02	1.5

No Species: 18 **Nat. Species:** 17 **Hybrids:** 0 **Total Counted:** 382 **Total Rel. Wt. :** 40701

IBI: 36.0 **MIwb:** 7.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 13.90 Date: 10/10/2016

Time Fished: 0 Distance: 0.200 Drainge (sq mi): 68.8 Depth: 0

Location: behind asphalt company on Cavett Dr. Lat: 39.23729 Long: -84.43925

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-010	GOLDEN REDHORSE	I	M	S	R	1	1.5	0.28	1050	2.81	700.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	48	72.0	13.41	8887	23.74	123.4
40-016	WHITE SUCKER	O	T	S	W	33	49.5	9.22	2220	5.93	44.8
43-001	COMMON CARP	O	T	M	G	7	10.5	1.96	17745	47.41	1690.0
43-002	GOLDFISH	O	T	M	G	2	3.0	0.56	720	1.92	240.0
43-032	SPOTFIN SHINER	I		M	N	10	15.0	2.79	75	0.20	5.0
43-034	SAND SHINER	I	M	M	N	1	1.5	0.28	1	0.00	1.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	8	12.0	2.23	37	0.10	3.1
43-044	CENTRAL STONEROLLER	H		N	N	187	280.5	52.23	2790	7.45	9.9
47-004	YELLOW BULLHEAD	I	T	C		7	10.5	1.96	1890	5.05	180.0
77-008	GREEN SUNFISH	I	T	C	S	23	34.5	6.42	1260	3.37	36.5
77-009	BLUEGILL SUNFISH	I	P	C	S	3	4.5	0.84	90	0.24	20.0
77-013	PUMPKINSEED SUNFISH	I	P	C	S	12	18.0	3.35	345	0.92	19.1
77-015	GREEN SF X BLUEGILL SF					1	1.5	0.28	120	0.32	80.0
77-016	GREEN SF X PUMPKINSEED					3	4.5	0.84	165	0.44	36.6
80-014	JOHNNY DARTER	I		C	D	8	12.0	2.23	15	0.04	1.2
80-023	ORANGETHROAT DARTER	I		S	D	1	1.5	0.28	3	0.01	2.0
80-024	FANTAIL DARTER	I		C	D	3	4.5	0.84	15	0.04	3.3

No Species: 16 **Nat. Species:** 14 **Hybrids:** 2 **Total Counted:** 358 **Total Rel. Wt. :** 37429

IBI: 34.0 **MIwb:** 7.6

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 14.80 Date: 08/02/2016

Time Fished: 1931 Distance: 0.150 Drainge (sq mi): 68.8 Depth: 0

Location: Ust. Formica entrance Rd. @ Mr. Clean Car Wash Lat: 39.24810 Long: -84.42725

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		2	4.0	1.82	380	1.30	95.0
40-016	WHITE SUCKER	O	T	S	W	5	10.0	4.55	1080	3.68	108.0
43-001	COMMON CARP	O	T	M	G	7	14.0	6.36	23640	80.57	1688.5
43-002	GOLDFISH	O	T	M	G	1	2.0	0.91	300	1.02	150.0
77-002	BLACK CRAPPIE	I		C	S	1	2.0	0.91	60	0.20	30.0
77-006	LARGEMOUTH BASS	C		C	F	7	14.0	6.36	20	0.07	1.4
77-008	GREEN SUNFISH	I	T	C	S	68	136.0	61.82	3470	11.83	25.5
77-009	BLUEGILL SUNFISH	I	P	C	S	14	28.0	12.73	240	0.82	8.5
77-013	PUMPKINSEED SUNFISH	I	P	C	S	4	8.0	3.64	150	0.51	18.7
80-014	JOHNNY DARTER	I		C	D	1	2.0	0.91	2	0.01	1.0

No Species: 10 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 110 **Total Rel. Wt. :** 29342

IBI: 28.0 **MIwb:** 4.1

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 14.80 Date: 10/05/2016

Time Fished: 1216 Distance: 0.150 Drainge (sq mi): 68.8 Depth: 0

Location: Ust. Formica entrance Rd. @ Mr. Clean Car Wash Lat: 39.24810 Long: -84.42725

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		13	26.0	12.75	3140	16.61	120.7
40-016	WHITE SUCKER	O	T	S	W	3	6.0	2.94	600	3.17	100.0
43-001	COMMON CARP	O	T	M	G	3	6.0	2.94	10640	56.30	1773.3
43-002	GOLDFISH	O	T	M	G	1	2.0	0.98	830	4.39	415.0
47-004	YELLOW BULLHEAD	I	T	C		2	4.0	1.96	760	4.02	190.0
77-006	LARGEMOUTH BASS	C		C	F	3	6.0	2.94	370	1.96	61.6
77-008	GREEN SUNFISH	I	T	C	S	63	126.0	61.76	1920	10.16	15.2
77-009	BLUEGILL SUNFISH	I	P	C	S	11	22.0	10.78	510	2.70	23.1
77-013	PUMPKINSEED SUNFISH	I	P	C	S	1	2.0	0.98	60	0.32	30.0
77-015	GREEN SF X BLUEGILL SF					2	4.0	1.96	70	0.37	17.5

No Species: 9 **Nat. Species:** 7 **Hybrids:** 1 **Total Counted:** 102 **Total Rel. Wt. :** 18900

IBI: 22.0 **MIwb:** 5.4

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 16.60 Date: 08/02/2016

Time Fished: 1558 Distance: 0.200 Drainge (sq mi): 50.5 Depth: 0

Location: Ust. E. Sharon Rd. Lat: 39.26966 Long: -84.43209

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		13	19.5	11.40	1860	11.71	95.3
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	3.0	1.75	270	1.70	90.0
40-016	WHITE SUCKER	O	T	S	W	22	33.0	19.30	3742	23.56	113.4
43-001	COMMON CARP	O	T	M	G	3	4.5	2.63	7800	49.10	1733.3
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.88	75	0.47	50.0
77-006	LARGEMOUTH BASS	C		C	F	6	9.0	5.26	112	0.71	12.5
77-008	GREEN SUNFISH	I	T	C	S	41	61.5	35.96	1290	8.12	20.9
77-009	BLUEGILL SUNFISH	I	P	C	S	24	36.0	21.05	682	4.30	18.9
77-015	GREEN SF X BLUEGILL SF					1	1.5	0.88	52	0.33	35.0
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.88	1	0.01	1.0

No Species: 9 **Nat. Species:** 8 **Hybrids:** 1 **Total Counted:** 114 **Total Rel. Wt. :** 15886

IBI: 28.0 **MIwb:** 5.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 16.60 Date: 10/05/2016

Time Fished: 2050 Distance: 0.200 Drainge (sq mi): 50.5 Depth: 0

Location: Ust. E. Sharon Rd. Lat: 39.26966 Long: -84.43209

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		1	1.5	0.84	210	0.78	140.0
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	3.0	1.68	270	1.00	90.0
40-016	WHITE SUCKER	O	T	S	W	11	16.5	9.24	1755	6.50	106.3
43-001	COMMON CARP	O	T	M	G	7	10.5	5.88	19950	73.89	1900.0
43-002	GOLDFISH	O	T	M	G	1	1.5	0.84	525	1.94	350.0
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.84	405	1.50	270.0
77-002	BLACK CRAPPIE	I		C	S	2	3.0	1.68	75	0.28	25.0
77-006	LARGEMOUTH BASS	C		C	F	4	6.0	3.36	585	2.17	97.5
77-008	GREEN SUNFISH	I	T	C	S	48	72.0	40.34	2325	8.61	32.2
77-009	BLUEGILL SUNFISH	I	P	C	S	42	63.0	35.29	900	3.33	14.2

No Species: 10 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 119 **Total Rel. Wt. :** 27000

IBI: 26.0 **MIwb:** 5.1

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 17.90 Date: 08/01/2016

Time Fished: 1458 Distance: 0.200 Drainge (sq mi): 42.2 Depth: 0

Location: RR trestle dst. East Fork Mill Creek Lat: 0.00000 Long: 0.00000

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		6	9.0	2.35	64	0.41	7.1
40-015	NORTHERN HOG SUCKER	I	M	S	R	7	10.5	2.75	870	5.53	82.8
40-016	WHITE SUCKER	O	T	S	W	25	37.5	9.80	2280	14.49	60.8
43-001	COMMON CARP	O	T	M	G	3	4.5	1.18	8062	51.24	1791.6
43-013	CREEK CHUB	G	T	N	N	1	1.5	0.39	4	0.03	3.0
43-025	STRIPED SHINER	I		S	N	2	3.0	0.78	15	0.10	5.0
43-032	SPOTFIN SHINER	I		M	N	19	28.5	7.45	123	0.78	4.3
43-034	SAND SHINER	I	M	M	N	1	1.5	0.39	3	0.02	2.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	1	1.5	0.39	4	0.03	3.0
43-044	CENTRAL STONEROLLER	H		N	N	51	76.5	20.00	225	1.43	2.9
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.39	45	0.29	30.0
77-002	BLACK CRAPPIE	I		C	S	1	1.5	0.39	30	0.19	20.0
77-006	LARGEMOUTH BASS	C		C	F	19	28.5	7.45	1005	6.39	35.2
77-008	GREEN SUNFISH	I	T	C	S	47	70.5	18.43	1515	9.63	21.4
77-009	BLUEGILL SUNFISH	I	P	C	S	53	79.5	20.78	1455	9.25	18.3
80-014	JOHNNY DARTER	I		C	D	4	6.0	1.57	7	0.05	1.2
80-023	ORANGETHROAT DARTER	I		S	D	14	21.0	5.49	24	0.15	1.1

No Species: 17 **Nat. Species:** 16 **Hybrids:** 0 **Total Counted:** 255 **Total Rel. Wt. :** 15733

IBI: 38.0 **MIwb:** 7.1

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 17.90 Date: 10/05/2016

Time Fished: 1331 Distance: 0.200 Drainge (sq mi): 42.2 Depth: 0

Location: RR trestle dst. East Fork Mill Creek Lat: 0.00000 Long: 0.00000

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	14	21.0	5.81	3052	34.68	145.3
40-016	WHITE SUCKER	O	T	S	W	18	27.0	7.47	1920	21.81	71.1
43-025	STRIPED SHINER	I		S	N	10	15.0	4.15	150	1.70	10.0
43-032	SPOTFIN SHINER	I		M	N	42	63.0	17.43	174	1.98	2.7
43-034	SAND SHINER	I	M	M	N	19	28.5	7.88	72	0.82	2.5
43-043	BLUNTNOSE MINNOW	O	T	C	N	5	7.5	2.07	10	0.12	1.4
43-044	CENTRAL STONEROLLER	H		N	N	28	42.0	11.62	330	3.75	7.8
47-004	YELLOW BULLHEAD	I	T	C		4	6.0	1.66	667	7.58	111.2
77-002	BLACK CRAPPIE	I		C	S	1	1.5	0.41	52	0.60	35.0
77-006	LARGEMOUTH BASS	C		C	F	5	7.5	2.07	652	7.41	87.0
77-008	GREEN SUNFISH	I	T	C	S	50	75.0	20.75	825	9.37	11.0
77-009	BLUEGILL SUNFISH	I	P	C	S	40	60.0	16.60	840	9.54	14.0
77-016	GREEN SF X PUMPKINSEED					1	1.5	0.41	45	0.51	30.0
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.41	3	0.03	2.0
80-023	ORANGETHROAT DARTER	I		S	D	3	4.5	1.24	7	0.09	1.6

No Species: 14 **Nat. Species:** 14 **Hybrids:** 1 **Total Counted:** 241 **Total Rel. Wt. :** 8802

IBI: 34.0 **MIwb:** 7.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 18.10 Date: 08/01/2016

Time Fished: 1813 Distance: 0.200 Drainge (sq mi): 32.4 Depth: 0

Location: 200 m Ust. confluence of E.Fk Mill Creek Lat: 39.29110 Long: -84.43530

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		40	60.0	20.00	4140	33.02	69.0
40-016	WHITE SUCKER	O	T	S	W	10	15.0	5.00	1335	10.65	89.0
43-001	COMMON CARP	O	T	M	G	1	1.5	0.50	1725	13.76	1150.0
43-025	STRIPED SHINER	I		S	N	2	3.0	1.00	6	0.05	2.0
43-032	SPOTFIN SHINER	I		M	N	9	13.5	4.50	60	0.48	4.4
43-034	SAND SHINER	I	M	M	N	4	6.0	2.00	15	0.12	2.5
43-043	BLUNTNOSE MINNOW	O	T	C	N	2	3.0	1.00	7	0.06	2.5
43-044	CENTRAL STONEROLLER	H		N	N	5	7.5	2.50	15	0.12	2.0
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.50	315	2.51	210.0
77-006	LARGEMOUTH BASS	C		C	F	22	33.0	11.00	1125	8.97	34.0
77-008	GREEN SUNFISH	I	T	C	S	28	42.0	14.00	1020	8.14	24.2
77-009	BLUEGILL SUNFISH	I	P	C	S	69	103.5	34.50	2595	20.70	25.0
77-013	PUMPKINSEED SUNFISH	I	P	C	S	2	3.0	1.00	52	0.42	17.5
77-015	GREEN SF X BLUEGILL SF					1	1.5	0.50	120	0.96	80.0
80-014	JOHNNY DARTER	I		C	D	2	3.0	1.00	3	0.02	1.0
80-023	ORANGETHROAT DARTER	I		S	D	2	3.0	1.00	3	0.02	1.0

No Species: 15 **Nat. Species:** 14 **Hybrids:** 1 **Total Counted:** 200 **Total Rel. Wt. :** 12537

