THE MIDDLE HURON RIVER WATERSHED MANAGEMENT PLAN, SECTION 2.

WASHTENAW COUNTY, MICHIGAN

INCLUDING:
THE HURON RIVER FROM BARTON POND TO THE CONFLUENCE OF FLEMING CREEK

FLEMING CREEKSHED

ALLENS CREEKSHED

MALLETTS CREEKSHED

MILLERS CREEKSHED

SWIFT RUN CREEKSHED

TRAVER CREEKSHED

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WATERSHED MANAGEMENT PLAN FOR THE MIDDLE HURON RIVER, SECTION 2.

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LIST OF ACRONYMS

BANCS: Bank Assessment for Non-point source Consequences of Sediment

BEHI: Bank Erosion Hazard Index

DO: Dissolved Oxygen

EGLE: Michigan's Department of Environment, Great Lakes, and Energy

EPA: U.S. Environmental Protection Agency

EPT: Ephemeroptera, Plecoptera, and Trichoptera

GIS: Geographic Information Systems

HRWC: Huron River Watershed Council

MDEQ: Michigan Department of Environmental Quality

MDNR or DNR: Michigan's Department of Natural Resources

NBS: Near bank stress

NPDES: National Pollutant Discharge Elimination System

NPS: Nonpoint source pollution

TMDL: Total Maximum Daily Load

TDS: Total Dissolved Solids

TSS: Total Suspended Solids

RCA: Reach contributing area (aka watershed)

SSC: Suspended Sediment Concentration

SEMCOG: Southeast Michigan Council of Governments

WMP: Watershed Management Plan

WWTP: Wastewater treatment plant

UNITS OF MEASURE:

CFU: Colony-forming Unit (bacteria)

cfs: Cubic feet per second (discharge/flow)

MPN: Most probable number (bacteria)

mg/L: milligram per liter (concentration of constituents in water), also equivalent to ppm: parts per million

µS/cm: microsiemens per centimeter (conductivity)

Chapter 1: Introduction

1.1 The Middle Huron River Watershed Management Plan: Section 2

The Middle Huron River Watershed Management Plan (WMP): Section 2 is part of an effort led by communities in this area seeking to plan activities to address water quality issues highlighted in the State of Michigan's Clean Water Act §303(d) report on impaired waters. The original WMP was completed in 1994, updated in 2000, 2008, and 2011, but was written for a larger area, covering the entire Middle Huron Watershed which covers the confluence of Mill Creek down to the end of Belleville Lake, and all tributaries draining to the Huron through that length. This 2020 version is the fourth update of that WMP, but it is narrower in scale as it only covers the middle geographic portion of that earlier WMP. Separate WMPs will be written for the upper (Section 1) and lower (Section 3) geographic portions.

For the purposes of this plan, Section 2 of the Middle Huron Watershed (Figure 1.1) will be referred to as the Watershed. It is composed of direct drainage to the Huron River from Barton Pond to the confluence of Huron River and Fleming Creek, as well as the Allens, Fleming, Malletts, Millers, Swift Run, and Traver subwatersheds (also called creeksheds throughout this document).

The Watershed is part of the Huron River Watershed, one of Michigan's natural treasures. The Huron River supplies drinking water to approximately 150,000 people, supports one of Michigan's finest smallmouth bass fisheries, and is the State's only designated Scenic River in southeast Michigan. The Huron River Watershed is a unique and valuable resource in southeast Michigan that contains ten Metroparks, two-thirds of all southeast Michigan's public recreational lands, and abundant county and city parks. In recognition of its value, the State Department of Natural Resources has officially designated 27 miles of the Huron River and three of its tributaries as "Country-Scenic" River under the State's Natural Rivers Act (Act 231, PA 1970). The Huron is home to 670,000 people, numerous threatened and endangered species and habitats, abundant bogs, wet meadows, and remnant prairies of statewide significance.

The Huron River basin encompasses approximately 900 square miles (576,000 acres) of Ingham, Jackson, Livingston, Monroe, Oakland, Washtenaw, and Wayne counties (Figure 1.1). The main stem of the Huron River is approximately 136 miles long, originating at Big Lake and the Huron Swamp in Springfield Township, Oakland County. The main stem of the river meanders from the headwaters through a complex series of wetlands and lakes in a southwesterly direction to the area of Portage Lake. Here, the river begins to flow south until reaching the Village of Dexter in Washtenaw County, where it turns southeasterly and flows to its final destination of Lake Erie. The Huron is not a free-flowing river. At least 98 dams segment the river system, of which 17 are located on the main stem.

The drainage area to the Watershed is 81 square miles (51,693 acres), representing approximately 9% of the total Huron River Watershed. All or portions of 10 local communities are situated in the Watershed, of which the largest portions are within the City of Ann Arbor, and the townships of Ann Arbor, Salem, Superior, and Pittsfield. The townships of Northfield, Lodi, Ypsilanti and Scio hold very small edge sections of the Watershed. The Watershed lies entirely in Washtenaw County.

The segment of the Huron River in the Watershed begins with Barton Pond and ends in the Huron River, just after the confluence with Fleming Creek. Six major tributaries run directly into the Huron River system in this section. The mainstem of the Huron River in the Watershed is approximately 9.6 miles long with additional 83.5 miles of contributing open perennial streams and 16.4 of intermittent stream. The elevation drops 73 feet over 9.6 river miles for an average gradient of 7.6 ft/mi. This gradient compares to an average of 3.3 ft/mi for the entire Huron River.

A relatively significant elevation drop from watershed inlet to outlet coupled with intensive urban development means that fewer lakes and wetlands remain in the Watershed than in the Upper Huron watersheds or other watersheds in Michigan. Approximately 3,707 acres of wetlands remain in the Watershed as of 2019, comprising about 7% of the total watershed area.[1] The Watershed area contains 41 bodies of open water (21 lakes (5 acres or greater), 19 ponds (less than 5 acres)

The Watershed contains several natural areas including Barton Park, Bird Hills Park, Gallup Park, Nichols Arboretum, Parker Mill County Park, Matthaei Botanical Gardens, as well as numerous other public and private local parks. The Watershed's land cover is dominated by urban and sub-urban residential, commercial and industrial uses, with low-density residential areas, grasslands/old agricultural fields, forested lands, and wetlands scattered primarily in the northern and eastern fringes of the watershed.

In recent decades, the Watershed has experienced amplified development pressures from a growing economy and urban sprawl. According to the U.S. Census data and the Southeast Michigan Council of Governments (SEMCOG)[2], Washtenaw County is currently the fastest growing county in southeast Michigan.

According to SEMCOG, Washtenaw County's population increased by almost 9% from 2000 to August 2007, compared with 2.2% in Oakland County, -0.9% in Wayne County (excluding Detroit) and 23% in Livingston County. From 2010-2018, the pattern of growth did not change in Washtenaw County although Livingston County's growth slowed substantially; Washtenaw County grew by 7.5%, as compared to 4.5% in Oakland, -3.8% in Wayne County, and 5.5% in Livingston County.

The fastest area of growth (from 2010-2018) in Washtenaw County is Salem Township (18.7%), part of which is within the Watershed. The population in other major land areas of the Watershed have increased as well: the City of Ann Arbor has grown at 5.6%; Ann Arbor Township, 15%; Superior Township, 5.1%; Pittsfield Township, 18.7%.

The SEMCOG forecast to 2045 shows a 30% increase in population from 2018 levels, across the southeast Michigan region. (This study does not break forecasting down for more specific land areas). Growth on this scale will result in the continued development of current open spaces and natural areas which will hasten the degradation of the hydrology and water quality of surface waters. Common practices that impact hydrology and water quality include draining wetlands, straightening and dredging streams ("drains"), removing riparian vegetation, installing impervious surfaces and storm sewers, inadequately controlling soil erosion, and poorly designed stream crossings. Such practices result in altered hydrology ("flashy" flows and flooding), soil erosion and sedimentation, elevated nutrients, nuisance algal blooms, dangerous levels of pathogens, and degraded fisheries.

Figure 1.1. The Huron River Watershed is located in Southeast Michigan. The focus of this report is on the subwatersheds highlighted in this map.