IBI: 34.0 **MIwb:** 7.3

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 18.10 Date: 10/04/2016

Time Fished: 2306 Distance: 0.200 Drainge (sq mi): 32.4 Depth: 0

Location: 200 m Ust. confluence of E.Fk Mill Creek Lat: 39.29110 Long: -84.43530

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		29	43.5	11.79	2707	14.10	62.2
40-015	NORTHERN HOG SUCKER	I	M	S	R	7	10.5	2.85	1350	7.03	128.5
40-016	WHITE SUCKER	O	T	S	W	19	28.5	7.72	3435	17.89	120.5
43-001	COMMON CARP	O	T	M	G	1	1.5	0.41	885	4.61	590.0
43-032	SPOTFIN SHINER	I		M	N	15	22.5	6.10	90	0.47	4.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	19	28.5	7.72	60	0.31	2.1
47-004	YELLOW BULLHEAD	I	T	C		1	1.5	0.41	45	0.23	30.0
77-006	LARGEMOUTH BASS	C		C	F	31	46.5	12.60	6937	36.12	149.1
77-008	GREEN SUNFISH	I	T	C	S	42	63.0	17.07	1275	6.64	20.2
77-009	BLUEGILL SUNFISH	I	P	C	S	75	112.5	30.49	2175	11.32	19.3
77-015	GREEN SF X BLUEGILL SF					4	6.0	1.63	240	1.25	40.0
80-014	JOHNNY DARTER	I		C	D	3	4.5	1.22	6	0.03	1.3

No Species: 11 **Nat. Species:** 10 **Hybrids:** 1 **Total Counted:** 246 **Total Rel. Wt. :** 19206

IBI: 36.0 **MIwb:** 7.7

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 18.70 Date: 07/26/2016

Time Fished: 1750 Distance: 0.200 Drainge (sq mi): 27.0 Depth: 0

Location: Dst. bridge E. Cresentview Rd. Lat: 39.29916 Long: -84.43436

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		49	73.5	18.49	3075	24.06	41.8
40-015	NORTHERN HOG SUCKER	I	M	S	R	1	1.5	0.38	3	0.02	2.0
40-016	WHITE SUCKER	O	T	S	W	19	28.5	7.17	3510	27.46	123.1
43-032	SPOTFIN SHINER	I		M	N	60	90.0	22.64	450	3.52	5.0
43-034	SAND SHINER	I	M	M	N	2	3.0	0.75	6	0.05	2.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	15	22.5	5.66	90	0.70	4.0
47-002	CHANNEL CATFISH			C	F	1	1.5	0.38	75	0.59	50.0
47-004	YELLOW BULLHEAD	I	T	C		5	7.5	1.89	622	4.87	83.0
77-006	LARGEMOUTH BASS	C		C	F	15	22.5	5.66	1297	10.15	57.6
77-008	GREEN SUNFISH	I	T	C	S	36	54.0	13.58	1275	9.98	23.6
77-009	BLUEGILL SUNFISH	I	P	C	S	54	81.0	20.38	2100	16.43	25.9
77-015	GREEN SF X BLUEGILL SF					4	6.0	1.51	270	2.11	45.0
80-014	JOHNNY DARTER	I		C	D	4	6.0	1.51	7	0.06	1.2

No Species: 12 **Nat. Species:** 12 **Hybrids:** 1 **Total Counted:** 265 **Total Rel. Wt. :** 12781

IBI: 38.0 **MIwb:** 7.5

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 18.70 Date: 10/03/2016

Time Fished: 2022 Distance: 0.200 Drainge (sq mi): 27.0 Depth: 0

Location: Dst. bridge E. Cresentview Rd. Lat: 39.29916 Long: -84.43436

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		37	55.5	16.23	5122	26.80	92.2
40-015	NORTHERN HOG SUCKER	I	M	S	R	3	4.5	1.32	465	2.43	103.3
40-016	WHITE SUCKER	O	T	S	W	21	31.5	9.21	3172	16.60	100.7
43-001	COMMON CARP	O	T	M	G	2	3.0	0.88	6000	31.39	2000.0
43-032	SPOTFIN SHINER	I		M	N	22	33.0	9.65	112	0.59	3.4
43-034	SAND SHINER	I	M	M	N	1	1.5	0.44	3	0.02	2.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	19	28.5	8.33	45	0.24	1.5
47-002	CHANNEL CATFISH			C	F	1	1.5	0.44	10	0.05	7.0
47-004	YELLOW BULLHEAD	I	T	C		7	10.5	3.07	712	3.73	67.8
77-006	LARGEMOUTH BASS	C		C	F	9	13.5	3.95	667	3.49	49.4
77-008	GREEN SUNFISH	I	T	C	S	46	69.0	20.18	1305	6.83	18.9
77-009	BLUEGILL SUNFISH	I	P	C	S	53	79.5	23.25	1350	7.06	16.9
77-013	PUMPKINSEED SUNFISH	I	P	C	S	1	1.5	0.44	37	0.20	25.0
77-015	GREEN SF X BLUEGILL SF					4	6.0	1.75	105	0.55	17.5
80-014	JOHNNY DARTER	I		C	D	2	3.0	0.88	6	0.03	2.0

No Species: 14 **Nat. Species:** 13 **Hybrids:** 1 **Total Counted:** 228 **Total Rel. Wt. :** 19114

IBI: 28.0 **MIwb:** 7.5

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 19.10 Date: 07/26/2016

Time Fished: 1571 Distance: 0.200 Drainge (sq mi): 26.5 Depth: 0

Location: Dst. Ikea retention pond spillway Lat: 39.31212 Long: -84.43501

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		8	12.0	2.58	510	7.05	42.5
40-015	NORTHERN HOG SUCKER	I	M	S	R	6	9.0	1.94	540	7.46	60.0
40-016	WHITE SUCKER	O	T	S	W	39	58.5	12.58	1575	21.76	26.9
43-013	CREEK CHUB	G	T	N	N	12	18.0	3.87	360	4.97	20.0
43-025	STRIPED SHINER	I		S	N	11	16.5	3.55	352	4.87	21.3
43-032	SPOTFIN SHINER	I		M	N	37	55.5	11.94	240	3.32	4.3
43-034	SAND SHINER	I	M	M	N	21	31.5	6.77	112	1.55	3.5
43-043	BLUNTNOSE MINNOW	O	T	C	N	19	28.5	6.13	120	1.66	4.2
43-044	CENTRAL STONEROLLER	H		N	N	49	73.5	15.81	420	5.80	5.7
47-002	CHANNEL CATFISH			C	F	1	1.5	0.32	3	0.04	2.0
47-004	YELLOW BULLHEAD	I	T	C		4	6.0	1.29	397	5.49	66.2
47-006	BLACK BULLHEAD	I	P	C		1	1.5	0.32	90	1.24	60.0
77-006	LARGEMOUTH BASS	C		C	F	39	58.5	12.58	510	7.05	8.7
77-008	GREEN SUNFISH	I	T	C	S	31	46.5	10.00	802	11.09	17.2
77-009	BLUEGILL SUNFISH	I	P	C	S	26	39.0	8.39	1192	16.48	30.5
77-011	LONGEAR SUNFISH	I	M	C	S	1	1.5	0.32	3	0.04	2.0
80-014	JOHNNY DARTER	I		C	D	4	6.0	1.29	7	0.10	1.2
80-024	FANTAIL DARTER	I		C	D	1	1.5	0.32	1	0.02	1.0

No Species: 18 **Nat. Species:** 18 **Hybrids:** 0 **Total Counted:** 310 **Total Rel. Wt. :** 7237

IBI: 38.0 **MIwb:** 8.4

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 19.10 Date: 10/03/2016

Time Fished: 1894 Distance: 0.200 Drainge (sq mi): 26.5 Depth: 0

Location: Dst. Ikea retention pond spillway Lat: 39.31212 Long: -84.43501

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
20-003	GIZZARD SHAD	O		M		6	9.0	3.31	300	1.88	33.3
40-015	NORTHERN HOG SUCKER	I	M	S	R	10	15.0	5.52	1275	8.00	85.0
40-016	WHITE SUCKER	O	T	S	W	16	24.0	8.84	2085	13.07	86.8
43-001	COMMON CARP	O	T	M	G	4	6.0	2.21	8745	54.84	1457.5
43-013	CREEK CHUB	G	T	N	N	3	4.5	1.66	52	0.33	11.6
43-025	STRIPED SHINER	I		S	N	1	1.5	0.55	37	0.24	25.0
43-032	SPOTFIN SHINER	I		M	N	42	63.0	23.20	1050	6.58	16.6
43-034	SAND SHINER	I	M	M	N	4	6.0	2.21	15	0.09	2.5
43-043	BLUNTNOSE MINNOW	O	T	C	N	6	9.0	3.31	30	0.19	3.3
43-044	CENTRAL STONEROLLER	H		N	N	8	12.0	4.42	30	0.19	2.5
47-002	CHANNEL CATFISH			C	F	1	1.5	0.55	30	0.19	20.0
47-004	YELLOW BULLHEAD	I	T	C		4	6.0	2.21	195	1.22	32.5
77-002	BLACK CRAPPIE	I		C	S	1	1.5	0.55	22	0.14	15.0
77-006	LARGEMOUTH BASS	C		C	F	11	16.5	6.08	210	1.32	12.7
77-008	GREEN SUNFISH	I	T	C	S	41	61.5	22.65	1425	8.94	23.1
77-009	BLUEGILL SUNFISH	I	P	C	S	21	31.5	11.60	435	2.73	13.8
77-015	GREEN SF X BLUEGILL SF					1	1.5	0.55	7	0.05	5.0
80-014	JOHNNY DARTER	I		C	D	1	1.5	0.55	1	0.01	1.0

No Species: 17 **Nat. Species:** 16 **Hybrids:** 1 **Total Counted:** 181 **Total Rel. Wt. :** 15946

IBI: 32.0 **MIwb:** 7.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 26.40 Date: 08/02/2016

Time Fished: 1508 Distance: 0.150 Drainge (sq mi): 4.1 Depth: 0

Location: Liberty-Fairfield Rd. Lat: 39.37640 Long: -84.47830

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	4.0	0.46	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	69	138.0	16.01	0	0.00	0.0
43-011	WESTERN BLACKNOSE DACE	G	T	S	N	1	2.0	0.23	0	0.00	0.0
43-013	CREEK CHUB	G	T	N	N	14	28.0	3.25	0	0.00	0.0
43-025	STRIPED SHINER	I		S	N	14	28.0	3.25	0	0.00	0.0
43-044	CENTRAL STONEROLLER	H		N	N	98	196.0	22.74	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		4	8.0	0.93	0	0.00	0.0
47-006	BLACK BULLHEAD	I	P	C		15	30.0	3.48	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	4	8.0	0.93	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	31	62.0	7.19	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	39	78.0	9.05	0	0.00	0.0
77-015	GREEN SF X BLUEGILL SF					1	2.0	0.23	0	0.00	0.0
80-014	JOHNNY DARTER	I		C	D	31	62.0	7.19	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	108	216.0	25.06	0	0.00	0.0

No Species: 13 **Nat. Species:** 13 **Hybrids:** 1 **Total Counted:** 431 **Total Rel. Wt. :** 0

IBI: 42.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-001 Mill Creek RM: 26.40 Date: 10/03/2016

Time Fished: 1741 Distance: 0.150 Drainge (sq mi): 4.1 Depth: 0

Location: Liberty-Fairfield Rd. Lat: 39.37640 Long: -84.47830

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	1	2.0	0.24	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	44	88.0	10.76	0	0.00	0.0
43-001	COMMON CARP	O	T	M	G	1	2.0	0.24	0	0.00	0.0
43-013	CREEK CHUB	G	T	N	N	7	14.0	1.71	0	0.00	0.0
43-025	STRIPED SHINER	I		S	N	4	8.0	0.98	0	0.00	0.0
43-044	CENTRAL STONEROLLER	H		N	N	69	138.0	16.87	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		13	26.0	3.18	0	0.00	0.0
47-006	BLACK BULLHEAD	I	P	C		27	54.0	6.60	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	5	10.0	1.22	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	48	96.0	11.74	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	97	194.0	23.72	0	0.00	0.0
77-013	PUMPKINSEED SUNFISH	I	P	C	S	1	2.0	0.24	0	0.00	0.0
77-015	GREEN SF X BLUEGILL SF					1	2.0	0.24	0	0.00	0.0
80-014	JOHNNY DARTER	I		C	D	15	30.0	3.67	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	76	152.0	18.58	0	0.00	0.0

No Species: 14 **Nat. Species:** 13 **Hybrids:** 1 **Total Counted:** 409 **Total Rel. Wt. :** 0

IBI: 40.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-004 West Fork Mill Creek (Mill Cr. RM 11.57) RM: 0.20 Date: 07/25/2016

Time Fished: 1522 Distance: 0.150 Drainge (sq mi): 36.4 Depth: 0

Location: dst. bridge at Elliot Ave. Lat: 39.21237 Long: -84.45750

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	9	18.0	2.55	1250	13.50	69.4
40-016	WHITE SUCKER	O	T	S	W	45	90.0	12.75	2800	30.23	31.1
43-013	CREEK CHUB	G	T	N	N	43	86.0	12.18	1120	12.09	13.0
43-025	STRIPED SHINER	I		S	N	1	2.0	0.28	2	0.02	1.0
43-032	SPOTFIN SHINER	I		M	N	7	14.0	1.98	60	0.65	4.2
43-043	BLUNTNOSE MINNOW	O	T	C	N	113	226.0	32.01	570	6.15	2.5
43-044	CENTRAL STONEROLLER	H		N	N	53	106.0	15.01	420	4.53	3.9
47-004	YELLOW BULLHEAD	I	T	C		2	4.0	0.57	380	4.10	95.0
77-011	LONGEAR SUNFISH	I	M	C	S	61	122.0	17.28	2620	28.29	21.4
80-014	JOHNNY DARTER	I		C	D	19	38.0	5.38	40	0.43	1.0

No Species: 10 **Nat. Species:** 10 **Hybrids:** 0 **Total Counted:** 353 **Total Rel. Wt. :** 9262

IBI: 24.0 **MIwb:** 7.2

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID:	River: 23-004	West Fork Mill Creek (Mill Cr. RM 11.57)	RM: 0.20	Date: 10/05/2016
Time Fished:	Distance:	Drainge (sq mi):	Depth:	
1746	0.150	36.4	0	
Location:		Lat:	Long:	
dst. bridge at Elliot Ave.		39.21237	-84.45750	

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	5	10.0	1.82	1200	13.81	120.0
40-016	WHITE SUCKER	O	T	S	W	26	52.0	9.49	1676	19.28	32.2
43-013	CREEK CHUB	G	T	N	N	60	120.0	21.90	1320	15.19	11.0
43-025	STRIPED SHINER	I		S	N	2	4.0	0.73	50	0.58	12.5
43-032	SPOTFIN SHINER	I		M	N	7	14.0	2.55	20	0.23	1.4
43-043	BLUNTNOSE MINNOW	O	T	C	N	76	152.0	27.74	260	2.99	1.7
43-044	CENTRAL STONEROLLER	H		N	N	16	32.0	5.84	90	1.04	2.8
47-004	YELLOW BULLHEAD	I	T	C		3	6.0	1.09	1000	11.50	166.6
77-007	WARMOUTH SUNFISH	C		C	S	1	2.0	0.36	6	0.07	3.0
77-011	LONGEAR SUNFISH	I	M	C	S	65	130.0	23.72	3050	35.09	23.4
80-014	JOHNNY DARTER	I		C	D	13	26.0	4.74	20	0.23	0.7

No Species: 11 **Nat. Species:** 11 **Hybrids:** 0 **Total Counted:** 274 **Total Rel. Wt. :** 8692

IBI: 26.0 **MIwb:** 7.0

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 0.10 Date: 10/04/2016

Time Fished: 2010 Distance: 0.150 Drainge (sq mi): 9.4 Depth: 0

Location: UST. Confluence of Mill Creek Lat: 39.28962 Long: -84.43391

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	8	16.0	5.13	3140	16.98	196.2
40-016	WHITE SUCKER	O	T	S	W	27	54.0	17.31	9540	51.60	176.6
43-032	SPOTFIN SHINER	I		M	N	3	6.0	1.92	20	0.11	3.3
43-044	CENTRAL STONEROLLER	H		N	N	1	2.0	0.64	6	0.03	3.0
47-004	YELLOW BULLHEAD	I	T	C		4	8.0	2.56	340	1.84	42.5
77-006	LARGEMOUTH BASS	C		C	F	7	14.0	4.49	160	0.87	11.4
77-008	GREEN SUNFISH	I	T	C	S	68	136.0	43.59	3140	16.98	23.0
77-009	BLUEGILL SUNFISH	I	P	C	S	32	64.0	20.51	1860	10.06	29.0
77-015	GREEN SF X BLUEGILL SF					5	10.0	3.21	280	1.51	28.0
80-014	JOHNNY DARTER	I		C	D	1	2.0	0.64	2	0.01	1.0

No Species: 9 **Nat. Species:** 9 **Hybrids:** 1 **Total Counted:** 156 **Total Rel. Wt. :** 18488

IBI: 22.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 0.40 Date: 07/29/2016

Time Fished: 1158 Distance: 0.120 Drainge (sq mi): 9.5 Depth: 0

Location: Fada Rd behind SubZero plant Lat: 39.29375 Long: -84.43004

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	9	22.5	10.23	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	7	17.5	7.95	0	0.00	0.0
43-032	SPOTFIN SHINER	I		M	N	4	10.0	4.55	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		1	2.5	1.14	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	6	15.0	6.82	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	21	52.5	23.86	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	31	77.5	35.23	0	0.00	0.0
77-015	GREEN SF X BLUEGILL SF					2	5.0	2.27	0	0.00	0.0
80-014	JOHNNY DARTER	I		C	D	2	5.0	2.27	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	5	12.5	5.68	0	0.00	0.0

No Species: 9 **Nat. Species:** 9 **Hybrids:** 1 **Total Counted:** 88 **Total Rel. Wt. :** 0

IBI: 36.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 0.70 Date: 07/29/2016

Time Fished: 1674 Distance: 0.150 Drainge (sq mi): 9.5 Depth: 0

Location: at E. Cressentview Rd. bridge Lat: 39.29810 Long: -84.42968

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	10	20.0	11.90	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	14	28.0	16.67	0	0.00	0.0
43-001	COMMON CARP	O	T	M	G	3	6.0	3.57	0	0.00	0.0
43-025	STRIPED SHINER	I		S	N	4	8.0	4.76	0	0.00	0.0
43-032	SPOTFIN SHINER	I		M	N	1	2.0	1.19	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		2	4.0	2.38	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	10	20.0	11.90	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	14	28.0	16.67	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	12	24.0	14.29	0	0.00	0.0
80-014	JOHNNY DARTER	I		C	D	8	16.0	9.52	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	5	10.0	5.95	0	0.00	0.0
80-024	FANTAIL DARTER	I		C	D	1	2.0	1.19	0	0.00	0.0

No Species: 12 **Nat. Species:** 11 **Hybrids:** 0 **Total Counted:** 84 **Total Rel. Wt. :** 0

IBI: 32.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 0.70 Date: 10/03/2016

Time Fished: 1885 Distance: 0.150 Drainge (sq mi): 9.5 Depth: 0

Location: at E. Cressentview Rd. bridge Lat: 39.29810 Long: -84.42968

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	10	20.0	12.35	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	9	18.0	11.11	0	0.00	0.0
43-001	COMMON CARP	O	T	M	G	11	22.0	13.58	0	0.00	0.0
43-025	STRIPED SHINER	I		S	N	8	16.0	9.88	0	0.00	0.0
43-032	SPOTFIN SHINER	I		M	N	3	6.0	3.70	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		2	4.0	2.47	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	4	8.0	4.94	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	30	60.0	37.04	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	4	8.0	4.94	0	0.00	0.0

No Species: 9 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 81 **Total Rel. Wt. :** 0

IBI: 24.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 1.00 Date: 07/29/2016

Time Fished: 1716 Distance: 0.150 Drainge (sq mi): 9.1 Depth: 0

Location: Lat: 39.30170 Long: -84.43110

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	2	4.0	0.45	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	131	262.0	29.77	0	0.00	0.0
43-001	COMMON CARP	O	T	M	G	14	28.0	3.18	0	0.00	0.0
43-013	CREEK CHUB	G	T	N	N	22	44.0	5.00	0	0.00	0.0
43-025	STRIPED SHINER	I		S	N	3	6.0	0.68	0	0.00	0.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	1	2.0	0.23	0	0.00	0.0
43-044	CENTRAL STONEROLLER	H		N	N	183	366.0	41.59	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		7	14.0	1.59	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	17	34.0	3.86	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	11	22.0	2.50	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	21	42.0	4.77	0	0.00	0.0
80-014	JOHNNY DARTER	I		C	D	16	32.0	3.64	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	12	24.0	2.73	0	0.00	0.0

No Species: 13 **Nat. Species:** 12 **Hybrids:** 0 **Total Counted:** 440 **Total Rel. Wt. :** 0

IBI: 32.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 1.00 Date: 10/04/2016

Time Fished: 1455 Distance: 0.150 Drainge (sq mi): 9.1 Depth: 0

Location: Lat: 39.30170 Long: -84.43110

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	6	12.0	3.16	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	38	76.0	20.00	0	0.00	0.0
43-001	COMMON CARP	O	T	M	G	15	30.0	7.89	0	0.00	0.0
43-025	STRIPED SHINER	I		S	N	8	16.0	4.21	0	0.00	0.0
43-032	SPOTFIN SHINER	I		M	N	7	14.0	3.68	0	0.00	0.0
43-044	CENTRAL STONEROLLER	H		N	N	71	142.0	37.37	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		4	8.0	2.11	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	7	14.0	3.68	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	18	36.0	9.47	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	12	24.0	6.32	0	0.00	0.0
80-014	JOHNNY DARTER	I		C	D	1	2.0	0.53	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	3	6.0	1.58	0	0.00	0.0

No Species: 12 **Nat. Species:** 11 **Hybrids:** 0 **Total Counted:** 190 **Total Rel. Wt. :** 0

IBI: 34.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 1.20 Date: 07/29/2016

Time Fished: 1072 Distance: 0.150 Drainge (sq mi): 9.5 Depth: 0

Location: Upstream WWTP outfall Lat: 39.30443 Long: -84.43085

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-015	NORTHERN HOG SUCKER	I	M	S	R	1	2.0	1.92	0	0.00	0.0
40-016	WHITE SUCKER	O	T	S	W	7	14.0	13.46	0	0.00	0.0
43-013	CREEK CHUB	G	T	N	N	5	10.0	9.62	0	0.00	0.0
43-025	STRIPED SHINER	I		S	N	1	2.0	1.92	0	0.00	0.0
43-043	BLUNTNOSE MINNOW	O	T	C	N	2	4.0	3.85	0	0.00	0.0
43-044	CENTRAL STONEROLLER	H		N	N	12	24.0	23.08	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	12	24.0	23.08	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	2	4.0	3.85	0	0.00	0.0
80-014	JOHNNY DARTER	I		C	D	1	2.0	1.92	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	9	18.0	17.31	0	0.00	0.0

No Species: 10 **Nat. Species:** 10 **Hybrids:** 0 **Total Counted:** 52 **Total Rel. Wt. :** 0

IBI: 34.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-006 East Fork Mill Creek RM: 1.20 Date: 10/04/2016

Time Fished: 1531 Distance: 0.150 Drainge (sq mi): 9.5 Depth: 0

Location: Upstream WWTP outfall Lat: 39.30443 Long: -84.43085

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
40-016	WHITE SUCKER	O	T	S	W	4	8.0	4.71	0	0.00	0.0
43-013	CREEK CHUB	G	T	N	N	1	2.0	1.18	0	0.00	0.0
43-044	CENTRAL STONEROLLER	H		N	N	15	30.0	17.65	0	0.00	0.0
47-004	YELLOW BULLHEAD	I	T	C		1	2.0	1.18	0	0.00	0.0
57-001	WESTERN MOSQUITOFISH	I		N	E	1	2.0	1.18	0	0.00	0.0
77-006	LARGEMOUTH BASS	C		C	F	11	22.0	12.94	0	0.00	0.0
77-008	GREEN SUNFISH	I	T	C	S	37	74.0	43.53	0	0.00	0.0
77-009	BLUEGILL SUNFISH	I	P	C	S	6	12.0	7.06	0	0.00	0.0
80-023	ORANGETHROAT DARTER	I		S	D	9	18.0	10.59	0	0.00	0.0

No Species: 9 **Nat. Species:** 8 **Hybrids:** 0 **Total Counted:** 85 **Total Rel. Wt. :** 0

IBI: 28.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-017 Bloody Run RM: 0.20 Date: 08/02/2016

Time Fished: 593 Distance: 0.150 Drainge (sq mi): 3.2 Depth: 0

Location: Lat: 39.18250 Long: -84.49310

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
99-999	NO FISH					0	0.0	***.**	0	0.00	*****.*

No Species: 0 **Nat. Species:** 1 **Hybrids:** 0 **Total Counted:** 0 **Total Rel. Wt. :** 0

IBI: 12.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-017 Bloody Run RM: 0.20 Date: 10/05/2016

Time Fished: 182 Distance: 0.150 Drainge (sq mi): 3.2 Depth: 0

Location: Lat: 39.18250 Long: -84.49310

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
99-999	NO FISH					0	0.0	***.**	0	0.00	*****.*

No Species: 0 **Nat. Species:** 1 **Hybrids:** 0 **Total Counted:** 0 **Total Rel. Wt. :** 0

IBI: 12.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-017 Bloody Run RM: 0.30 Date: 08/02/2016

Time Fished: 0 Distance: 0.150 Drainge (sq mi): 3.2 Depth: 0

Location: Lat: 39.18250 Long: -84.49220

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
99-997	Dry Site					0	0.0	***.**	0	0.00	*****.*

No Species: 1 **Nat. Species:** 1 **Hybrids:** 0 **Total Counted:** 0 **Total Rel. Wt. :** 0

IBI: 12.0 **MIwb:** N/A

Appendix Table B-2. Midwest Biodiversity Institute
Fish Species List

Site ID: River: 23-017 Bloody Run RM: 0.30 Date: 10/05/2016

Time Fished: 158 Distance: 0.150 Drainge (sq mi): 3.2 Depth: 0

Location: Lat: 39.18250 Long: -84.49220

Species Code:	Species Name:	Feed Guild	Toler-ance	Breed Guild	IBI Group	No. Fish	Rel. No.	% by No.	Rel. Wt.	% by Wt.	Av. Wt.
99-999	NO FISH					0	0.0	***.**	0	0.00	*****.*

No Species: 0 **Nat. Species:** 1 **Hybrids:** 0 **Total Counted:** 0 **Total Rel. Wt. :** 0

IBI: 12.0 **MIwb:** N/A

APPENDIX C

Mill Creek 2016 Macroinvertebrate Assemblage Data

C-1: Invertebrate Community Index (ICI) Metrics and Scores

D-2: Macroinvertebrate Taxa by Site and Sample

Appendix Table C-1. ICI metrics and index scores for sites in Mill Creek.