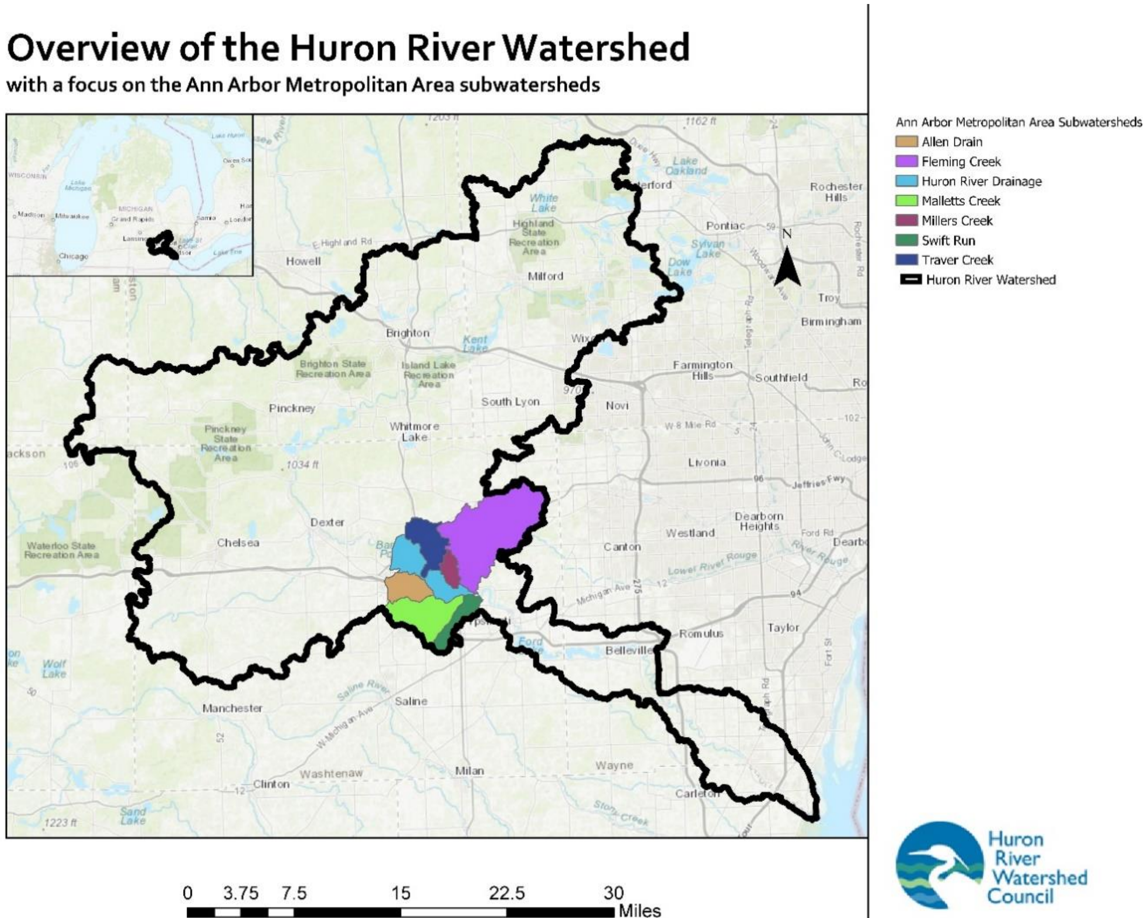
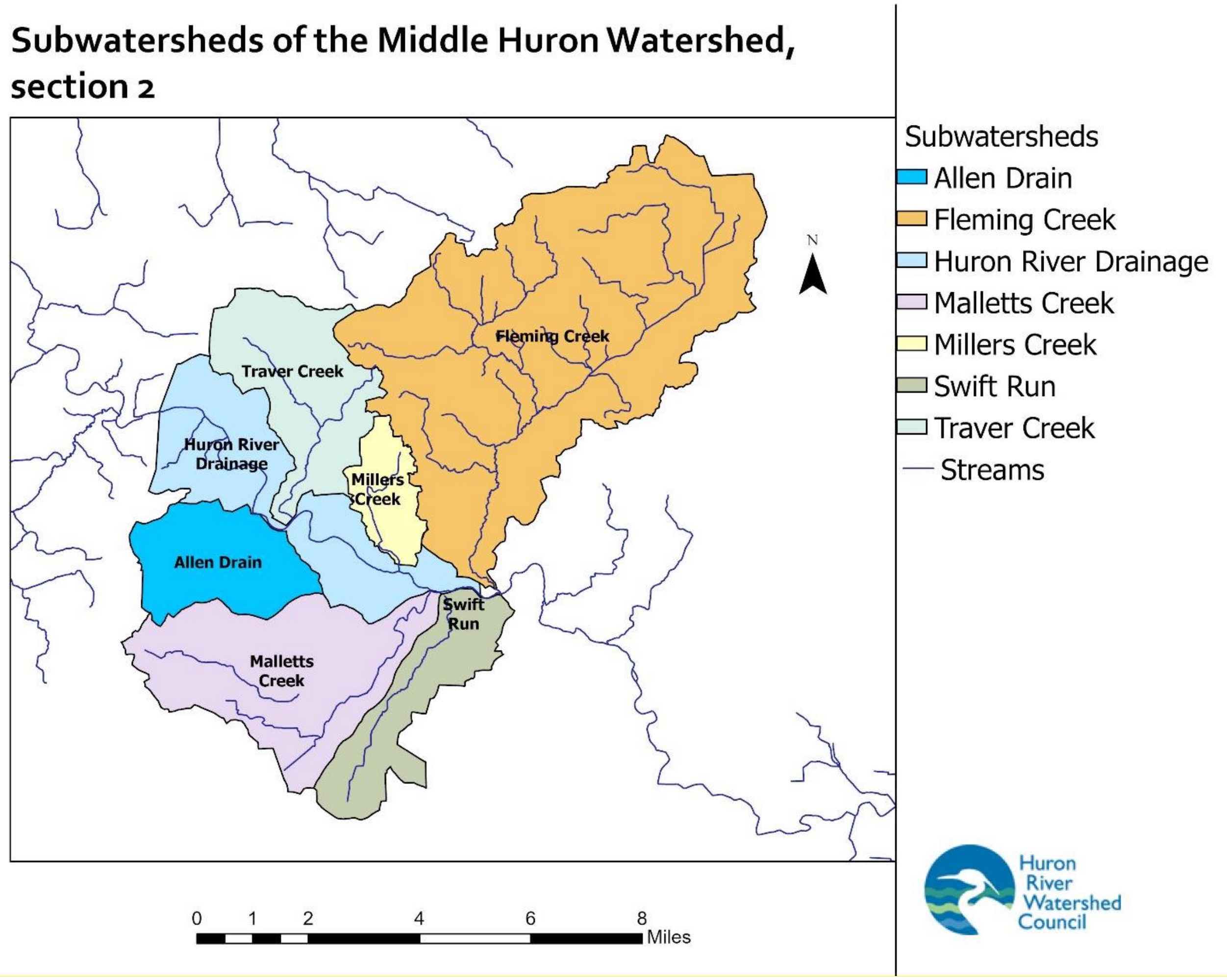


Figure 1.2 The Watershed, the focus of this WMP, is comprised of direct drainage to the Huron River from Barton Pond to the confluence of Huron River and Fleming Creek, as well as the Allens, Fleming, Malletts, Millers, Swift Run, and Traver subwatersheds



1.2 Purpose of the Watershed Management Plan

The primary purpose of this plan is to address water quality impairments for the Middle Huron Watershed. The plan represents a broad effort to restore and protect the integrity of water quality and quantity of the watershed system. This plan presents a state-approved methodology to diminish the adverse effects of nonpoint source pollution (NPS) to meet the established impairment elimination plans and proactively address others that will be developed within the watershed. This plan outlines both quantitative and qualitative steps considered necessary to meet water quality goals for the Huron River and its watershed.

In order for the State of Michigan to approve a watershed plan, the plan must meet the following criteria as established in State Rule 324.8810:

> *A watershed management plan submitted to EGLE for approval under this section shall contain current information, be detailed, and identify all of the following:*
>
> *(a) The geographic scope of the watershed.*
> *(b) The designated uses and desired uses of the watershed.*
> *(c) The water quality threats or impairments in the watershed.*
> *(d) The causes of the impairments or threats, including pollutants.*
> *(e) A clear statement of the water quality improvement or protection goals of the watershed management plan.*
> *(f) The sources of the pollutants causing the impairments or threats and the sources that are critical to control in order to meet water quality standards or other water quality goals.*
> *(g) The tasks that need to be completed to prevent or control the critical sources of pollution or address causes of impairment, including, as appropriate, all of the following:*
> *(i) The best management practices needed.*
> *(ii) Revisions needed or proposed to local zoning ordinances and other land use management tools.*
> *(iii) Informational and educational activities.*
> *(iv) Activities needed to institutionalize watershed protection.*
> *(h) The estimated cost of implementing the best management practices needed.*
> *(i) A summary of the public participation process, including the opportunity for public comment, during watershed management plan development and the partners that were involved in the development of the watershed management plan.*
> *(j) The estimated periods of time needed to complete each task and the proposed sequence of task completion.*

The above criteria are necessary for approval under the Clean Michigan Initiative guidelines. To be approved for funding under federal Clean Water Act section 319, a plan must meet the "9 Minimum Elements:"

a. *An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan). Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed.*
b. *An estimate of the load reductions expected for the management measures described under paragraph (c) below. Estimates should be provided at the same level as in item (a) above.*
c. *A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.*

d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan.
e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.
f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.
g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

The communities involved in the development of this plan are committed to protecting the sensitive natural areas of the watershed, mitigating impacts of existing point and nonpoint source pollution, and restoring degraded areas.

1.2.1 Designated and Desired Uses

According to Michigan's Department of Environment, Great Lakes, and Energy (EGLE), the primary criterion for water quality is whether or not the water body meets its designated uses. Designated uses are recognized uses of water established by state and federal water quality programs. In Michigan, the goal is to have all waters of the state meet all designated uses. It is important to note that not all of the uses listed below may be attainable, but they may serve as goals toward which the watershed can move.

All surface waters of the state of Michigan are designated for and shall be protected for all of the following uses.[3] The designated uses that apply to the Watershed are in boldface:

- **Agriculture**
- **Industrial water supply**
- **Public water supply at the point of intake**
- **Navigation**
- **Warmwater fishery**
- **Other indigenous aquatic life and wildlife**
- **Partial body contact recreation**
- **Total body contact recreation between May 1 and October 31**
- Coldwater fishery

Due to human impacts and the impairments they cause throughout the Watershed, not all of the designated uses are fulfilled. The impairments are discussed in more detail in Chapter 2.

In addition to state-designated uses, the residents of the watershed wish to use its surface waters in ways that are not yet achievable. The following desired uses have been identified by the communities in the watershed over the course of the development and updating of the WMP:

- **Coordinated development**
  Promote a balance of environmental and economic considerations through intentional community planning and coordinated development within and among the Watershed communities.

- **Hydrologic functions of natural features**
  Protect and enhance natural features related to water quantity and quality, including wetlands, floodplains, riparian buffer zones, and stream channels that regulate the flow of stormwater runoff, protect against flooding, and reduce soil erosion and sedimentation.

- **Open space, recreation and urban amenities**
  Protect priority natural habitat, recreational areas and trails, agricultural lands, and urban open spaces from development in order to maintain their natural functions, preserve rural character, and enhance recreational opportunities for present and future generations.

1.2.2 Total Maximum Daily Load Program

A Total Maximum Daily Load (TMDL) is the maximum amount of a particular pollutant a waterbody can assimilate without violating state water quality standards. Water quality standards identify the applicable "designated uses" for each waterbody, such as swimming, agricultural or industrial use, public drinking water, fishing, and aquatic life. EGLE establishes scientific criteria for protecting these uses in the form of a number or a description of conditions necessary to ensure that a waterbody is safe for all of its applicable designated uses.

The state also monitors water quality to determine the adequacy of pollution controls from point source discharges. If a waterbody cannot meet the state's water quality criteria with point-source controls alone, the Clean Water Act requires that a TMDL must be established. TMDLs provide a basis for determining the pollutant reductions necessary from both point *and nonpoint* sources to restore and maintain the water quality standards. Point sources is the term used to describe direct discharges to a waterway, such as industrial facilities or wastewater treatment plants. Nonpoint sources are those that enter the waterways in a variety of semi- or non-traceable ways such as stormwater runoff.