Site ID	River Mile	Drainage Area (sq mi)	Number of				Percent:						
			Total Taxa	Mayfly Taxa	Caddisfly Taxa	Dipteran Taxa	Mayflies	Caddis-flies	Tany-tarsini	Other Dipt/NI	Tolerant Organisms	Qual. EPT	ICI or Narrative
Mill Creek (23-001)													
Year: 2016													
MC206	26.40	4.40	39(6)	4(2)	6(6)	20(6)	73.0(6)	7.2(6)	3.7(2)	14.8(6)	1.6(6)	12(6)	52
MC12	19.10	26.70	41(6)	3(2)	4(6)	22(6)	19.8(4)	18.7(6)	13.0(4)	42.4(4)	13.8(4)	6(2)	44
MC10	18.70	27.00	38(6)	3(2)	6(6)	17(4)	14.4(4)	20.6(6)	12.6(4)	43.6(4)	4.7(6)	8(4)	46
MC08	18.10	32.40	40(6)	4(2)	6(6)	14(4)	23.4(4)	18.2(6)	9.2(2)	48.4(2)	10.0(4)	7(2)	38
MC101	17.90	42.20	40(6)	4(2)	7(6)	18(4)	4.8(2)	36.6(6)	11.9(2)	45.2(4)	12.1(4)	6(2)	38
MC06	16.60	50.50	37(4)	4(2)	6(6)	14(4)	4.8(2)	47.7(6)	9.6(2)	34.6(4)	2.7(6)	8(2)	38
MC04	14.80	61.30	32(4)	3(2)	6(6)	15(4)	5.6(2)	48.0(6)	4.6(2)	38.5(4)	2.1(6)	8(2)	38
MC11	13.90	68.80										9	VG
MC104	13.70	71.60	31(4)	3(2)	7(6)	15(4)	10.4(2)	51.0(6)	2.8(2)	33.6(4)	1.5(6)	9(2)	38
MC02	13.20	72.30	38(6)	4(2)	5(6)	17(4)	11.6(2)	66.3(6)	2.1(2)	18.3(6)	1.2(6)	7(2)	42
MC01	11.30	73.90										8	VG
MC80	10.00	115.00	35(4)	4(2)	6(6)	19(4)	12.9(2)	53.6(6)	6.3(2)	26.9(6)	2.2(6)	8(2)	40
MC79	8.70	120.00	42(6)	5(2)	5(6)	22(6)	23.9(4)	35.8(6)	7.4(2)	31.1(4)	3.3(6)	7(2)	44
MC77	7.50	126.00										9	G
MC09	6.90	128.00										4	LF
MC07	6.40	135.00	21(2)	3(2)	3(4)	14(4)	8.9(2)	20.2(6)	5.0(2)	65.9(0)	27.0(0)	6(2)	24
MC75	5.10	136.00	38(6)	5(2)	6(6)	22(6)	9.4(2)	20.3(6)	5.6(2)	64.0(0)	17.9(0)	10(4)	34
MC74	4.30	141.00										7	MG
MC73	3.50	154.00										7	MG
MC72	3.10	155.00	32(4)	3(2)	5(6)	13(4)	2.0(2)	11.5(4)	4.1(2)	80.2(0)	35.6(0)	7(2)	26
MC05	2.50	154.00	34(4)	3(2)	5(6)	19(6)	8.9(2)	14.1(4)	2.9(2)	72.4(0)	20.1(0)	8(2)	28
MC03	1.70	163.00	34(4)	4(2)	6(6)	19(6)	2.5(2)	9.2(2)	6.4(2)	81.2(0)	40.7(0)	5(0)	24
West Fork Mill Creek (23-004)													
Year: 2016													
MC45	0.20	36.40	31(4)	5(4)	3(6)	18(4)	64.7(6)	9.3(6)	2.3(2)	22.5(6)	0.9(6)	9(4)	48
East Fork Mill Creek (23-006)													
Year: 2016													
MC18	1.20	9.20	41(6)	4(2)	6(6)	21(6)	5.1(2)	19.4(6)	3.5(2)	40.9(4)	10.9(4)	8(4)	42
MC15	1.00	9.20	34(4)	4(2)	4(6)	14(4)	4.2(2)	30.2(6)	7.6(2)	55.2(2)	15.0(4)	6(2)	34
MC14	0.70	9.50	28(4)	3(2)	5(6)	9(2)	4.8(2)	51.9(6)	11.0(4)	31.2(4)	4.1(6)	7(4)	40
MC16a	0.10	9.60	31(4)	3(2)	5(6)	14(4)	68.3(6)	12.1(6)	2.0(2)	15.4(6)	1.9(6)	11(6)	48
Bloody Run (23-017)													
Year: 2016													
MC102	0.30	3.80										0	VP
MC103	0.20	3.80										0	VP

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/12/2016* RM: **26.40**

Site ID: **MC00** Location: *Liberty-Fairfield Rd.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		**F**	2	+
03360	Plumatella sp		**F**		+
03600	Oligochaeta		**T**	12	
04664	Helobdella stagnalis		**T**		+
05900	Lirceus sp		**MT**	10	+
08601	Hydrachnidia		**F**		+
11120	Baetis flavistriga		**F**	10	+
11130	Baetis intercalaris		**F**	42	+
11200	Callibaetis sp		**MT**		+
13521	Stenonema femoratum		**F**	23	+
17200	Caenis sp		**F**	694	+
21200	Calopteryx sp		**F**	2	+
22001	Coenagrionidae		**T**		+
22300	Argia sp		**F**	6	+
50301	Chimarra aterrima		**MI**	6	+
50315	Chimarra obscura		**MI**	2	+
51600	Polycentropus sp		**MI**	2	
52200	Cheumatopsyche sp		**F**	46	+
52430	Ceratopsyche morosa group		**MI**	13	+
52530	Hydropsyche depravata group		**F**	7	+
53501	Hydroptilidae		**F**		+
59700	Triaenodes sp		**MI**		+
68025	Ectopria sp		**F**	1	+
68075	Psephenus herricki		**MI**	1	+
68708	Dubiraphia vittata group		**F**		+
69400	Stenelmis sp		**F**	3	+
70600	Antocha sp		**MI**	1	
71900	Tipula sp		**F**	2	
77500	Conchapelopia sp		**F**	6	
77800	Helopelopia sp		**F**	21	
78450	Nilotanypus fimbriatus		**F**	2	
79701	Diamesinae				+
80360	Corynoneura floridaensis		**MI**	4	
80370	Corynoneura lobata		**F**	9	
82730	Chironomus (C.) decorus group		**T**	2	
83040	Dicrotendipes neomodestus		**F**	12	
83840	Microtendipes pedellus group		**F**	37	
83900	Nilothauma sp		**F**		+
84315	Phaenopsectra flavipes		**MT**	2	
84450	Polypedilum (Uresipedilum) flavum		**F**	29	+
84470	Polypedilum (P.) illinoense		**T**	2	
84960	Pseudochironomus sp		**F**	2	
85230	Cladotanytarsus mancus group		**F**	2	+
85261	Cladotanytarsus vanderwulpi		**MI**	2	
85500	Paratanytarsus sp		**F**	10	
85625	Rheotanytarsus sp		**F**	2	
85800	Tanytarsus sp		**F**	2	
85821	Tanytarsus glabrescens group sp 7		**F**	21	
96900	Ferrissia sp		**F**	1	

No. Quantitative Taxa:	39	Total Taxa;	49
No. Qualitative Taxa:	28	ICI:	52
Number of Organisms:	1053	Qual EPT:	12

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/14/2016* RM: **19.10**

Site ID: **MC12** Location: *Ust. Windisch Rd.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		F	24 +
03360	Plumatella sp		F	4
03600	Oligochaeta		T	147 +
04664	Helobdella stagnalis		T	1
08250	Orconectes (Procericambarus) rusticus		F	+
11120	Baetis flavistriga		F	+
11130	Baetis intercalaris		F	126 +
13521	Stenonema femoratum		F	37 +
17200	Caenis sp		F	191 +
22001	Coenagrionidae		T	1 +
22300	Argia sp		F	59 +
50301	Chimarra aterrima		MI	1
50315	Chimarra obscura		MI	13 +
51206	Cyrnellus fraternus		F	27
52200	Cheumatopsyche sp		F	294 +
68708	Dubiraphia vittata group		F	15 +
69200	Optioservus sp		MI	5
69400	Stenelmis sp		F	28 +
74501	Ceratopogonidae		T	8
77120	Ablabesmyia mallochi		F	16
77750	Hayesomyia senata or Thienemannimyia norena		F	62
77800	Helopelopia sp		F	10
78450	Nilotanypus fimbriatus		F	24
80370	Corynoneura lobata		F	16
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		F	8
81240	Nanocladius (N.) distinctus		MT	32 +
81650	Parametriocnemus sp	X	F	8
82141	Thienemanniella xena		F	8
82820	Cryptochironomus sp		F	8
83040	Dicrotendipes neomodestus		F	40
83300	Glyptotendipes (G.) sp		MT	137 +
84450	Polypedilum (Uresipedilum) flavum		F	40 +
84470	Polypedilum (P.) illinoense		T	24 +
84520	Polypedilum (Tripodura) halterale group		MT	+
84540	Polypedilum (Tripodura) scalaenum group		F	56
84750	Stictochironomus sp		F	+
84790	Tribelos fuscicorne		F	16
85500	Paratanytarsus sp		F	8
85625	Rheotanytarsus sp		F	56
85800	Tanytarsus sp		F	24
85821	Tanytarsus glabrescens group sp 7		F	145 +
87540	Hemerodromia sp		F	8
96120	Menetus (Micromenetus) dilatatus		MT	+
96900	Ferrissia sp		F	43
97601	Corbicula fluminea		F	11 +
98600	Sphaerium sp		F	6 +

No. Quantitative Taxa:	41	Total Taxa;	46
No. Qualitative Taxa:	23	ICI:	44
Number of Organisms:	1787	Qual EPT:	6

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/14/2016* RM: **18.70**

Site ID: **MC10** Location: *Ust. Crescent View Rd.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
00401	Spongillidae		**F**	+
01801	Turbellaria		**F**	45 +
03360	Plumatella sp		**F**	1 +
03600	Oligochaeta		**T**	33 +
04664	Helobdella stagnalis		**T**	1 +
05900	Lirceus sp		**MT**	1
08601	Hydrachnidia		**F**	2
11120	Baetis flavistriga		**F**	+
11130	Baetis intercalaris		**F**	139 +
11200	Callibaetis sp		**MT**	+
13521	Stenonema femoratum		**F**	18 +
17200	Caenis sp		**F**	58 +
22001	Coenagrionidae		**T**	+
22300	Argia sp		**F**	1 +
50315	Chimarra obscura		**MI**	3 +
51206	Cyrnellus fraternus		**F**	15
52200	Cheumatopsyche sp		**F**	267 +
52430	Ceratopsyche morosa group		**MI**	2
52530	Hydropsyche depravata group		**F**	20 +
53800	Hydroptila sp		**F**	2
68075	Psephenus herricki		**MI**	+
68708	Dubiraphia vittata group		**F**	17 +
69400	Stenelmis sp		**F**	114 +
77750	Hayesomyia senata or Thienemannimyia norena		**F**	42
77800	Helopelopia sp		**F**	11
78450	Nilotanypus fimbriatus		**F**	14
80363	Corynoneura sp 12		**MI**	2
80420	Cricotopus (C.) bicinctus		**T**	15
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	15
83040	Dicrotendipes neomodestus		**F**	23
83300	Glyptotendipes (G.) sp		**MT**	68 +
84450	Polypedilum (Uresipedilum) flavum		**F**	218 +
84460	Polypedilum (P.) fallax group		**F**	8
84520	Polypedilum (Tripodura) halterale group		**MT**	8
84540	Polypedilum (Tripodura) scalaenum group		**F**	105
84790	Tribelos fuscicorne		**F**	15
85625	Rheotanytarsus sp		**F**	143
85800	Tanytarsus sp		**F**	8
85821	Tanytarsus glabrescens group sp 7		**F**	38
87501	Empididae		**F**	1
96900	Ferrissia sp		**F**	14
97601	Corbicula fluminea		**F**	2 +
98600	Sphaerium sp		**F**	8

No. Quantitative Taxa:	38	Total Taxa;	43
No. Qualitative Taxa:	21	ICI:	46
Number of Organisms:	1497	Qual EPT:	8

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/21/2016* RM: **18.10**

Site ID: **MC08** Location: *Ust. 200 meter E. Fork Mill Cr. Confluence* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		F	60
01900	Nemertea		F	8
03360	Plumatella sp		F	3 +
03600	Oligochaeta		T	253 +
04660	Helobdella sp		MT	1
04664	Helobdella stagnalis		T	1
04666	Helobdella papillata		MT	1
04964	Erpobdella microstoma		MT	+
08601	Hydrachnidia		F	+
11120	Baetis flavistriga		F	6
11130	Baetis intercalaris		F	1272 +
13521	Stenonema femoratum		F	6 +
17200	Caenis sp		F	84 +
22001	Coenagrionidae		T	+
22300	Argia sp		F	10 +
50301	Chimarra aterrima		MI	16
50315	Chimarra obscura		MI	18 +
51206	Cyrnellus fraternus		F	208
52200	Cheumatopsyche sp		F	805 +
52530	Hydropsyche depravata group		F	2 +
53800	Hydroptila sp		F	13 +
59970	Petrophila sp		MI	12 +
65800	Berosus sp		MT	1
68708	Dubiraphia vittata group		F	9 +
69400	Stenelmis sp		F	16 +
74100	Simulium sp		F	+
77120	Ablabesmyia mallochi		F	+
77750	Hayesomyia senata or Thienemannimyia norena		F	192
78140	Labrundinia pilosella		F	+
78450	Nilotanypus fimbriatus		F	96
80410	Cricotopus (C.) sp		F	115
80420	Cricotopus (C.) bicinctus		T	115 +
80430	Cricotopus (C.) tremulus group		MT	77
81240	Nanocladius (N.) distinctus		MT	77 +
82121	Thienemanniella lobapodema		F	4
83040	Dicrotendipes neomodestus		F	77 +
83300	Glyptotendipes (G.) sp		MT	462
83900	Nilothauma sp		F	+
84450	Polypedilum (Uresipedilum) flavum		F	1100 +
84470	Polypedilum (P.) illinoense		T	77 +
84540	Polypedilum (Tripodura) scalaenum group		F	38
85625	Rheotanytarsus sp		F	308
85821	Tanytarsus glabrescens group sp 7		F	231 +
95100	Physella sp		T	2
95501	Planorbidae		MT	1
96900	Ferrissia sp		F	62
97601	Corbicula fluminea		F	8 +
98600	Sphaerium sp		F	+

No. Quantitative Taxa:	40	Total Taxa;	48
No. Qualitative Taxa:	28	ICI:	38
Number of Organisms:	5847	Qual EPT:	7

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/21/2016* RM: **17.90**

Site ID: **MC101** Location: *RR trestle dst. East Fork Mill Creek* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	52 +
03000	Ectoprocta		**F**	1
03600	Oligochaeta		**T**	73 +
04964	Erpobdella microstoma		**MT**	1
06700	Crangonyx sp		**MT**	8
11120	Baetis flavistriga		**F**	15
11130	Baetis intercalaris		**F**	53 +
13521	Stenonema femoratum		**F**	15 +
17200	Caenis sp		**F**	45 +
21200	Calopteryx sp		**F**	+
22001	Coenagrionidae		**T**	1 +
22300	Argia sp		**F**	13 +
50301	Chimarra aterrima		**MI**	5
50315	Chimarra obscura		**MI**	15 +
51206	Cyrnellus fraternus		**F**	57
52200	Cheumatopsyche sp		**F**	836 +
52430	Ceratopsyche morosa group		**MI**	18 +
52530	Hydropsyche depravata group		**F**	20
53501	Hydroptilidae		**F**	16
65800	Berosus sp		**MT**	2
68708	Dubiraphia vittata group		**F**	10 +
69400	Stenelmis sp		**F**	13
77100	Ablabesmyia sp			66
77750	Hayesomyia senata or Thienemannimyia norena		**F**	66
78450	Nilotanypus fimbriatus		**F**	12
80400	Cricotopus sp		**F**	82 +
80420	Cricotopus (C.) bicinctus		**T**	148 +
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	16
81240	Nanocladius (N.) distinctus		**MT**	33
82141	Thienemanniella xena		**F**	16
83000	Dicrotendipes sp		**F**	33
83040	Dicrotendipes neomodestus		**F**	99
83300	Glyptotendipes (G.) sp		**MT**	33
84450	Polypedilum (Uresipedilum) flavum		**F**	313 +
84470	Polypedilum (P.) illinoense		**T**	66
84540	Polypedilum (Tripodura) scalaenum group		**F**	49 +
85625	Rheotanytarsus sp		**F**	157
85821	Tanytarsus glabrescens group sp 7		**F**	140
85840	Tanytarsus sepp		**F**	16
87540	Hemerodromia sp		**F**	17
97601	Corbicula fluminea		**F**	9 +

No. Quantitative Taxa:	40	Total Taxa;	41
No. Qualitative Taxa:	17	ICI:	38
Number of Organisms:	2640	Qual EPT:	6

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/13/2016* RM: **16.60**

Site ID: **MC06** Location: *East Sharon Rd.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		F	10	+
03000	Ectoprocta		F	1	+
03600	Oligochaeta		T	17	
04510	Hirudinida		MT	1	
04814	Haemopis marmorata		VT		+
06700	Crangonyx sp		MT		+
08200	Orconectes sp		F	1	
08601	Hydrachnidia		F	8	
11120	Baetis flavistriga		F	1	+
11130	Baetis intercalaris		F	80	+
13521	Stenonema femoratum		F	4	+
17200	Caenis sp		F	58	+
21200	Calopteryx sp		F		+
22001	Coenagrionidae		T		+
22300	Argia sp		F	5	+
50315	Chimarra obscura		MI	36	+
51206	Cyrnellus fraternus		F	29	
52200	Cheumatopsyche sp		F	981	+
52430	Ceratopsyche morosa group		MI	172	+
52530	Hydropsyche depravata group		F	178	+
53800	Hydroptila sp		F	17	
59970	Petrophila sp		MI	16	
65800	Berosus sp		MT	1	
69400	Stenelmis sp		F	73	+
74100	Simulium sp		F		+
77750	Hayesomyia senata or Thienemannimyia norena		F	170	
78450	Nilotanypus fimbriatus		F	23	
80350	Corynoneura sp			14	
80420	Cricotopus (C.) bicinctus		T	28	+
81650	Parametriocnemus sp	X	F	14	
82100	Thienemanniella sp			4	
83040	Dicrotendipes neomodestus		F	43	
83300	Glyptotendipes (G.) sp		MT	43	
84000	Parachironomus sp		MT		+
84450	Polypedilum (Uresipedilum) flavum		F	568	+
84470	Polypedilum (P.) illinoense		T	28	
84540	Polypedilum (Tripodura) scalaenum group		F	14	+
84960	Pseudochironomus sp		F	14	
85625	Rheotanytarsus sp		F	227	+
85821	Tanytarsus glabrescens group sp 7		F	57	+
96900	Ferrissia sp		F	8	
97601	Corbicula fluminea		F	10	
98001	Pisidiidae			8	

No. Quantitative Taxa:	37	Total Taxa;	43
No. Qualitative Taxa:	23	ICI:	38
Number of Organisms:	2962	Qual EPT:	8

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/14/2016* RM: **14.80**

Site ID: **MC04** Location: *Glendale-Milford Express Way* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		**F**	44	+
03360	Plumatella sp		**F**	2	+
03600	Oligochaeta		**T**		+
04664	Helobdella stagnalis		**T**		+
04901	Erpobdellidae		**MT**		+
05900	Lirceus sp		**MT**	6	+
06001	Amphipoda				+
08250	Orconectes (Procericambarus) rusticus		**F**		+
11120	Baetis flavistriga		**F**		+
11130	Baetis intercalaris		**F**	154	+
13521	Stenonema femoratum		**F**	1	+
17200	Caenis sp		**F**	8	
21001	Calopterygidae		**F**		+
22001	Coenagrionidae		**T**		+
22300	Argia sp		**F**		+
50301	Chimarra aterrima		**MI**	9	+
50315	Chimarra obscura		**MI**	29	+
52200	Cheumatopsyche sp		**F**	620	+
52430	Ceratopsyche morosa group		**MI**	575	+
52530	Hydropsyche depravata group		**F**	151	+
53501	Hydroptilidae		**F**	5	
59970	Petrophila sp		**MI**	26	
65800	Berosus sp		**MT**		+
68075	Psephenus herricki		**MI**	1	+
69400	Stenelmis sp		**F**	70	+
74100	Simulium sp		**F**	1	+
77750	Hayesomyia senata or Thienemannimyia norena		**F**	139	
78450	Nilotanypus fimbriatus		**F**	40	+
80400	Cricotopus sp		**F**	15	
80420	Cricotopus (C.) bicinctus		**T**	31	+
81200	Nanocladius sp		**F**		+
81240	Nanocladius (N.) distinctus		**MT**	15	
81825	Rheocricotopus (Psilocricotopus) robacki		**F**	15	
84450	Polypedilum (Uresipedilum) flavum		**F**	759	+
84470	Polypedilum (P.) illinoense		**T**	15	
84540	Polypedilum (Tripodura) scalaenum group		**F**	15	
84960	Pseudochironomus sp		**F**	15	
85625	Rheotanytarsus sp		**F**	64	
85720	Stempellinella fimbriata		**MI**	8	
85821	Tanytarsus glabrescens group sp 7		**F**	46	+
85840	Tanytarsus sepp		**F**	15	
96900	Ferrissia sp		**F**	1	
97601	Corbicula fluminea		**F**	1	+

No. Quantitative Taxa:	32	Total Taxa;	43
No. Qualitative Taxa:	29	ICI:	38
Number of Organisms:	2896	Qual EPT:	8

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/16/2016* RM: **13.90**

Site ID: **MC11** Location: *Behind asphalt plant- Cavett Dr.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	+
03600	Oligochaeta		**T**	+
05900	Lirceus sp		**MT**	+
06201	Hyalella azteca		**F**	+
11130	Baetis intercalaris		**F**	+
13521	Stenonema femoratum		**F**	+
16700	Tricorythodes sp		**MI**	+
17200	Caenis sp		**F**	+
21200	Calopteryx sp		**F**	+
22001	Coenagrionidae		**T**	+
22300	Argia sp		**F**	+
28208	Erythemis simplicicollis		**MT**	+
50315	Chimarra obscura		**MI**	+
52200	Cheumatopsyche sp		**F**	+
52430	Ceratopsyche morosa group		**MI**	+
52530	Hydropsyche depravata group		**F**	+
53800	Hydroptila sp		**F**	+
68025	Ectopria sp		**F**	+
68075	Psephenus herricki		**MI**	+
69400	Stenelmis sp		**F**	+
80420	Cricotopus (C.) bicinctus		**T**	+
84450	Polypedilum (Uresipedilum) flavum		**F**	+
84470	Polypedilum (P.) illinoense		**T**	+
84540	Polypedilum (Tripodura) scalaenum group		**F**	+
85625	Rheotanytarsus sp		**F**	+
85821	Tanytarsus glabrescens group sp 7		**F**	+
85840	Tanytarsus sepp		**F**	+

No. Quantitative Taxa:	0	Total Taxa;	27
No. Qualitative Taxa:	27	ICI:	VG
Number of Organisms:	0	Qual EPT:	9

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/16/2016* RM: **13.70**

Site ID: **MC104** Location: *Immediately dst. CSO700 outfall* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		**F**	57	+
03360	Plumatella sp		**F**	1	
03600	Oligochaeta		**T**		+
05900	Lirceus sp		**MT**	2	
11130	Baetis intercalaris		**F**	216	+
13521	Stenonema femoratum		**F**	8	+
16700	Tricorythodes sp		**MI**		+
17200	Caenis sp		**F**	9	+
21200	Calopteryx sp		**F**		+
21300	Hetaerina sp		**F**	1	+
22001	Coenagrionidae		**T**		+
50301	Chimarra aterrima		**MI**	3	
50315	Chimarra obscura		**MI**	227	+
51206	Cyrnellus fraternus		**F**	2	
52200	Cheumatopsyche sp		**F**	398	+
52430	Ceratopsyche morosa group		**MI**	153	+
52530	Hydropsyche depravata group		**F**	345	+
53501	Hydroptilidae		**F**	20	+
59970	Petrophila sp		**MI**		+
68075	Psephenus herricki		**MI**		+
68708	Dubiraphia vittata group		**F**		+
69400	Stenelmis sp		**F**	49	+
74100	Simulium sp		**F**	1	
77750	Hayesomyia senata or Thienemannimyia norena		**F**	54	
78450	Nilotanypus fimbriatus		**F**	8	
80420	Cricotopus (C.) bicinctus		**T**		+
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	11	
81240	Nanocladius (N.) distinctus		**MT**	11	
83040	Dicrotendipes neomodestus		**F**	21	
83300	Glyptotendipes (G.) sp		**MT**	21	
84450	Polypedilum (Uresipedilum) flavum		**F**	492	+
84460	Polypedilum (P.) fallax group		**F**	11	
84470	Polypedilum (P.) illinoense		**T**	11	+
84540	Polypedilum (Tripodura) scalaenum group		**F**	11	+
84790	Tribelos fuscicorne		**F**	11	
84960	Pseudochironomus sp		**F**	32	
85625	Rheotanytarsus sp		**F**	21	
85821	Tanytarsus glabrescens group sp 7		**F**	43	
96900	Ferrissia sp		**F**	1	
97601	Corbicula fluminea		**F**		+

No. Quantitative Taxa:	31	Total Taxa;	40
No. Qualitative Taxa:	23	ICI:	38
Number of Organisms:	2251	Qual EPT:	9

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/16/2016* RM: **13.20**

Site ID: **MC02** Location: *Dst. W. Columbia Rd.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		F	1	+
03360	Plumatella sp		F	1	+
03600	Oligochaeta		T	49	
04964	Erpobdella microstoma		MT		+
05900	Lirceus sp		MT	1	
06201	Hyalella azteca		F		+
08601	Hydrachnidia		F	8	
11120	Baetis flavistriga		F		+
11130	Baetis intercalaris		F	600	+
13521	Stenonema femoratum		F	23	+
16700	Tricorythodes sp		MI	1	
17200	Caenis sp		F	1	+
21200	Calopteryx sp		F		+
22001	Coenagrionidae		T		+
22300	Argia sp		F	1	+
50315	Chimarra obscura		MI	462	+
52200	Cheumatopsyche sp		F	1863	+
52430	Ceratopsyche morosa group		MI	890	+
52530	Hydropsyche depravata group		F	342	
53501	Hydroptilidae		F	1	
59970	Petrophila sp		MI	1	+
68075	Psephenus herricki		MI		+
68130	Helichus sp		F	1	
68708	Dubiraphia vittata group		F		+
69400	Stenelmis sp		F	85	+
77500	Conchapelopia sp		F	23	
77750	Hayesomyia senata or Thienemannimyia norena		F	89	
78140	Labrundinia pilosella		F		+
78350	Meropelopia sp	X	F	9	
78450	Nilotanypus fimbriatus		F	64	
80350	Corynoneura sp			32	
80360	Corynoneura floridaensis		MI	8	
80410	Cricotopus (C.) sp		F		+
80510	Cricotopus (Isocladius) sylvestris group		T		+
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		F	9	
81650	Parametriocnemus sp	X	F	9	
81825	Rheocricotopus (Psilocricotopus) robacki		F	19	
82820	Cryptochironomus sp		F		+
84450	Polypedilum (Uresipedilum) flavum		F	613	+
84460	Polypedilum (P.) fallax group		F	9	
84540	Polypedilum (Tripodura) scalaenum group		F	19	
84790	Tribelos fuscicorne		F	9	
85625	Rheotanytarsus sp		F	65	
85821	Tanytarsus glabrescens group sp 7		F	37	
85840	Tanytarsus sepp		F	9	
87501	Empididae		F	1	
96900	Ferrissia sp		F	8	
97601	Corbicula fluminea		F	2	
98600	Sphaerium sp		F	1	

No. Quantitative Taxa:	38	Total Taxa;	49
No. Qualitative Taxa:	23	ICI:	42
Number of Organisms:	5366	Qual EPT:	7