In Michigan, the responsibility to establish TMDLs rests with EGLE. Once a TMDL has been established by EGLE, affected stakeholders must develop and implement a plan to meet the TMDL, which will bring the waterbody into compliance with state water quality standards

As of the 2018 List of Nonattaining Waterbodies from EGLE, seven waterbodies as delinieated by Assessment Unit Identifiers (AUID) in the Watershed are listed for water quality problems that can be addressed by this plan.

Figure 1.3: Stream reaches with Impaired Designate Uses
(Source: EGLE 2018 list of nonattaining waterbodies)

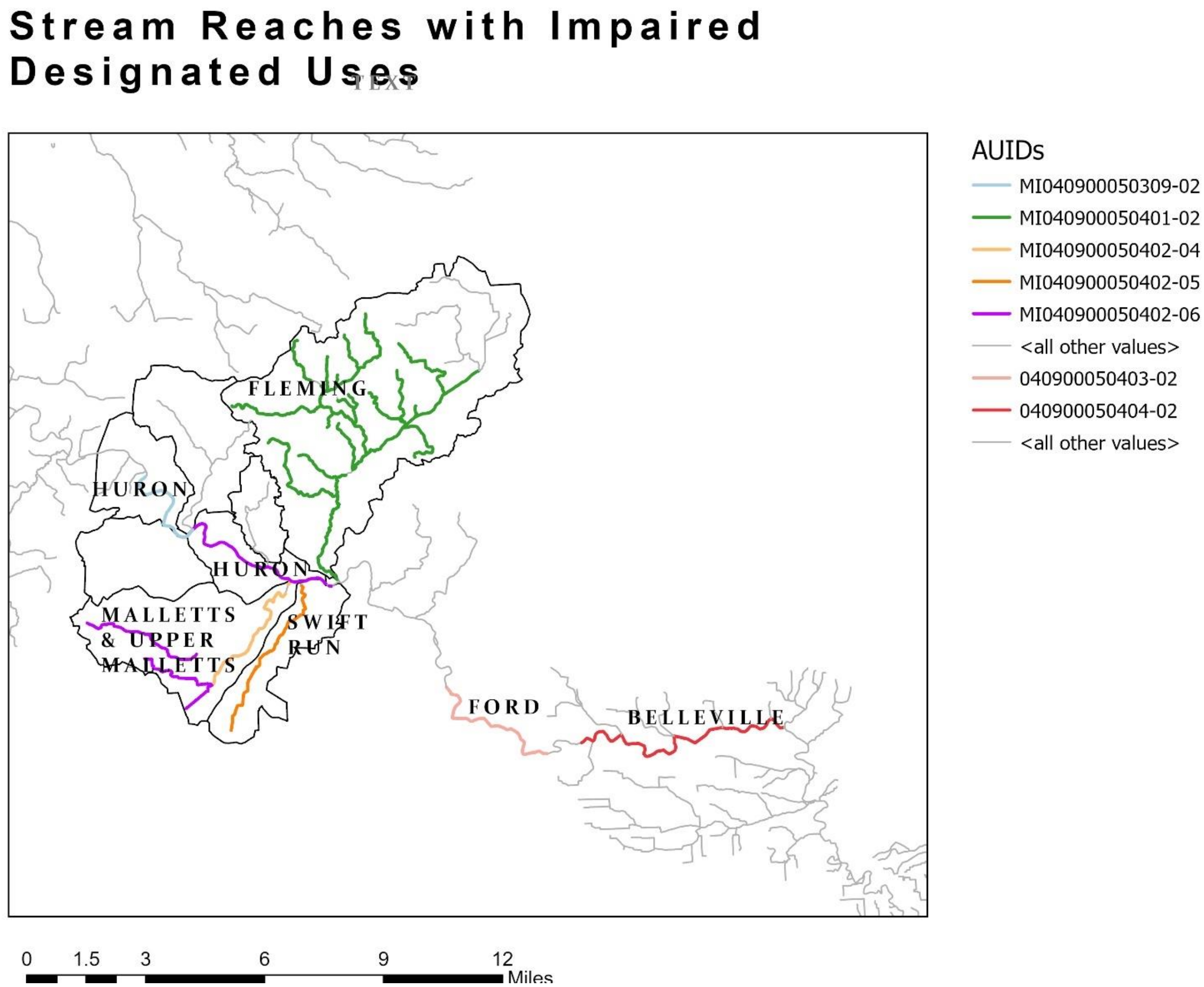


Table 1.1: Stream reaches with Impaired Designate Uses and established TMDLs

AUID	Subwatershed	Designated Use Not Met	Pollutant	Stream length (miles)
MI040900050309-02	Huron River	Fish Consumption	DDT in fish tissues.	3.07
MI040900050401-02	Fleming Creek	Partial Body Contact Recreation	*E. Coli*	37.08
MI040900050401-02	Fleming Creek	Total Body Contact Recreation	*E. Coli*	37.08
MI040900050402-04	Malletts Creek	Partial Body Contact Recreation	*E. Coli*	3.87

MI040900050402-04	Malletts Creek	Total Body Contact Recreation	*E. Coli*	3.87
MI040900050402-04	Malletts Creek	Other Indigenous Aquatic Life and Wildlife	Flow Regime Modification	3.87
MI040900050402-04	Malletts Creek	Warm Water Fishery	Flow Regime Modification	3.87
MI040900050402-05	Swift Run Creek	Total Body Contact Recreation	*E. Coli*	4.79
MI040900050402-05	Swift Run Creek	Partial Body Contact Recreation	*E. Coli*	4.79
MI040900050402-05	Swift Run Creek	Other Indigenous Aquatic Life and Wildlife	Flow Regime Modification	4.79
MI040900050402-05	Swift Run Creek	Other Indigenous Aquatic Life and Wildlife	Sedimentation/Siltation	4.79
MI040900050402-06	Huron River and Malletts Creek headwaters	Total Body Contact Recreation	*E. Coli*	11.31
MI040900050403-02	Ford Lake*	Other Indigenous Aquatic Life and Wildlife	Total Phosphorus	Lake: 1.523 mi²
MI040900050404-02	Belleville Lake*	Other Indigenous Aquatic Life and Wildlife	Total Phosphorus	Lake: 1.984 mi²

* The Ford and Belleville Phosphorus TMDL includes the whole watershed area of this WMP, although Ford and Belleville Lakes themselves are outside the boundaries of this WMP.

Multiple waters throughout the Huron River watershed are also listed as impaired for fish consumption due to PCB or mercury contamination. The impairments are addressed by statewide TMDLs developed in 2013 for PCBs and in 2018 for mercury. However, because the problems associated with PCB and mercury TMDLs are linked to broadly diffuse air-deposition, actions designed to address this TMDL are not emphasized in this plan, which focuses on locally-sourced impairments. The PCB and mercury TMDLs identify air emission sources inside and outside the state of Michigan, with most being outside the Huron River watershed. No waters (or fish tissue) in the target watershed are impaired for mercury contamination. Some PCB reduction activities are recommended, but generally the recommendation is to maintain the current trend of declining PCB concentrations in the environment.

1.2.3 Other Subwatershed Management Plans

This Plan was developed with the intention of fulfilling the watershed management planning criteria for the U.S. EPA’s Clean Water Act §319 Program and EGLE’s Clean Michigan Initiative Program. In addition, many of the communities have developed plans to comply with the NPDES Phase II Stormwater Program. It should also be noted that several other “subwatershed” plans have been developed previously through a combination of community, public and private collaborative efforts. These include the Millers Creek Plan (Appendix A1), the Malletts Creek Restoration Plan (Appendix B2), and the Allens Creek Plan (Appendix C).

Additionally, point source and nonpoint source Pollutant Reduction Implementation Plans have been developed as part of the voluntary Middle Huron Partnership Initiative to implement the Ford and Belleville Lakes TMDL. These plans and efforts are described in further detail in other chapters of the plan. Information and recommendations from all these plans have been incorporated into this watershed management plan, so it is the most current assessment and prescription for action.

1.3 The Watershed Management Plan Community Input

The first task involved in developing the original 1994 Watershed Management Plan was the formation of a Policy Advisory Committee, with members representing each of the communities in the project area. In January 1993, an initial meeting of this group was convened to discuss issues related to nonpoint source pollution in the planning area and individual community concerns. Following this introductory meeting, goals and objectives for controlling water quality were developed and submitted to committee members for review and approval. Since that time the Committee has continued to meet on a regular basis to assist in watershed planning activities throughout the Middle Huron basin. Currently, the Middle Huron Partnership Initiative coordinates the meeting of these communities with the expressed intent to plan and implement activities to address the Ford and Belleville Lakes TMDL for phosphorus.

The Huron River Watershed Council (HRWC) was the primary author of the WMP starting in 1994 and continues this role for the 2020 update.

For the 2008 update, an Advisory Committee was established, with representation from each of the communities in the Middle Huron Watershed, with the exception of Van Buren Township and the City of Belleville, as Belleville Lake was added to the geographic scope late in the update process. Project staff held bi-monthly meetings with the Advisory Committee to get feedback on different sections of the WMP. Materials were also distributed to Committee members and other interested parties for review, comment and input. All communities were given draft copies of the WMP for review prior to finalizing. Small updates to the plan were made in 2011.

For the 2020 update, HRWC assembled a stakeholder group which consisted of the primary governments in the Watershed and other major landowners with property on or near a waterway. These stakeholders included:

- Washtenaw County Water Resources Commissioner
- Washtenaw County Road Commissioner
- City of Ann Arbor
- Ann Arbor Township:
- Superior Township
- Pittsfield Township
- Salem Township

- University of Michigan
- Domino Farms

Stakeholders were given a detailed overview of HRWC's data collection and monitoring efforts over the past 10 years, and gave input as to what projects their municipalities have accomplished since 2008 and what projects they would like to yet see implemented. All stakeholders were given draft copies of the WMP for review prior to finalizing.

1.3.1. Technical Advisory Committees

Several Technical Advisory Committees were established to provide input to individual components of this plan. A Committee was established to assist in revising the Drain Commissioner's standards governing the design of stormwater management systems in new developments. Members included staff from local planning, engineering, building inspection and utilities departments. Private engineering and planning consultants were also represented, as well as the HRWC, the County Soil Conservation District and the Michigan Department of Natural Resources (DNR). Committee members were provided with working drafts of the Drain Commissioner's standards (including explanations about how revisions work to improve water quality and quantity control) and asked to provide feedback on their practicality for implementation within Washtenaw County. Revised standards were adopted in 1994. Public involvement and review also guided the 2000 update, the 2008 update, and the 2020 update.

Additionally, the Middle Huron Partnership was formed to address the Ford and Belleville Lakes TMDL. The Partnership originally formed in 1999 following development of the TMDL, and an updated Cooperative Agreement was signed in 2005 (Appendix D) and was effective through 2009. The group still continues to meet and work in 2020, and is still facilitated by HRWC. While the agreement has expired, the Agreement still serves as a voluntary guide for the partners to address the phosphorus reduction targets described in the TMDL. The Partnership now meets multiple times a year to report on progress and also serves as an advisory body for this WMP.

1.3.2 Input from Local Subwatershed and Creek Groups

Creek groups have contributed a unique community involvement component to the development of the original WMP and updates. Several creek groups (Fleming, Malletts, Millers, Allens) have formed since the development of the original WMP, and several of these have developed subwatershed plans or other sets of recommendations. This plan incorporates these components not simply as feedback for the update, but as a basic framework for updating the plan. Recommendations made in this document represent a collaborative effort between the HRWC, the Washtenaw County Water Resources Commissioner's Office, the individual creek groups and the greater creekshed communities.

Staff from HRWC and the Washtenaw County Water Resources Commissioner's Office have met, and will continue to meet with creek groups, throughout the process of developing and implementing watershed plans. Involving these groups will continue to foster community support for WMP implementation and creek restoration activities. Representatives of the HRWC and the Water Resources Commissioner's Office will remain involved in these groups to assist in their development, management planning, grant proposals, policy and technical assistance, and special event coordination. In addition, creek group representatives will continue to advise the Water Resources Commissioner's Office and HRWC in program development as they have for current and past restoration projects.

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[1] US Fish and Wildlife Service, 2019. The National Wetlands Inventory.

[2] SEMCOG, the Southeast Michigan Council of Governments. November 2018. Population and Household Estimate for Southeast Michigan. www.semcog.org.

[3] Brown, E., A. Peterson, R. Kline-Roback, K. Smith, and L. Wolfson. February 2000. Developing a Watershed Management Plan for Water Quality; and Introductory Guide, Institute for Water Research, Michigan State University Extension, Michigan Department of Environmental Quality, P.10.45 R323.1100 of Part 4, Part 31 of PA 451, 1994, revised 4/2/99.

Chapter 2:
Current Conditions

An effort has been made to collect all readily available information to establish a baseline of current conditions of the Watershed. The information collection effort included requests to Advisory Committee members and researchers in the area. Numerous studies and datasets of relevance were obtained in this process. In addition, spatial data was gathered and analyzed in a Geographic Information System.

2.1 Landscape and Natural Features

2.1.1 Climate

The rapidly changing climate in Southeast Michigan merits special consideration and for this watershed management plan was given a separate chapter (Chapter 3).

2.1.2 Geology, Soils, and Groundwater

The soils in the Watershed are primary end moraines of fine or medium-textured till (Figure 2.1). End moraines are areas where glacial processes deposited huge quantities of rock and soil material of various sizes in one place. The mixture of varying sized soil particles increases the soils' ability to hold moisture and nutrients, which is conducive to agriculture.

The other primary soil type in the Watershed is glacial outwash sand and gravel. Glacial outwash plains were created by melting glaciers whose runoff sorted soils into layers of similarly sized particles. These well-sorted soils include sand and gravel that allow rapid infiltration of surface water to groundwater aquifers and stream systems. These soils are found in the riparian zone of the Huron River, Fleming Creek, and Malletts Creek; these areas are also the areas with the highest groundwater recharge rates. (Figure 2.2)

Figure 2.1. The Watershed's Glacial Geology.

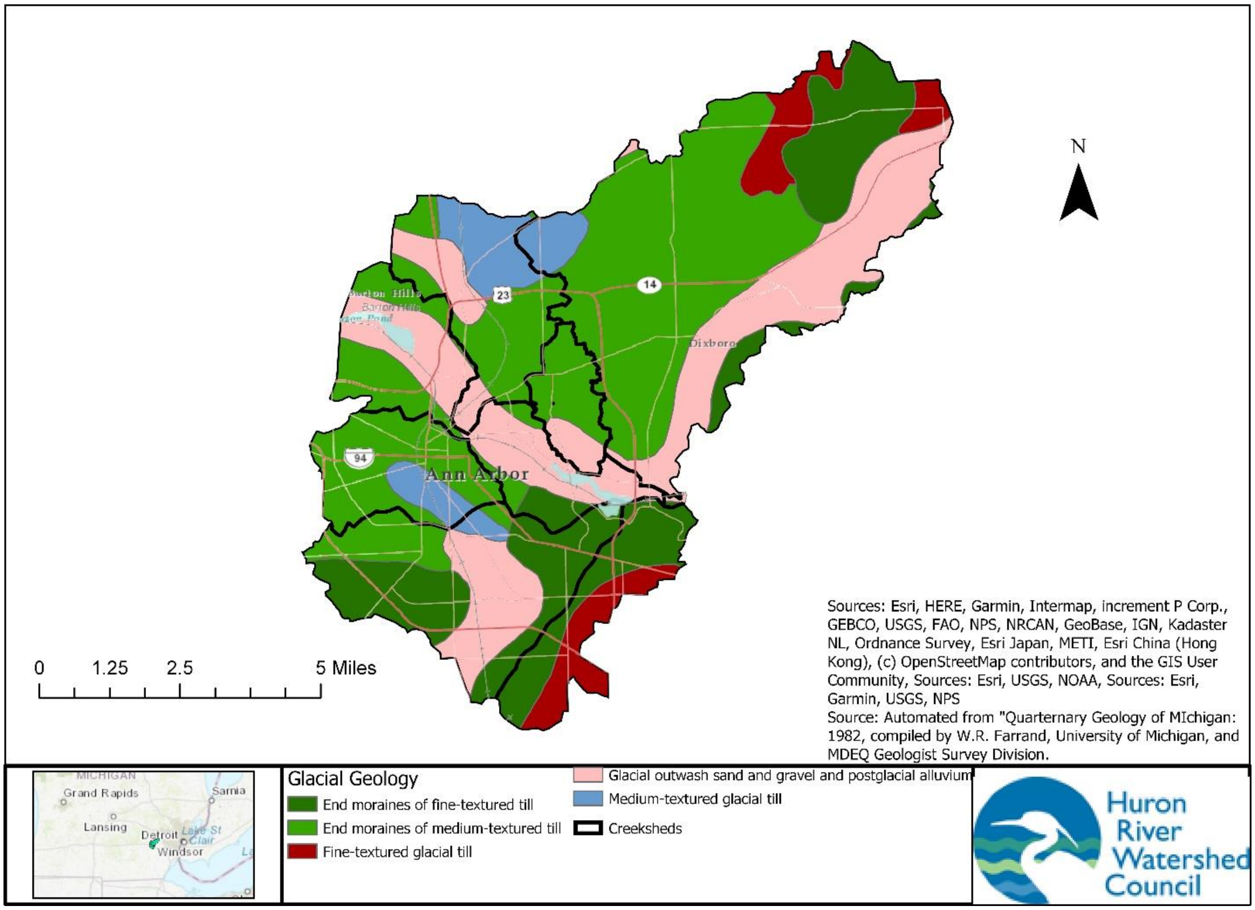
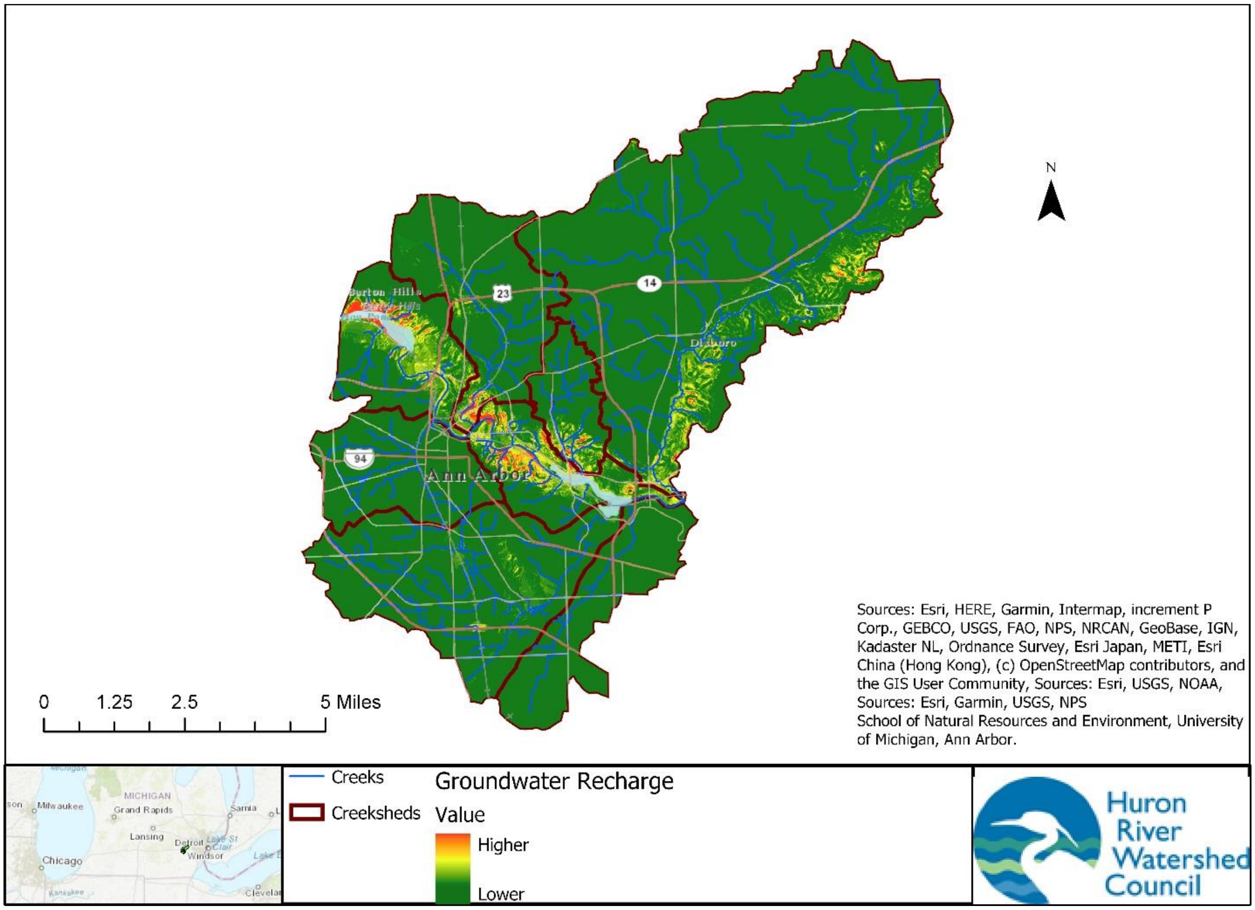


Figure 2.2. General groundwater recharge rates across the Watershed.