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/17/2016* RM: **11.30**

Site ID: **MC01** Location: *Dst. Galbraith Rd.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	+
03000	Ectoprocta		**F**	+
03600	Oligochaeta		**T**	+
04666	Helobdella papillata		**MT**	+
04964	Erpobdella microstoma		**MT**	+
05900	Lirceus sp		**MT**	+
11130	Baetis intercalaris		**F**	+
13521	Stenonema femoratum		**F**	+
17200	Caenis sp		**F**	+
22001	Coenagrionidae		**T**	+
22300	Argia sp		**F**	+
50315	Chimarra obscura		**MI**	+
52200	Cheumatopsyche sp		**F**	+
52430	Ceratopsyche morosa group		**MI**	+
52530	Hydropsyche depravata group		**F**	+
53501	Hydroptilidae		**F**	+
80400	Cricotopus sp		**F**	+
83040	Dicrotendipes neomodestus		**F**	+
84210	Paratendipes albimanus or P. duplicatus		**F**	+
84450	Polypedilum (Uresipedilum) flavum		**F**	+
84470	Polypedilum (P.) illinoense		**T**	+
97601	Corbicula fluminea		**F**	+

No. Quantitative Taxa:	0	Total Taxa;	22
No. Qualitative Taxa:	22	ICI:	VG
Number of Organisms:	0	Qual EPT:	8

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/17/2016* RM: **10.00**

Site ID: **MC80** Location: *Dst. Anthony Wayne Ave.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		**F**	8	+
03360	Plumatella sp		**F**	4	+
03600	Oligochaeta		**T**	16	
05900	Lirceus sp		**MT**		+
06700	Crangonyx sp		**MT**		+
08601	Hydrachnidia		**F**	16	
11130	Baetis intercalaris		**F**	480	+
13400	Stenacron sp		**F**		+
13521	Stenonema femoratum		**F**	60	+
16700	Tricorythodes sp		**MI**	1	
17200	Caenis sp		**F**	18	+
21001	Calopterygidae		**F**		+
22300	Argia sp		**F**		+
50315	Chimarra obscura		**MI**	97	+
51206	Cyrnellus fraternus		**F**	1	
52200	Cheumatopsyche sp		**F**	1862	+
52430	Ceratopsyche morosa group		**MI**	301	+
52530	Hydropsyche depravata group		**F**	60	+
53501	Hydroptilidae		**F**	8	
59970	Petrophila sp		**MI**		+
68075	Psephenus herricki		**MI**		+
69400	Stenelmis sp		**F**	15	+
74100	Simulium sp		**F**	8	+
77500	Conchapelopia sp		**F**	41	
77750	Hayesomyia senata or Thienemannimyia norena		**F**	82	
78450	Nilotanypus fimbriatus		**F**	48	
80350	Corynoneura sp			32	
80370	Corynoneura lobata		**F**	24	
80410	Cricotopus (C.) sp		**F**	15	
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**		+
81240	Nanocladius (N.) distinctus		**MT**	46	
81270	Nanocladius (N.) spiniplenus		**F**	15	
81825	Rheocricotopus (Psilocricotopus) robacki		**F**	15	
82141	Thienemanniella xena		**F**	16	
84450	Polypedilum (Uresipedilum) flavum		**F**	705	+
84460	Polypedilum (P.) fallax group		**F**	15	
84470	Polypedilum (P.) illinoense		**T**	15	
84700	Stenochironomus sp		**F**	31	
84900	Zavreliella marmorata			15	
85625	Rheotanytarsus sp		**F**	153	
85821	Tanytarsus glabrescens group sp 7		**F**	123	+
86501	Stratiomyidae			1	
96900	Ferrissia sp		**F**	2	
97601	Corbicula fluminea		**F**		+
98600	Sphaerium sp		**F**		+

No. Quantitative Taxa:	35	Total Taxa;	45
No. Qualitative Taxa:	23	ICI:	40
Number of Organisms:	4349	Qual EPT:	8

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/17/2016* RM: **8.70**

Site ID: **MC79** Location: *Dst. Este Ave. bridge* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		**F**	13	+
03360	Plumatella sp		**F**	4	+
03600	Oligochaeta		**T**	32	+
04664	Helobdella stagnalis		**T**	1	
05900	Lirceus sp		**MT**	2	
06700	Crangonyx sp		**MT**		+
06810	Gammarus fasciatus		**F**	4	
08601	Hydrachnidia		**F**		+
11130	Baetis intercalaris		**F**	307	+
13400	Stenacron sp		**F**	3	+
13521	Stenonema femoratum		**F**	130	+
16700	Tricorythodes sp		**MI**	2	
17200	Caenis sp		**F**	91	
22300	Argia sp		**F**	10	
44501	Corixidae		**F**		+
50315	Chimarra obscura		**MI**	38	+
51206	Cyrnellus fraternus		**F**	4	
52200	Cheumatopsyche sp		**F**	675	+
52430	Ceratopsyche morosa group		**MI**	48	+
52530	Hydropsyche depravata group		**F**	32	+
59970	Petrophila sp		**MI**	4	
69400	Stenelmis sp		**F**	27	+
77120	Ablabesmyia mallochi		**F**	7	
77500	Conchapelopia sp		**F**	14	
77750	Hayesomyia senata or Thienemannimyia norena		**F**	130	
78450	Nilotanypus fimbriatus		**F**	8	
80370	Corynoneura lobata		**F**	12	
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	22	
81825	Rheocricotopus (Psilocricotopus) robacki		**F**	7	
82141	Thienemanniella xena		**F**	8	
82730	Chironomus (C.) decorus group		**T**	7	
82820	Cryptochironomus sp		**F**	7	
83000	Dicrotendipes sp		**F**		+
83040	Dicrotendipes neomodestus		**F**		+
83300	Glyptotendipes (G.) sp		**MT**	7	
83310	Glyptotendipes (Heynotendipes) chelonia		**MI**	7	
84100	Paracladopelma sp				+
84450	Polypedilum (Uresipedilum) flavum		**F**	252	+
84460	Polypedilum (P.) fallax group		**F**	7	
84470	Polypedilum (P.) illinoense		**T**	7	
84540	Polypedilum (Tripodura) scalaenum group		**F**	79	+
84700	Stenochironomus sp		**F**	7	
84790	Tribelos fuscicorne		**F**	29	
85625	Rheotanytarsus sp		**F**	29	
85800	Tanytarsus sp		**F**	43	+
85821	Tanytarsus glabrescens group sp 7		**F**	86	
85840	Tanytarsus sepp		**F**	7	+
96900	Ferrissia sp		**F**	20	

No. Quantitative Taxa:	42	Total Taxa;	48
No. Qualitative Taxa:	21	ICI:	44
Number of Organisms:	2229	Qual EPT:	7

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/19/2016* RM: **7.50**

Site ID: **MC77** Location: *RR Trestle Winton Place* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	+
03000	Ectoprocta		**F**	+
05900	Lirceus sp		**MT**	+
08200	Orconectes sp		**F**	+
11130	Baetis intercalaris		**F**	+
13400	Stenacron sp		**F**	+
13521	Stenonema femoratum		**F**	+
17200	Caenis sp		**F**	+
22300	Argia sp		**F**	+
50315	Chimarra obscura		**MI**	+
51206	Cyrnellus fraternus		**F**	+
52200	Cheumatopsyche sp		**F**	+
52430	Ceratopsyche morosa group		**MI**	+
53800	Hydroptila sp		**F**	+
69400	Stenelmis sp		**F**	+
77120	Ablabesmyia mallochi		**F**	+
80400	Cricotopus sp		**F**	+
80420	Cricotopus (C.) bicinctus		**T**	+
83040	Dicrotendipes neomodestus		**F**	+
84450	Polypedilum (Uresipedilum) flavum		**F**	+
84470	Polypedilum (P.) illinoense		**T**	+
84540	Polypedilum (Tripodura) scalaenum group		**F**	+
85625	Rheotanytarsus sp		**F**	+
97601	Corbicula fluminea		**F**	+

No. Quantitative Taxa:	0	Total Taxa;	24
No. Qualitative Taxa:	24	ICI:	G
Number of Organisms:	0	Qual EPT:	9

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/19/2016* RM: **6.90**

Site ID: **MC09** Location: *Dst. Sumchers outfalls* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
11120	Baetis flavistriga		**F**	+
50315	Chimarra obscura		**MI**	+
52200	Cheumatopsyche sp		**F**	+
52430	Ceratopsyche morosa group		**MI**	+
69400	Stenelmis sp		**F**	+
80411	Cricotopus (Isocladius) sp nr. absurdus		**MT**	+
80420	Cricotopus (C.) bicinctus		**T**	+
82220	Tvetenia discoloripes group		**MI**	+
84450	Polypedilum (Uresipedilum) flavum		**F**	+
84540	Polypedilum (Tripodura) scalaenum group		**F**	+

No. Quantitative Taxa:	0	Total Taxa;	10
No. Qualitative Taxa:	10	ICI:	LF
Number of Organisms:	0	Qual EPT:	4

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/19/2016* RM: **6.40**

Site ID: **MC07** Location: *at RR tressel dst. Springgrove Ave.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.		Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**		+					
03600	Oligochaeta		**T**	51						
11130	Baetis intercalaris		**F**	58	+					
13521	Stenonema femoratum		**F**	4	+					
16700	Tricorythodes sp		**MI**	2						
17200	Caenis sp		**F**		+					
22300	Argia sp		**F**		+					
50315	Chimarra obscura		**MI**	70						
52200	Cheumatopsyche sp		**F**	58	+					
52430	Ceratopsyche morosa group		**MI**	17	+					
53501	Hydroptilidae		**F**		+					
69400	Stenelmis sp		**F**		+					
77750	Hayesomyia senata or Thienemannimyia norena		**F**	12						
80350	Corynoneura sp			6						
80400	Cricotopus sp		**F**	6	+					
80420	Cricotopus (C.) bicinctus		**T**	119	+					
81200	Nanocladius sp		**F**	77						
81200	Nanocladius sp		**F**		+					
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	30						
81250	Nanocladius (N.) minimus		**F**	6						
83040	Dicrotendipes neomodestus		**F**	6						
83300	Glyptotendipes (G.) sp		**MT**	6						
84450	Polypedilum (Uresipedilum) flavum		**F**	131	+					
84460	Polypedilum (P.) fallax group		**F**	6						
84470	Polypedilum (P.) illinoense		**T**	18	+					
84960	Pseudochironomus sp		**F**		+					
85625	Rheotanytarsus sp		**F**	30						
85821	Tanytarsus glabrescens group sp 7		**F**	6						

No. Quantitative Taxa:	21	Total Taxa;	28
No. Qualitative Taxa:	15	ICI:	24
Number of Organisms:	719	Qual EPT:	6

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/19/2016* RM: **5.10**

Site ID: **MC75** Location: *Adj. Salway Park* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	34 +
03600	Oligochaeta		**T**	146
04664	Helobdella stagnalis		**T**	1
11120	Baetis flavistriga		**F**	2 +
11130	Baetis intercalaris		**F**	110 +
11200	Callibaetis sp		**MT**	+
13400	Stenacron sp		**F**	+
13521	Stenonema femoratum		**F**	19 +
16700	Tricorythodes sp		**MI**	1
17200	Caenis sp		**F**	34 +
22001	Coenagrionidae		**T**	+
22300	Argia sp		**F**	+
50315	Chimarra obscura		**MI**	6 +
51206	Cyrnellus fraternus		**F**	10
52200	Cheumatopsyche sp		**F**	320 +
52430	Ceratopsyche morosa group		**MI**	16 +
52530	Hydropsyche depravata group		**F**	5
53800	Hydroptila sp		**F**	3 +
68025	Ectopria sp		**F**	9
69400	Stenelmis sp		**F**	3 +
77120	Ablabesmyia mallochi		**F**	10
77750	Hayesomyia senata or Thienemannimyia norena		**F**	69
77800	Helopelopia sp		**F**	22
78140	Labrundinia pilosella		**F**	10
79100	Thienemannimyia group		**F**	+
80363	Corynoneura sp 12		**MI**	4
80410	Cricotopus (C.) sp		**F**	91 +
80420	Cricotopus (C.) bicinctus		**T**	111 +
80430	Cricotopus (C.) tremulus group		**MT**	61
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	30
81240	Nanocladius (N.) distinctus		**MT**	61 +
82820	Cryptochironomus sp		**F**	20
83000	Dicrotendipes sp		**F**	10
83040	Dicrotendipes neomodestus		**F**	81 +
83300	Glyptotendipes (G.) sp		**MT**	30
84450	Polypedilum (Uresipedilum) flavum		**F**	182 +
84520	Polypedilum (Tripodura) halterale group		**MT**	10
84540	Polypedilum (Tripodura) scalaenum group		**F**	91 +
84960	Pseudochironomus sp		**F**	61
85500	Paratanytarsus sp		**F**	10
85625	Rheotanytarsus sp		**F**	50
85800	Tanytarsus sp		**F**	10
85821	Tanytarsus glabrescens group sp 7		**F**	30

No. Quantitative Taxa:	38	Total Taxa;	43
No. Qualitative Taxa:	21	ICI:	34
Number of Organisms:	1773	Qual EPT:	10

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/20/2016* RM: **4.30**

Site ID: **MC74** Location: *Ust. S. Ludlow Ave. bridge* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	+
03000	Ectoprocta		**F**	+
03600	Oligochaeta		**T**	+
04660	Helobdella sp		**MT**	+
04964	Erpobdella microstoma		**MT**	+
11130	Baetis intercalaris		**F**	+
13521	Stenonema femoratum		**F**	+
17200	Caenis sp		**F**	+
22001	Coenagrionidae		**T**	+
22300	Argia sp		**F**	+
43300	Ranatra sp		**F**	+
43570	Neoplea sp		**F**	+
50315	Chimarra obscura		**MI**	+
52200	Cheumatopsyche sp		**F**	+
52430	Ceratopsyche morosa group		**MI**	+
53800	Hydroptila sp		**F**	+
69400	Stenelmis sp		**F**	+
77120	Ablabesmyia mallochi		**F**	+
80400	Cricotopus sp		**F**	+
80420	Cricotopus (C.) bicinctus		**T**	+
81200	Nanocladius sp		**F**	+
83040	Dicrotendipes neomodestus		**F**	+
84450	Polypedilum (Uresipedilum) flavum		**F**	+
84540	Polypedilum (Tripodura) scalaenum group		**F**	+
84960	Pseudochironomus sp		**F**	+
85821	Tanytarsus glabrescens group sp 7		**F**	+

No. Quantitative Taxa:	0	Total Taxa;	26
No. Qualitative Taxa:	26	ICI:	MG
Number of Organisms:	0	Qual EPT:	7

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/20/2016* RM: **3.50**

Site ID: **MC73** Location: *Ust. Mill Creek Rd. bridge* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	+
03000	Ectoprocta		**F**	+
03600	Oligochaeta		**T**	+
11130	Baetis intercalaris		**F**	+
13521	Stenonema femoratum		**F**	+
17200	Caenis sp		**F**	+
21200	Calopteryx sp		**F**	+
21300	Hetaerina sp		**F**	+
22300	Argia sp		**F**	+
50315	Chimarra obscura		**MI**	+
52200	Cheumatopsyche sp		**F**	+
52430	Ceratopsyche morosa group		**MI**	+
59400	Nectopsyche sp		**MI**	+
77750	Hayesomyia senata or Thienemannimyia norena		**F**	+
80420	Cricotopus (C.) bicinctus		**T**	+
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	+
83040	Dicrotendipes neomodestus		**F**	+
83300	Glyptotendipes (G.) sp		**MT**	+
84450	Polypedilum (Uresipedilum) flavum		**F**	+
84470	Polypedilum (P.) illinoense		**T**	+
84960	Pseudochironomus sp		**F**	+
85625	Rheotanytarsus sp		**F**	+
85821	Tanytarsus glabrescens group sp 7		**F**	+
97601	Corbicula fluminea		**F**	+

No. Quantitative Taxa:	0	Total Taxa;	24
No. Qualitative Taxa:	24	ICI:	MG
Number of Organisms:	0	Qual EPT:	7

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/20/2016* RM: **3.10**

Site ID: **MC72** Location: *Dst. Mill Creek bridge* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.		Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	9	+					
03000	Ectoprocta		**F**	1	+					
03600	Oligochaeta		**T**	25	+					
05900	Lirceus sp		**MT**	10						
08601	Hydrachnidia		**F**	3						
11130	Baetis intercalaris		**F**	30	+					
13521	Stenonema femoratum		**F**	2	+					
17200	Caenis sp		**F**	10	+					
21200	Calopteryx sp		**F**		+					
21300	Hetaerina sp		**F**	1						
22001	Coenagrionidae		**T**		+					
22300	Argia sp		**F**	6	+					
50315	Chimarra obscura		**MI**	17	+					
51206	Cyrnellus fraternus		**F**	1						
52200	Cheumatopsyche sp		**F**	175	+					
52430	Ceratopsyche morosa group		**MI**	10	+					
53800	Hydroptila sp		**F**	33	+					
59970	Petrophila sp		**MI**	8						
68601	Ancyronyx variegata		**F**	8						
69400	Stenelmis sp		**F**	21	+					
77750	Hayesomyia senata or Thienemannimyia norena		**F**	104	+					
79100	Thienemannimyia group		**F**	21						
80410	Cricotopus (C.) sp		**F**	249						
80420	Cricotopus (C.) bicinctus		**T**	664	+					
80430	Cricotopus (C.) tremulus group		**MT**	21						
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	21	+					
82820	Cryptochironomus sp		**F**		+					
83040	Dicrotendipes neomodestus		**F**	62	+					
84450	Polypedilum (Uresipedilum) flavum		**F**	228	+					
84470	Polypedilum (P.) illinoense		**T**	42	+					
84540	Polypedilum (Tripodura) scalaenum group		**F**	104	+					
84960	Pseudochironomus sp		**F**	83						
85625	Rheotanytarsus sp		**F**	42						
85821	Tanytarsus glabrescens group sp 7		**F**	42						
97601	Corbicula fluminea		**F**	2	+					

No. Quantitative Taxa:	32	Total Taxa;	35
No. Qualitative Taxa:	23	ICI:	26
Number of Organisms:	2055	Qual EPT:	7

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/13/2016* RM: **2.50**

Site ID: **MC05** Location: *Dst. Hopple St. bridge* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	3 +
03000	Ectoprocta		**F**	3 +
03360	Plumatella sp		**F**	+
03600	Oligochaeta		**T**	232 +
04964	Erpobdella microstoma		**MT**	+
05900	Lirceus sp		**MT**	4 +
08601	Hydrachnidia		**F**	4 +
11120	Baetis flavistriga		**F**	+
11130	Baetis intercalaris		**F**	130 +
13521	Stenonema femoratum		**F**	10 +
17200	Caenis sp		**F**	6 +
21300	Hetaerina sp		**F**	+
22300	Argia sp		**F**	+
43570	Neoplea sp		**F**	+
50315	Chimarra obscura		**MI**	34
51206	Cyrnellus fraternus		**F**	+
52200	Cheumatopsyche sp		**F**	131 +
52430	Ceratopsyche morosa group		**MI**	47 +
52530	Hydropsyche depravata group		**F**	11
53800	Hydroptila sp		**F**	8 +
59970	Petrophila sp		**MI**	1
69400	Stenelmis sp		**F**	24 +
77120	Ablabesmyia mallochi		**F**	+
77750	Hayesomyia senata or Thienemannimyia norena		**F**	25
77800	Helopelopia sp		**F**	12
79100	Thienemannimyia group		**F**	86
80400	Cricotopus sp		**F**	147
80420	Cricotopus (C.) bicinctus		**T**	98 +
80430	Cricotopus (C.) tremulus group		**MT**	24
82820	Cryptochironomus sp		**F**	12
83040	Dicrotendipes neomodestus		**F**	24 +
83050	Dicrotendipes lucifer		**MT**	12
83300	Glyptotendipes (G.) sp		**MT**	73
83310	Glyptotendipes (Heynotendipes) chelonia		**MI**	86 +
84000	Parachironomus sp		**MT**	73 +
84450	Polypedilum (Uresipedilum) flavum		**F**	220
84470	Polypedilum (P.) illinoense		**T**	+
84540	Polypedilum (Tripodura) scalaenum group		**F**	12
84960	Pseudochironomus sp		**F**	36
85230	Cladotanytarsus mancus group		**F**	+
85500	Paratanytarsus sp		**F**	12
85625	Rheotanytarsus sp		**F**	24
85800	Tanytarsus sp		**F**	+
85821	Tanytarsus glabrescens group sp 7		**F**	12
87540	Hemerodromia sp		**F**	4
98600	Sphaerium sp		**F**	+

No. Quantitative Taxa:	34	Total Taxa;	46
No. Qualitative Taxa:	28	ICI:	28
Number of Organisms:	1640	Qual EPT:	8

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-001** River: ***Mill Creek*** Coll. Date: *09/20/2016* RM: **1.70**

Site ID: **MC03** Location: *Dst. Lick Run CSO* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
03000	Ectoprocta		**F**	3	
03600	Oligochaeta		**T**	739	
04510	Hirudinida		**MT**		+
04660	Helobdella sp		**MT**		+
05900	Lirceus sp		**MT**	5	+
06201	Hyalella azteca		**F**		+
08200	Orconectes sp		**F**		+
11130	Baetis intercalaris		**F**	72	+
13521	Stenonema femoratum		**F**	6	+
16700	Tricorythodes sp		**MI**	20	
17200	Caenis sp		**F**	6	+
42700	Belostoma sp		**T**		+
50315	Chimarra obscura		**MI**	15	
51206	Cyrnellus fraternus		**F**	1	
52200	Cheumatopsyche sp		**F**	319	+
52430	Ceratopsyche morosa group		**MI**	20	
52530	Hydropsyche depravata group		**F**	11	
53800	Hydroptila sp		**F**	14	+
63300	Hydroporini		**T**		+
65800	Berosus sp		**MT**		+
68075	Psephenus herricki		**MI**		+
69400	Stenelmis sp		**F**	23	+
74501	Ceratopogonidae		**T**	4	
77120	Ablabesmyia mallochi		**F**	37	
77750	Hayesomyia senata or Thienemannimyia norena		**F**	262	
78100	Labrundinia sp		**F**	37	
80400	Cricotopus sp		**F**	262	
80420	Cricotopus (C.) bicinctus		**T**	899	+
80430	Cricotopus (C.) tremulus group		**MT**	37	
81200	Nanocladius sp		**F**		+
81231	Nanocladius (N.) crassicornus or N. (N.) "rectinervis"		**F**	75	
82700	Chironomus sp		**MT**		+
82820	Cryptochironomus sp		**F**	37	
83000	Dicrotendipes sp		**F**	75	
83040	Dicrotendipes neomodestus		**F**	75	+
83300	Glyptotendipes (G.) sp		**MT**	37	
84450	Polypedilum (Uresipedilum) flavum		**F**	450	
84470	Polypedilum (P.) illinoense		**T**	37	
84540	Polypedilum (Tripodura) scalaenum group		**F**	225	
84960	Pseudochironomus sp		**F**	37	
85625	Rheotanytarsus sp		**F**	112	
85821	Tanytarsus glabrescens group sp 7		**F**	150	
87540	Hemerodromia sp		**F**	5	
97601	Corbicula fluminea		**F**	5	+

No. Quantitative Taxa:	34	Total Taxa;	44
No. Qualitative Taxa:	20	ICI:	24
Number of Organisms:	4112	Qual EPT:	5

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-004** River: ***West Fork Mill Creek (Mill Cr. RM 11.57)*** Coll. Date: *09/15/2016* RM: **0.20**

Site ID: **MC45** Location: *dst. bridge at Elliot Ave.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
00401	Spongillidae		F	+
01801	Turbellaria		F	3 +
03600	Oligochaeta		T	5
04964	Erpobdella microstoma		MT	+
05900	Lirceus sp		MT	+
08250	Orconectes (Procericambarus) rusticus		F	+
08601	Hydrachnidia		F	+
11120	Baetis flavistriga		F	2 +
11130	Baetis intercalaris		F	721 +
13400	Stenacron sp		F	30 +
13521	Stenonema femoratum		F	92 +
17200	Caenis sp		F	91 +
22300	Argia sp		F	5 +
49101	Sisyridae		F	+
50315	Chimarra obscura		MI	6 +
52200	Cheumatopsyche sp		F	110 +
52430	Ceratopsyche morosa group		MI	+
52530	Hydropsyche depravata group		F	18 +
68075	Psephenus herricki		MI	+
69400	Stenelmis sp		F	13 +
74100	Simulium sp		F	+
77120	Ablabesmyia mallochi		F	15
77500	Conchapelopia sp		F	7
77750	Hayesomyia senata or Thienemannimyia norena		F	4
77800	Helopelopia sp		F	7
78450	Nilotanypus fimbriatus		F	28
80350	Corynoneura sp			8
80370	Corynoneura lobata		F	8
81650	Parametriocnemus sp	X	F	4
81825	Rheocricotopus (Psilocricotopus) robacki		F	4
82121	Thienemanniella lobapodema		F	4
82141	Thienemanniella xena		F	16
83300	Glyptotendipes (G.) sp		MT	4
84450	Polypedilum (Uresipedilum) flavum		F	201 +
84470	Polypedilum (P.) illinoense		T	4
84888	Xenochironomus xenolabis		F	+
85500	Paratanytarsus sp		F	7
85625	Rheotanytarsus sp		F	7 +
85821	Tanytarsus glabrescens group sp 7		F	15
85840	Tanytarsus sepp		F	4
96900	Ferrissia sp		F	4 +
97601	Corbicula fluminea		F	+
98600	Sphaerium sp		F	+

No. Quantitative Taxa:	31	Total Taxa;	43
No. Qualitative Taxa:	26	ICI:	48
Number of Organisms:	1447	Qual EPT:	9

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-006** River: ***East Fork Mill Creek*** Coll. Date: *09/20/2016* RM: **1.20**

Site ID: **MC18** Location: *Ust Bulter Co. Upper Mill Creek WWTP outfall* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		F	115 +
03600	Oligochaeta		T	85 +
04964	Erpobdella microstoma		MT	1
05900	Lirceus sp		MT	14 +
06700	Crangonyx sp		MT	2
11120	Baetis flavistriga		F	6 +
11130	Baetis intercalaris		F	17 +
13521	Stenonema femoratum		F	12 +
14501	Leptophlebiidae			+
17200	Caenis sp		F	18 +
21200	Calopteryx sp		F	+
22001	Coenagrionidae		T	+
22300	Argia sp		F	+
27500	Somatochlora sp		MT	+
50301	Chimarra aterrima		MI	14
50315	Chimarra obscura		MI	17
51600	Polycentropus sp		MI	+
52200	Cheumatopsyche sp		F	100 +
52430	Ceratopsyche morosa group		MI	32
52530	Hydropsyche depravata group		F	24 +
53800	Hydroptila sp		F	16
60900	Peltodytes sp		MT	+
65800	Berosus sp		MT	5
68025	Ectopria sp		F	1
68075	Psephenus herricki		MI	3 +
69400	Stenelmis sp		F	315 +
74501	Ceratopogonidae		T	1
77120	Ablabesmyia mallochi		F	2
77750	Hayesomyia senata or Thienemannimyia norena		F	19
77800	Helopelopia sp		F	17
78450	Nilotanypus fimbriatus		F	7
80363	Corynoneura sp 12		MI	8
80400	Cricotopus sp		F	10 +
80420	Cricotopus (C.) bicinctus		T	24 +
81650	Parametriocnemus sp	X	F	2
82820	Cryptochironomus sp		F	2
83840	Microtendipes pedellus group		F	2
84210	Paratendipes albimanus or P. duplicatus		F	15
84450	Polypedilum (Uresipedilum) flavum		F	51 +
84470	Polypedilum (P.) illinoense		T	5
84540	Polypedilum (Tripodura) scalaenum group		F	+
84750	Stictochironomus sp		F	+
85625	Rheotanytarsus sp		F	2
85720	Stempellinella fimbriata		MI	1
85800	Tanytarsus sp		F	5
85821	Tanytarsus glabrescens group sp 7		F	24
85840	Tanytarsus sepp		F	5
87540	Hemerodromia sp		F	8
95100	Physella sp		T	+
97601	Corbicula fluminea		F	30