The groundwater recharge potential map utilizes Darcy's Law to predict the probability of groundwater recharge areas in the watershed. As shown in Figure 2.2, Darcy's Law predicts that areas adjacent to the river and tributary systems generally hold the greatest probability of having groundwater recharge. Figures 2.3 and 2.4 illustrate the depth to groundwater (recharge map) and soil permeability (permeability map) characteristics for the watershed. Such information is useful when considering the applicability of certain stormwater control structures (i.e., best management practices), especially infiltration-based, and the appropriateness of certain development proposals that may require added water quality precautions within the watershed (i.e., gas stations, chemical storage facilities, etc.). Some of this data yield conflicting results. A more detailed analysis of groundwater recharge could be undertaken to resolve or clarify these areas of conflict.

Figure 2.3. Depth to groundwater in the Watershed.

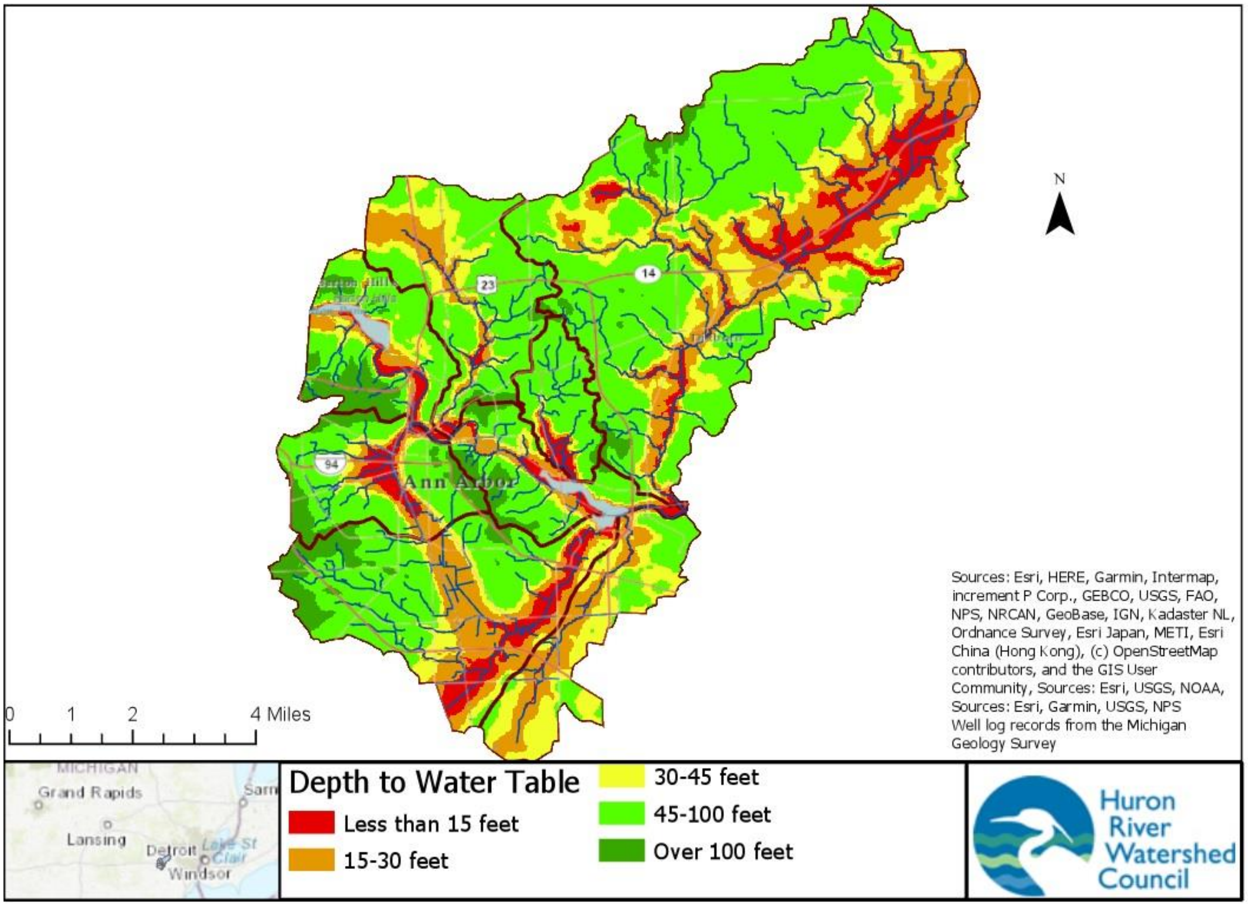
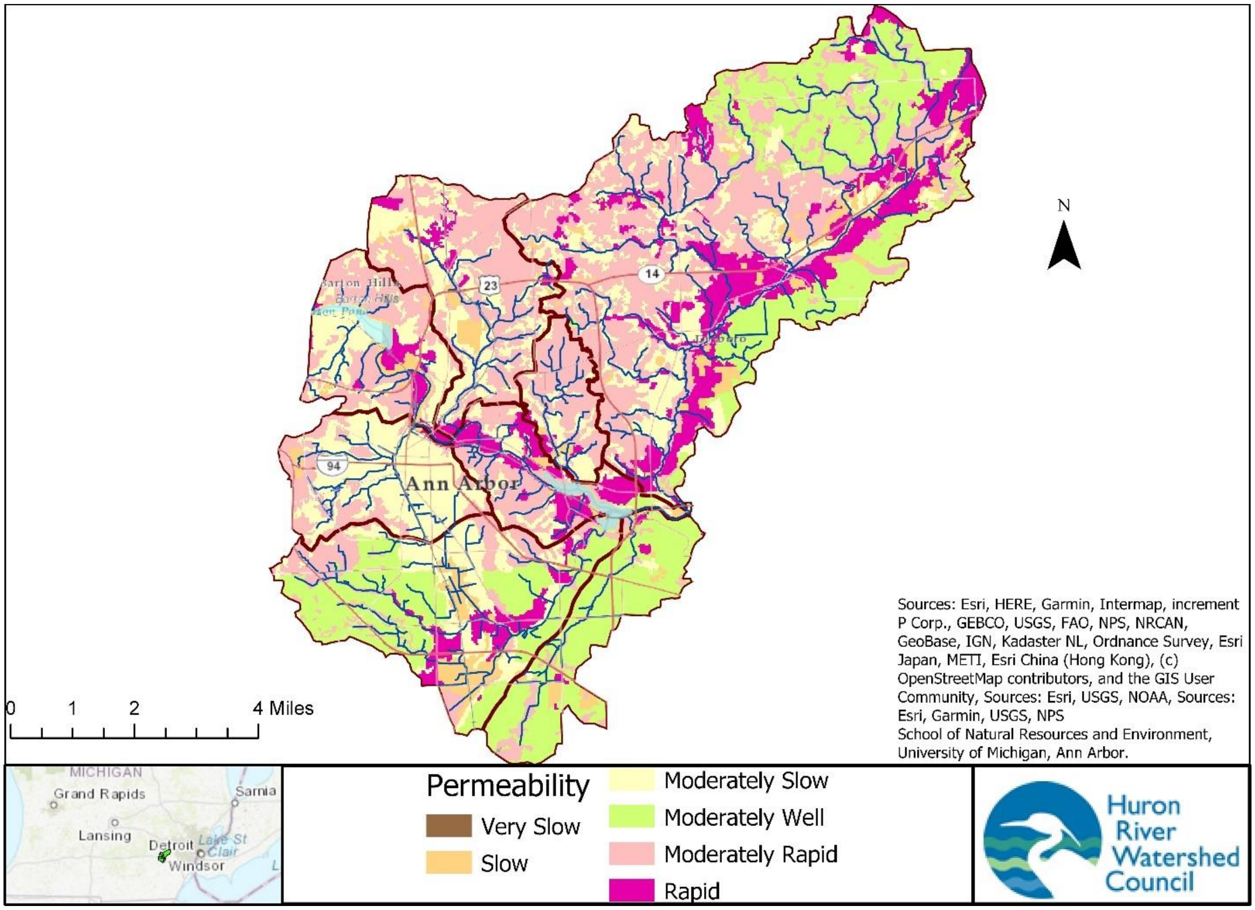


Figure 2.4. Relative soil permeability characteristics for the Watershed.



2.1.3 Significant Natural Features and Biota

Since the Watershed frames the city of Ann Arbor, significant building pressure has caused the land to become altered and degraded. Still, pockets of high-quality habitat and diverse species persist due to conscientious planning and policy-making efforts that seek to preserve wildlife habitat. The expansiveness and ecological quality of the remaining open spaces and native habitats directly impact the quality of life and quality of water in the Watershed. Researchers have recognized plant and animal species and plant community types as integral parts of the Watershed that deserve protecting. Among those conservation targets are the threatened and endangered species that have been observed in the Watershed (Table 2.1)[1]. Many of the plant and animal occurrences in the table are partially or entirely dependent on aquatic ecosystems for survival.

Table 2.1. Threatened, Endangered, and Special Concern Occurrences in Washtenaw County from 1968-Present. As many have not be seen/recorded in some time, it is possible they have been extirpated. Digital version of this table links directly to the MNFI website. Explanation of codes is below.

Common Name	Scientific Name	Federal Status	State Status	State Rank	Global Rank	Occurrences in County	Last Observed in County
AMPHIBIAN							
Blanchard's cricket frog	Acris blanchardi		T	S2S3	G5	10	2012
Pickerel frog	Lithobates palustris		SC	S3S4	G5	6	2018
Smallmouth salamander	Ambystoma texanum		E	S1	G5	2	2001
BIRD							
American bittern	Botaurus lentiginosus		SC	S3	G5	1	1989
Bald eagle	Haliaeetus leucocephalus		SC	S4	G5	4	2017
Cerulean warbler	Setophaga cerulea		T	S3	G4	4	2018
Dickcissel	Spiza americana		SC	S3	G5	4	2017
Grasshopper sparrow	Ammodramus savannarum		SC	S4	G5	3	2008
Henslow's sparrow	Ammodramus henslowii		E	S3	G4	4	2007
Hooded warbler	Setophaga citrina		SC	S3	G5	5	2010
Least bittern	Ixobrychus exilis		T	S3	G5	2	2006
Louisiana waterthrush	Parkesia motacilla		T	S2	G5	1	2005
Marsh wren	Cistothorus palustris		SC	S3	G5	3	2006
Osprey	Pandion haliaetus		SC	S4	G5	6	2019

Peregrine falcon	Falco peregrinus		E	S3	G4	1	2018
Prairie warbler	Setophaga discolor		E	S3	G5	1	2005
Prothonotary warbler	Protonotaria citrea		SC	S3	G5	1	2018
Red-shouldered hawk	Buteo lineatus		T	S4	G5	1	2005
Trumpeter swan	Cygnus buccinator		T	S3	G4	4	2018
King rail	Rallus elegans		E	S2	G4	3	1948
CRUSTACEAN							
Big water crayfish	Cambarus robustus		SC	S2?	G5	3	2015
FISH							
Bigeye chub	Notropis amblops		X	SH	G5	1	1931
Brindled madtom	Noturus miurus		SC	S2	G5	13	2008
Lake herring or Cisco	Coregonus artedi		T	S3	G5	6	2009
Northern madtom	Noturus stigmosus		E	S1	G3	7	2008
Orangethroat darter	Etheostoma spectabile		SC	S1	G5	13	1995
Pugnose shiner	Notropis anogenus		E	S1S2	G3	1	1938
Redside dace	Clinostomus elongatus		E	S2	G3G4	3	2012
Silver shiner	Notropis photogenis		E	S1	G5	7	2000
Southern redbelly dace	Chrosomus erythrogaster		E	SH	G5	7	1973
GASTROPOD							
A land snail (no common name)	Catinella protracta		E	SNR	G2Q	1	1947
Banded globe	Anguispira kochi		SC	S1	G5	1	1970
Brown walker	Pomatiopsis cincinnatiensis		SC	SH	G4	4	1970
Campeloma spire snail	Cincinnatia cincinnatiensis		SC	S3	G5	1	
Copper button	Mesomphix cupreus		SC	S1	G5	17	1944
Depressed ambersnail	Oxyloma peoriense		SC	SNR	G4G5	1	
Domed disc	Discus patulus		SC	S1S2	G5	1	1970
Gravel pyrg	Pyrgulopsis letsoni		SC	SH	GU	2	1946

Lambda snaggletooth	Gastrocopta holzingeri		E	S1	G5	1	1942
Widespread column	Pupilla muscorum		SC	S2	G5	1	1962
- **INSECT**							
American bumble bee	Bombus pensylvanicus		SC	SNR	G3G4	7	1981
American burying beetle	Nicrophorus americanus	E	X	SH	G2G3	2	1917
Angular spittlebug	Lepyronia angulifera		SC	S3	G3	2	2008
Black and gold bumble bee	Bombus auricomus		SC	SNR	G4G5	4	2010
Blazing star borer	Papaipema beeriana		SC	S2	G2G3	2	2013
Corylus dagger moth	Acronicta falcula		SC	S2S3	G2G4	1	1963
Culvers root borer	Papaipema sciata		SC	S3	G3	1	2016
Dukes' skipper	Euphyes dukesi		T	S2	G3	4	2005
Laura's snaketail	Stylurus laurae		SC	S3	G4	1	1933
Leafhopper	Dorydiella kansana		SC	S3	GNR	3	2009
Mitchell's satyr	Neonympha mitchellii mitchellii	E	E	S1	G2T2	2	2015
Pipevine swallowtail	Battus philenor		SC	S2S3	G5	1	2015
Poweshiek skipperling	Oarisma poweshiek	E	T	S1	G1	2	2012
Regal fritillary	Speyeria idalia		E	SH	G3	3	1958
Rusty-patched bumble bee	Bombus affinis	E	SC	SNR	G1	5	1999
Silphium borer moth	Papaipema silphii		T	S1	G3G4	1	1996
Swamp metalmark	Calephelis mutica		SC	S1	G3	5	1988
Tamarack tree cricket	Oecanthus laricis		SC	S3	G1G2	4	2008
- **MAMMAL**							
Indiana bat	Myotis sodalis	E	E	S1	G2	3	2005
Least shrew	Cryptotis parva		T	S1S2	G5	7	1958
Little brown bat	Myotis lucifugus		SC	S1	G3	3	1992
Northern long-eared bat	Myotis septentrionalis	T	SC	S1	G1G2	2	2003
Woodland vole	Microtus pinetorum		SC	S3S4	G5	2	1929
-							

MOLLUSK							
Black sandshell	Ligumia recta		E	S1?	G4G5	3	2007
Creek heelsplitter	Lasmigona compressa		SC	S3	G5	5	1978
Elktoe	Alasmidonta marginata		SC	S3?	G4	11	2010
Ellipse	Venustaconcha ellipsiformis		SC	S3	G4	1	2000
Flat dome	Ventridens suppressus		SC	SNR	G5	4	1962
Flutedshell	Lasmigona costata		SC	SNR	G5	3	1943
Hickorynut	Obovaria olivaria		E	S1	G4	1	1996
Kidney shell	Ptychobranchus fasciolaris		SC	S2	G4G5	9	2018
Ornamanted peaclam	Pisidium cruciatum		SC	SNR	G4?	1	1941
Paper pondshell	Utterbackia imbecillis		SC	S2S3	G5	6	1946
Purple wartyback	Cyclonaias tuberculata		T	S2	G5	11	2010
Rainbow	Villosa iris		SC	S3	G5Q	11	2018
River fingernail clam	Sphaerium fabale		SC	SNR	G5	3	1959
Round pigtoe	Pleurobema sintoxia		SC	S3	G4G5	6	2010
Slippershell	Alasmidonta viridis		T	S2S3	G4G5	18	2018
Snuffbox	Epioblasma triquetra	E	E	S1S2	G3	3	1977
Wavyrayed lampmussel	Lampsilis fasciola		T	S2	G5	13	2018
PLANT							
American bugseed	Corispermum americanum		SC	SNR	G5?	1	2011
American chestnut	Castanea dentata		E	S1S2	G4	1	2014
American lotus	Nelumbo lutea		T	S2	G4	1	2018
Bald-rush	Rhynchospora scirpoides		T	S2	G4	2	1995
Beaked agrimony	Agrimonia rostellata		T	S2	G5	2	2018
Black haw	Viburnum prunifolium		SC	S3	G5	1	2013
Blue-eyed Mary	Collinsia verna		SC	SNR	G5	1	1894
Bog bluegrass	Poa paludigena		T	S2	G3	4	2001
Broad-leaved puccoon	Lithospermum latifolium		SC	S2	G4	4	2018

Canada cinquefoil	Potentilla canadensis		SC	SNR	G5	3	1966
Canadian burnet	Sanguisorba canadensis		E	S1	G5	3	2011
Canadian milk vetch	Astragalus canadensis		T	S1S2	G5	3	1990
Climbing fumitory	Adlumia fungosa		SC	S3	G4	1	1984
Clinton's bulrush	Trichophorum clintonii		SC	S3	G4	4	1990
Common gallinule	Gallinula galeata		T	S3	G5	2	2005
Compass plant	Silphium laciniatum		T	S1S2	G5	2	1983
Cooper's milk vetch	Astragalus neglectus		SC	S3	G4	1	1930
Creeping whitlow grass	Draba reptans		T	S1	G5	1	2012
Cup plant	Silphium perfoliatum		T	S2	G5	3	2018
Davis's sedge	Carex davisii		SC	S3	G4	1	1939
Downy gentian	Gentiana puberulenta		E	S1	G4G5	1	1867
Dwarf-bulrush	Lipocarpha micrantha		SC	S3	G5	1	1987
Edible valerian	Valeriana edulis var. ciliata		T	S2	G5T3	6	2012
False hop sedge	Carex lupuliformis		T	S2	G4	3	2012
Fescue sedge	Carex festucacea		SC	S1	G5	1	1970
Ginseng	Panax quinquefolius		T	S2S3	G3G4	10	2014
Goldenseal	Hydrastis canadensis		T	S2	G3G4	20	2018
Gray birch	Betula populifolia		SC	S3	G5	1	2015
Green violet	Hybanthus concolor		SC	S3	G5	4	2001
Hairy angelica	Angelica venenosa		SC	S3	G5	7	2008
Hairy wild petunia	Ruellia humilis		T	S1	G5	1	1931
Hairy-fruited sedge	Carex trichocarpa		SC	S2	G4	3	2004
Hemlock-parsley	Conioselinum chinense		SC	SNR	G5	6	2011
Horsetail spike rush	Eleocharis equisetoides		SC	S3	G4	7	2018
Jacob's ladder	Polemonium reptans		T	S2	G5	1	1982
Least pinweed	Lechea minor		X	S1	G5	1	1924
Leiberg's panic grass	Dichanthelium leibergii		T	S2	G4	11	2008