No. Quantitative Taxa:	41	Total Taxa;	50
No. Qualitative Taxa:	23	ICI:	42
Number of Organisms:	1044	Qual EPT:	8

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-006** River: ***East Fork Mill Creek*** Coll. Date: *09/13/2016* RM: **1.00**

Site ID: **MC15** Location: *Dst. Butler Co. Upper Mill Creek WWTP Outfall* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
00401	Spongillidae		**F**	1 +
01801	Turbellaria		**F**	256 +
03000	Ectoprocta		**F**	+
03600	Oligochaeta		**T**	24 +
04901	Erpobdellidae		**MT**	+
04935	Erpobdella punctata punctata		**MT**	+
04964	Erpobdella microstoma		**MT**	1
04968	Erpobdella tetragon			30
05900	Lirceus sp		**MT**	1 +
11120	Baetis flavistriga		**F**	16
11130	Baetis intercalaris		**F**	56 +
13521	Stenonema femoratum		**F**	20 +
17200	Caenis sp		**F**	102 +
21200	Calopteryx sp		**F**	+
22001	Coenagrionidae		**T**	+
22300	Argia sp		**F**	1 +
28955	Plathemis lydia		**T**	+
50301	Chimarra aterrima		**MI**	+
51206	Cyrnellus fraternus		**F**	105
52200	Cheumatopsyche sp		**F**	965 +
52430	Ceratopsyche morosa group		**MI**	161
52530	Hydropsyche depravata group		**F**	169 +
60900	Peltodytes sp		**MT**	+
65800	Berosus sp		**MT**	10 +
68075	Psephenus herricki		**MI**	+
68708	Dubiraphia vittata group		**F**	16 +
68901	Macronychus glabratus		**F**	1
69400	Stenelmis sp		**F**	102 +
71900	Tipula sp		**F**	1
77100	Ablabesmyia sp			32
77750	Hayesomyia senata or Thienemannimyia norena		**F**	128
79100	Thienemannimyia group		**F**	64
80420	Cricotopus (C.) bicinctus		**T**	224
81240	Nanocladius (N.) distinctus		**MT**	128
82700	Chironomus sp		**MT**	64
82730	Chironomus (C.) decorus group		**T**	+
83040	Dicrotendipes neomodestus		**F**	192
83300	Glyptotendipes (G.) sp		**MT**	416
84450	Polypedilum (Uresipedilum) flavum		**F**	672
84470	Polypedilum (P.) illinoense		**T**	320 +
84750	Stictochironomus sp		**F**	+
85625	Rheotanytarsus sp		**F**	160 +
85821	Tanytarsus glabrescens group sp 7		**F**	192
87540	Hemerodromia sp		**F**	8
95100	Physella sp		**T**	1 +
95501	Planorbidae		**MT**	+

No. Quantitative Taxa:	34	Total Taxa;	46
No. Qualitative Taxa:	28	ICI:	34
Number of Organisms:	4639	Qual EPT:	6

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-006** River: ***East Fork Mill Creek*** Coll. Date: *09/12/2016* RM: **0.70**

Site ID: **MC14** Location: *Crescentville Rd.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.		Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	17	+					
03600	Oligochaeta		**T**	4	+					
04960	Erpobdella sp (= Mooreobdella)		**MT**	2						
05900	Lirceus sp		**MT**	1						
06700	Crangonyx sp		**MT**		+					
11120	Baetis flavistriga		**F**	3						
11130	Baetis intercalaris		**F**	34	+					
11200	Callibaetis sp		**MT**		+					
13521	Stenonema femoratum		**F**		+					
17200	Caenis sp		**F**	243	+					
21200	Calopteryx sp		**F**		+					
22001	Coenagrionidae		**T**		+					
22300	Argia sp		**F**	2	+					
23501	Aeshnidae			4						
50315	Chimarra obscura		**MI**	32						
51206	Cyrnellus fraternus		**F**	104						
52200	Cheumatopsyche sp		**F**	2226	+					
52430	Ceratopsyche morosa group		**MI**	165	+					
52530	Hydropsyche depravata group		**F**	508	+					
60900	Peltodytes sp		**MT**		+					
68025	Ectopria sp		**F**	8						
68075	Psephenus herricki		**MI**	9	+					
68901	Macronychus glabratus		**F**	1						
69400	Stenelmis sp		**F**	40	+					
77750	Hayesomyia senata or Thienemannimyia norena		**F**	88						
80420	Cricotopus (C.) bicinctus		**T**	59	+					
81240	Nanocladius (N.) distinctus		**MT**	176						
83040	Dicrotendipes neomodestus		**F**	29						
83050	Dicrotendipes lucifer		**MT**	29						
83300	Glyptotendipes (G.) sp		**MT**	234	+					
84450	Polypedilum (Uresipedilum) flavum		**F**	1141	+					
85625	Rheotanytarsus sp		**F**	644						
87540	Hemerodromia sp		**F**	32						
95100	Physella sp		**T**		+					
97601	Corbicula fluminea		**F**	16	+					

No. Quantitative Taxa:	28	Total Taxa;	35
No. Qualitative Taxa:	21	ICI:	40
Number of Organisms:	5851	Qual EPT:	7

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-006** River: ***East Fork Mill Creek*** Coll. Date: *09/12/2016* RM: **0.10**

Site ID: **MC16** Location: *Ust confluence with Mill Creek* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	
01801	Turbellaria		**F**		+
03600	Oligochaeta		**T**	4	
05900	Lirceus sp		**MT**	1	
08601	Hydrachnidia		**F**		+
11130	Baetis intercalaris		**F**	16	+
11651	Procloeon sp (w/o hindwing pads)		**MI**		+
13521	Stenonema femoratum		**F**	34	+
17200	Caenis sp		**F**	1310	+
22001	Coenagrionidae		**T**	8	+
22300	Argia sp		**F**	13	+
23501	Aeshnidae				+
43570	Neoplea sp		**F**		+
50315	Chimarra obscura		**MI**		+
51206	Cyrnellus fraternus		**F**	32	+
51600	Polycentropus sp		**MI**	1	
52200	Cheumatopsyche sp		**F**	167	+
52430	Ceratopsyche morosa group		**MI**	17	+
52530	Hydropsyche depravata group		**F**	23	+
59500	Oecetis sp		**F**		+
59700	Triaenodes sp		**MI**		+
60900	Peltodytes sp		**MT**		+
65800	Berosus sp		**MT**	2	
68075	Psephenus herricki		**MI**	1	
68708	Dubiraphia vittata group		**F**		+
69400	Stenelmis sp		**F**	18	+
69901	Curculionidae			1	
77750	Hayesomyia senata or Thienemannimyia norena		**F**	8	
78450	Nilotanypus fimbriatus		**F**	7	
80370	Corynoneura lobata		**F**	2	
80420	Cricotopus (C.) bicinctus		**T**		+
81240	Nanocladius (N.) distinctus		**MT**	4	
83040	Dicrotendipes neomodestus		**F**	28	
83300	Glyptotendipes (G.) sp		**MT**	16	
84450	Polypedilum (Uresipedilum) flavum		**F**	176	+
84470	Polypedilum (P.) illinoense		**T**	24	+
84540	Polypedilum (Tripodura) scalaenum group		**F**	32	+
85201	Cladotanytarsus species group A		**F**	4	
85500	Paratanytarsus sp		**F**	4	
85625	Rheotanytarsus sp		**F**	16	+
85821	Tanytarsus glabrescens group sp 7		**F**	4	+
85840	Tanytarsus sepp		**F**	12	
95100	Physella sp		**T**	5	+

No. Quantitative Taxa:	31	Total Taxa;	42
No. Qualitative Taxa:	27	ICI:	48
Number of Organisms:	1990	Qual EPT:	11

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-017** River: ***Bloody Run*** Coll. Date: *09/21/2016* RM: **0.30**

Site ID: **MC102** Location: *Ust. Vine St.* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.	Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
03600	Oligochaeta		**T**	+					
72600	Aedes sp		**T**	+					
84470	Polypedilum (P.) illinoense		**T**	+					
95100	Physella sp		**T**	+					

No. Quantitative Taxa:	0	Total Taxa;	4
No. Qualitative Taxa:	4	ICI:	VP
Number of Organisms:	0	Qual EPT:	0

Appendix Table C-2. Macroinvertebrate taxa collected by MBI at sites in Mill Creek study area in 2016.

River Code: **23-017** River: ***Bloody Run*** Coll. Date: *09/21/2016* RM: **0.20**

Site ID: **MC103** Location: *Rumpke Consolidated Co. Inc. Recycling Center* **MK**

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.
01801	Turbellaria		**F**	+
03600	Oligochaeta		**T**	+
68075	Psephenus herricki		**MI**	+
80420	Cricotopus (C.) bicinctus		**T**	+
82710	Chironomus (C.) sp		**MT**	+
84470	Polypedilum (P.) illinoense		**T**	+

Taxa Code	Taxa	CWH Taxa	Tol.	Qt./Ql.

No. Quantitative Taxa:	0	Total Taxa;	6
No. Qualitative Taxa:	6	ICI:	VP
Number of Organisms:	0	Qual EPT:	0

APPENDIX D

D-1: Mill Creek 2016 QHEI Metrics and Scores

Appendix D-1. QHEI metric scores for sites in the Mill Creek study area in 2016.

River Mile	QHEI	QHEI Metrics: Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient & Score	Narrative
(23001) Mill Creek									
Year: 2016									
26.40	**59.50**	14.0	12.0	13.0	5.50	7.0	4.0	50.10 - (4)	**Fair**
19.10	**70.50**	16.0	15.0	12.0	4.50	9.0	4.0	16.70 - (10)	**Good**
18.70	**66.00**	13.0	16.0	10.5	3.00	11.0	2.5	16.40 - (10)	**Good**
18.10	**77.00**	14.0	13.0	14.0	8.00	10.0	8.0	15.40 - (10)	**Excellent**
17.90	**64.00**	14.0	15.0	8.0	4.00	9.0	6.0	14.80 - (8)	**Good**
16.60	**60.00**	15.0	16.0	8.0	4.00	8.0	1.0	12.80 - (8)	**Good**
14.80	**53.00**	9.0	15.0	7.0	4.00	8.0	0.0	10.20 - (10)	**Fair**
13.90	**78.00**	16.0	15.0	15.0	3.50	12.0	6.5	9.16 - (10)	**Excellent**
13.70	**77.00**	15.0	15.0	14.5	3.50	12.0	7.0	8.95 - (10)	**Excellent**
13.20	**58.50**	15.0	16.0	5.0	3.50	9.0	0.0	8.51 - (10)	**Fair**
11.30	**70.75**	15.0	13.0	11.0	4.75	12.0	7.0	7.45 - (8)	**Good**
10.00	**79.00**	18.0	13.0	12.0	6.00	12.0	8.0	7.42 - (10)	**Excellent**
8.70	**73.50**	14.0	14.0	12.0	4.00	12.0	7.5	7.76 - (10)	**Good**
7.50	**48.00**	17.0	4.0	7.0	3.50	2.0	4.5	7.25 - (10)	**Fair**
6.90	**37.00**	8.0	2.0	7.0	3.00	4.0	3.0	7.35 - (10)	**Poor**
6.40	**27.50**	-1.5	2.0	7.0	3.00	4.0	3.0	7.57 - (10)	**Very Poor**
5.10	**47.00**	7.0	11.0	6.0	5.00	8.0	0.0	7.00 - (10)	**Fair**
4.30	**65.00**	14.0	12.0	11.0	5.50	10.0	2.5	6.83 - (10)	**Good**
3.50	**61.75**	13.0	11.0	10.5	4.75	10.0	2.5	6.72 - (10)	**Good**
3.10	**50.50**	12.0	5.0	8.0	5.50	8.0	2.0	6.89 - (10)	**Fair**
2.50	**60.50**	11.0	10.0	8.0	4.50	9.0	8.0	6.77 - (10)	**Good**
1.70	**54.00**	9.0	12.0	8.0	5.00	9.0	1.0	6.35 - (10)	**Fair**
0.70	**51.00**	9.0	15.0	6.0	5.00	6.0	0.0	6.52 - (10)	**Fair**
0.30	**49.50**	11.0	14.0	5.0	3.50	6.0	0.0	6.43 - (10)	**Fair**
0.05	**50.50**	11.0	10.0	10.0	3.50	6.0	0.0	6.35 - (10)	**Fair**
(23004) West Fork Mill Creek (Mill Cr. RM 11.57)									
Year: 2016									
0.20	**68.50**	15.0	14.0	13.0	3.00	9.0	6.5	19.20 - (8)	**Good**
(23006) East Fork Mill Creek									
Year: 2016									
1.20	**57.00**	13.0	11.0	9.0	6.00	10.0	4.0	50.70 - (4)	**Fair**
1.00	**73.00**	16.0	16.0	14.0	5.00	11.0	7.0	49.50 - (4)	**Good**
0.70	**58.50**	11.0	14.0	8.0	4.00	12.0	5.5	47.60 - (4)	**Fair**
0.40	**53.75**	11.0	12.0	8.0	2.25	11.0	5.5	46.10 - (4)	**Fair**

Appendix D-1. QHEI metric scores for sites in the Mill Creek study area in 2016.

River Mile	QHEI	QHEI Metrics: Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient & Score	Narrative
(23006) East Fork Mill Creek									
Year: 2016									
0.10	**65.50**	14.0	12.0	15.0	6.50	9.0	5.0	45.20 - (4)	**Good**
(23017) Bloody Run									
Year: 2016									
0.30	**44.50**	15.5	6.0	12.0	4.00	2.0	1.0	47.70 - (4)	**Poor**
0.20	**40.50**	5.5	8.0	12.0	4.00	4.0	3.0	47.70 - (4)	**Poor**