Lesser ladies'-tresses	Spiranthes ovalis		T	S1	G5?	3	2011
Love grass	Eragrostis capillaris		SC	SH	G5	1	1999
Low-forked chickweed	Paronychia fastigiata		X	SX	G5	1	1909
Mat muhly	Muhlenbergia richardsonis		T	S2	G5	2	2004
Murray birch	Betula murrayana		SC	S1	G1Q	1	1994
Northern appressed clubmoss	Lycopodiella subappressa		SC	S2	G2	1	2010
Northern bayberry	Myrica pensylvanica		T	S2	G5	1	2008
Northern prostrate clubmoss	Lycopodiella margueritae		T	S2	G1G2	1	2010
Orange- or yellow-fringed orchid	Platanthera ciliaris		E	S1S2	G5	4	1986
Pale avens	Geum virginianum		SC	S1S2	G5	4	2016
Pale beard tongue	Penstemon pallidus		SC	SX	G5	1	1936
Panicled screwstem	Bartonia paniculata		T	S2	G5	1	2014
Prairie buttercup	Ranunculus rhomboideus		T	S2	G5	1	1924
Prairie dropseed	Sporobolus heterolepis		SC	S3	G5	4	2013
Prairie white-fringed orchid	Platanthera leucophaea	T	E	S1	G2G3	2	2016
Purple coneflower	Echinacea purpurea		X	SX	G4	1	1868
Purple false oats	Graphephorum melicoides		SC	SNR	G4	1	1892
Purple milkweed	Asclepias purpurascens		T	S2	G5?	3	2018
Purple turtlehead	Chelone obliqua		E	S1	G4	3	2004
Ram's head lady's-slipper	Cypripedium arietinum		SC	S3	G3	1	1892
Red mulberry	Morus rubra		T	S2	G5	4	2013
Rosepink	Sabatia angularis		T	S2	G5	1	1963
Rosinweed	Silphium integrifolium		T	S2	G5	1	1984
Sedge	Carex amphibola		SC	SNR	G5	2	2011
Sedge	Carex seorsa		T	S2	G5	2	1994
Sedge	Carex squarrosa		SC	S1	G4G5	3	2014
Showy orchis	Galearis spectabilis		T	S2	G5	4	1963
Side-oats grama grass	Bouteloua curtipendula		E	S1	G5	4	2012

Smooth carrion-flower	Smilax herbacea		SC	S3	G5	1	1971
Spike rush	Eleocharis radicans		X	S1	G5	1	1930
Spike-rush	Eleocharis geniculata		X	SX	G5	2	1936
Stiff gentian	Gentianella quinquefolia		T	S2	G5	4	2012
Sullivant's milkweed	Asclepias sullivantii		T	S2	G5	1	2013
Swamp or Black cottonwood	Populus heterophylla		E	S1	G5	2	1989
Tall nut rush	Scleria triglomerata		SC	S3	G5	2	1990
Three-seed sedge	Carex billingsii		SC	SNR	G5T4	1	1995
Toadshade	Trillium sessile		T	S2S3	G4G5	2	1999
Trailing wild Bean	Strophostyles helvula		SC	S3	G5	1	1924
Twinleaf	Jeffersonia diphylla		SC	S3	G5	4	2018
Umbrella-grass	Fuirena pumila		T	S2	G4	2	1994
Upland boneset	Eupatorium sessilifolium		T	S1	G5	3	2018
Virginia flax	Linum virginianum		T	S2	G4G5	2	1922
Virginia snakeroot	Endodeca serpentaria		T	S2	G4	4	2009
Virginia spiderwort	Tradescantia virginiana		SC	S2	G5	1	1918
Wahoo	Euonymus atropurpureus		SC	S3	G5	6	2003
Water willow	Justicia americana		T	S2	G5	6	2018
Western mugwort	Artemisia ludoviciana		T	S1	G5	1	1985
Whiskered sunflower	Helianthus hirsutus		SC	S3	G5	3	2018
White gentian	Gentiana alba		E	S1	G4	5	1981
White lady slipper	Cypripedium candidum		T	S2	G4	20	2016
White or prairie false indigo	Baptisia lactea		SC	S3	G4Q	2	2015
Whorled pogonia	Isotria verticillata		T	S2	G5	1	1990
Wild rice	Zizania aquatica		T	S2S3	G5	1	1918
Willow aster	Symphyotrichum praealtum		SC	S3	G5	3	2004
Woodland goosefoot	Chenopodium standleyanum		SC	SNR	G5	1	1959
- **REPTILE**							

Blanding's turtle	Emydoidea blandingii		SC	S2S3	G4	21	2019
Butler's garter snake	Thamnophis butleri		SC	S4	G4	1	2016
Eastern box turtle	Terrapene carolina carolina		SC	S2S3	G5T5	6	2001
Eastern massasauga	Sistrurus catenatus	T	SC	S3	G3	17	2018
Gray ratsnake	Pantherophis spiloides		SC	S2S3	G4G5	1	1996
Kirtland's snake	Clonophis kirtlandii		E	S1	G2	4	1960
Queen snake	Regina septemvittata		SC	S2S3	G5	2	2017
Spotted turtle	Clemmys guttata		T	S2	G5	6	2016

Explanation of codes

Federal:

E	Listed Endangered
T	Listed Threatened

State:

E	Endangered
T	Threatened
SC	Special Concern (no legal protections)

State Rank:

S1	Critically imperiled in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation in the state.
S2	Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.
S3	Rare or uncommon in state (on the order of 21 to 100 occurrences).
S4	Apparently secure in state, with many occurrences.
S5	Demonstrably secure in state and essentially ineradicable under present conditions.
SA	Accidental in state, including species (usually birds or butterflies) recorded once or twice or only at very great intervals, hundreds or even thousands of miles outside their usual range.
SE	An exotic established in the state; may be native elsewhere in North America (e.g. house finch or catalpa in eastern states).
SH	Of historical occurrence in state and suspected to be still extant.
SN	Regularly occurring, usually migratory and typically nonbreeding species.
SR	Reported from state, but without persuasive documentation which would provide a basis for either accepting or rejecting the report.
SRF	Reported falsely (in error) from state but this error persisting in the literature.

SU	Possibly in peril in state, but status uncertain; need more information.
SX	Apparently extirpated from state.

Global Ranking:

G1	Critically imperiled globally because of extreme rarity (5 or fewer occurrences range-wide or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2	Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3	Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g. a single western state, a physiographic region in the East) or because of other factor(s) making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100.
G4	Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GH	Of historical occurrence throughout its range, i.e. formerly part of the established biota, with the expectation that it may be rediscovered (e.g. Bachman's Warbler).
GU	Possibly in peril range-wide, but status uncertain; need more information.
GX	Believed to be extinct throughout its range (e.g. Passenger Pigeon) with virtually no likelihood that it will be rediscovered.

Recovering these species requires protecting the ecosystems on which they depend. Key conservation areas of the Watershed system include critical habitat for plant and animal communities (including habitat for rare, threatened or endangered species), such as wetlands; large forest tracts; springs; spawning areas; the aquatic corridor, including floodplains, stream channels, springs and seeps; steep slopes; and riparian forests (Figure 2.5). Priority areas are those with intact, native ecosystems due to floral and faunal integrity.

In addition to their importance as wildlife habitat, undeveloped areas, such as forest, meadow, prairie, wetlands, ponds and lakes, and groundwater recharge areas, provide a host of services to the Watershed otherwise unobtainable by human invention, including the following:

- Groundwater. Natural systems allow rainwater and snowmelt to infiltrate into groundwater aquifers. About 50% of Michigan residents rely on groundwater for drinking water. Groundwater also provides irrigation water for agriculture and cooling water for industry.
- Surface water. By intercepting runoff and keeping surface waters supplied with a constant flow of clean, cool groundwater, natural systems keep streams, rivers and lakes clean.
- Pollutant removal. As water infiltrates into the ground or passes through wetlands, soil filters out many pollutants. Vegetation also takes up nutrients and other pollutants, including phosphorus, nitrogen, bacteria, and even some toxic metals.
- Erosion control. Vegetation intercepts water and soil absorbs it, keeping it from eroding streambanks and hillsides. River- and lakeside wetlands are especially important for erosion control along riverbanks and lakeshores.
- Air purification. Vegetation purifies the air we breathe.
- Flood and drought control. Vegetation and soil intercept runoff water, moderating floods and droughts.

- Wildlife habitat and biodiversity. Natural systems are vital to the survival of aquatic and terrestrial wildlife. In addition to its aesthetic value, maintaining the biodiversity of species is vital to our economy and health.
- Recreation. Natural areas provide recreation such as hiking, bird-watching, canoeing, hunting, and fishing that generate revenues for the local community.
- Cooling. Tracts of land soak up solar heat and prevent heat islands from forming. Heat islands warm water runoff, which leads warm water to flow into streams and disrupts the aquatic climate.
- Property values. Natural areas enhance the value of neighboring properties.

The remaining undeveloped, natural areas in the Watershed were mapped and ranked in 2002, and updated in 2007 and 2018 through the Bioreserve project of the Huron River Watershed Council (Figure 2.6) [2]. In order to help prioritize protection and conservation efforts, the mapped sites were ranked based on the following ecological and hydrological factors: size; core size, presence of water; presence of wetlands; groundwater recharge potential; potential for rare remnant plant community; topographical diversity; glacial diversity, how connected they were or could be to other natural areas, vegetation quality, potential for restoration, and biodiversity.

80 sites (9314 acres) in the Middle Huron Watershed were identified as priority natural areas, with 3 sites (1016 acres) ranked as highest biotic quality (Barton Nature Area, Nichols-Arboretum/Furstenberg Nature Area, Parker-Mill County Park region), 16 sites (3,308 acres) ranked as medium-high, , 47 sites (4,366 acres) ranked as medium-low, and 14 sites (624 acres) ranked as low.

Figure 2.5. Location of Endangered/threatened species or communities and regions of hydric soils.

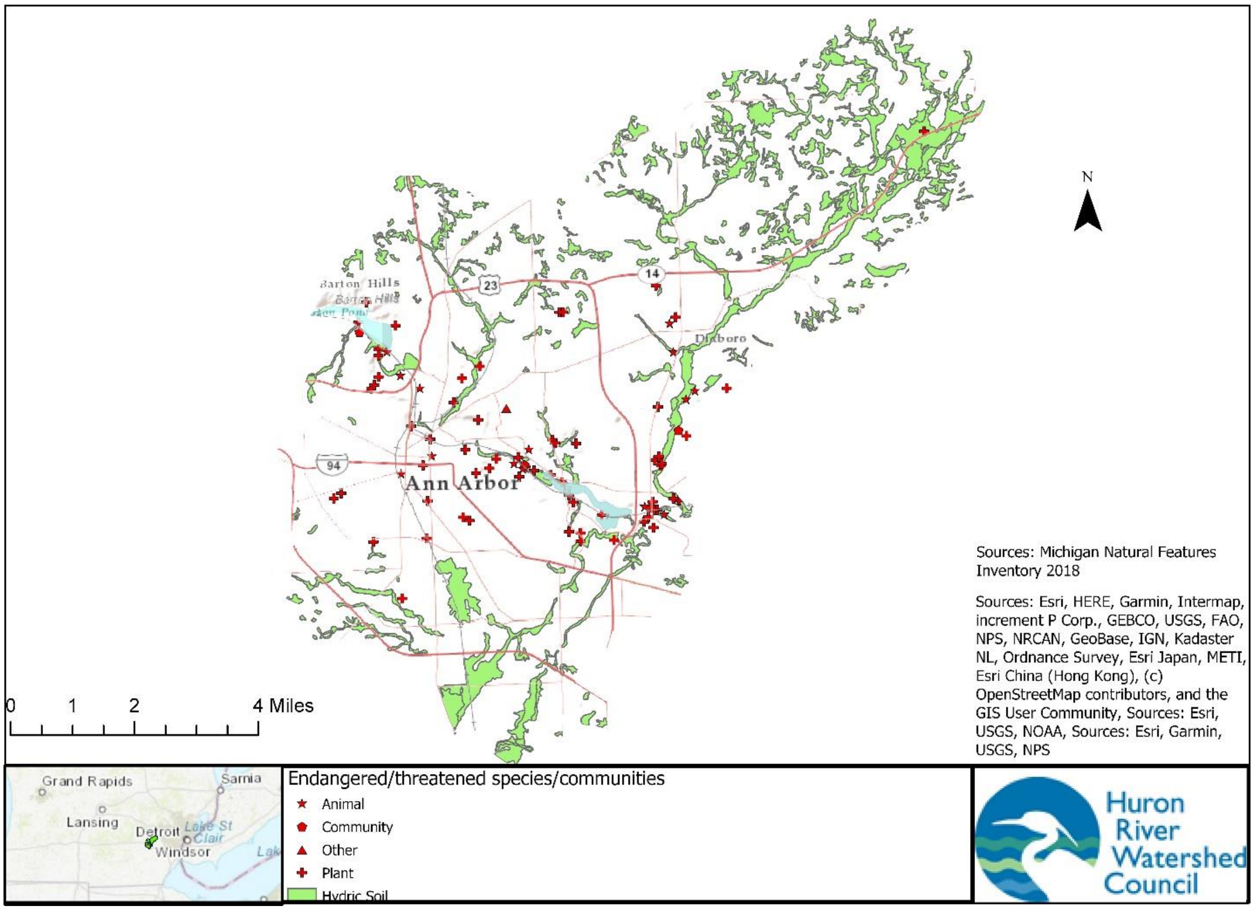
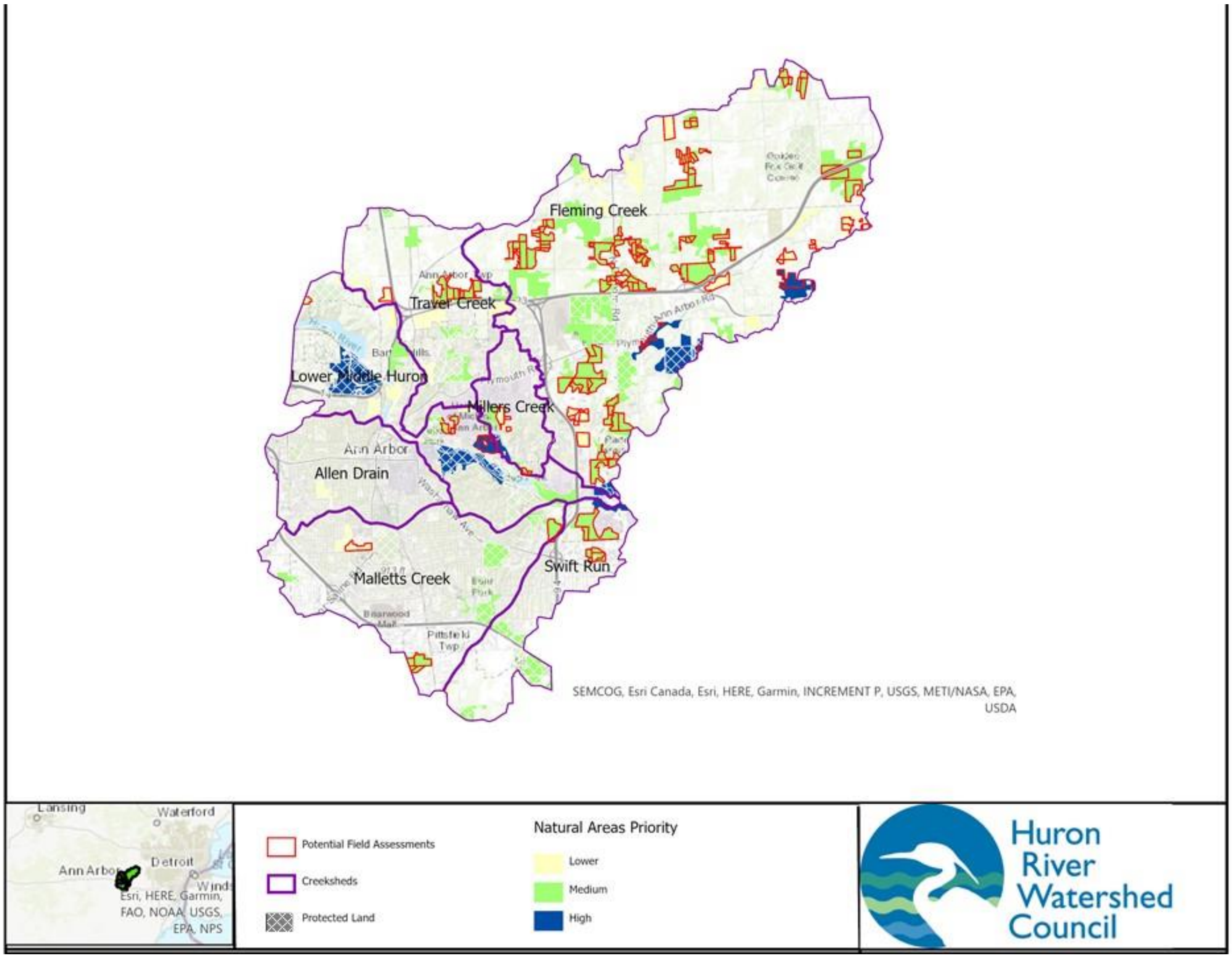


Figure 2.6. Quality of natural areas in the Watershed, as determined by HRWC's Bioreserve program, combined with hash-mark indications of places that are already protected from development through various programs like park land or development easement.



2.1.4 Hydrology

Hydrology refers to the study of water quantity and flow characteristics in a river system. How much and at what rate water flows through a river system, and how these factors compare to the system's historic or "pristine" state, are critical in determining the long-term health of the waterway. In a natural river system, precipitation in the form of rain or snow is intercepted by the leaves of plants, absorbed by plant roots, infiltrated into groundwater, soaked up by wetlands, and is slowly released into the surface water system. Very little rainwater and snowmelt flows directly into waterways via surface runoff because there are so many natural barriers in between.

When vegetated areas are replaced by roads, rooftops, sidewalks, and lawns, a larger proportion of rainwater and snowmelt falls onto impervious (hard) surfaces. In less developed areas, this stormwater runoff flows either into roadside ditches that drain to the nearest creek, or, in the more densely developed areas, it flows into a system of storm drainpipes that eventually outlet to the creek. During a rain event, this increased runoff causes the flow rate of the creek to increase dramatically over a short period of time, resulting in what is referred to as "flashy flows." In addition to rapidly increasing flows during storm events, the increase in impervious surface also decreases base flows during non-storm conditions because less water infiltrates into the ground to be slowly released into the creek via groundwater seeps.

Extreme flashiness can lead to rapid erosion of streambanks, especially in areas where the streambank vegetation has been removed or altered, and sedimentation. These impacts create unstable conditions for the macroinvertebrates and fish. Directly connected impervious landscapes pose a significant problem to hydrology. An example of a directly connected impervious surface is a rooftop connected to a driveway via a downspout that is then connected to the street where stormwater ultimately flows into the storm drain and into local creeks and streams.

The Huron River and its tributaries in the Watershed have been altered substantially by wetlands drainage, stream channelization, dam construction, deforestation, and urbanization. These activities have affected the hydrology of the Huron River and its tributaries: flow volume and flow stability have changed substantially, along with channel morphological features, such as gradient and shape. The extensive network of dams and lake control structures, developed areas, engineered drains, and construction sites all play a role in producing flashy, sediment-laden flows. These hydrologic alterations are particularly significant problems in Millers Creek, where streambanks have been severely eroded; Malletts Creek, where fish and macroinvertebrate habitat have been severely degraded to require a TMDL to be established; and Allens Creek, where most of the creek has been engineered into undersized drains leading to potentially severe future flooding and further impacts on the Huron River downstream of its outlet.

The Huron River begins at an elevation of 1016 feet in the headwaters and descends 444 feet to an elevation of 572 feet at its confluence with Lake Erie, for an average gradient of 3.3 feet per mile (0.06%). By comparison, the Huron River flowing through our Watershed region averages 7.6 feet per mile (0.14%). In its natural state, the river reflected this gradient, with numerous sections of rapids identified prior to the construction of dams. It is this gradient that, in fact, creates the desirable conditions for dam construction. The many mills and other control structures that have been constructed have since muted the impacts that the fast-flowing water had on the topography and river habitat. The river channel gradient is a controlling influence on river habitat such as flow rates, depth, width, channel meandering, and sediment transport.

Stream flow data for the Huron River in the Middle Huron Watershed has been collected at the U.S. Geological Survey (USGS) gage stations at the Huron River (#04174500) between Argo and Geddes dams since 1914 (near Wall Street, its current location since 1947)[3]. In 2018, the mean annual flow at the Wall Street station was 630.2 cubic feet per second (cfs), representing a drainage area of 729 square miles, or 0.86 cfs per square mile. Across the whole historical data record, an average year would flow at 470 cfs. Examining the average years over time, the data record show that flow has increased in the Huron River since 1914 (Figure 2.7)

While monthly streamflow naturally varies from year to year, Figure 2.8 shows that despite the year, conditions in the watershed vary most in the spring and early winter and remain relatively constant over the summer months (Figure 2.8). Seasonally high flows generally occur in early spring during winter snowmelt and spring rains, with baseflow conditions most apparent between July and October.

Increasing development and resulting changes to the hydrology and hydraulics are still a significant threat to the watershed. Human impacts and development have generally increased daily fluctuations in the Huron's streamflow. Land drainage for urban or agricultural use has degraded the original, more stable flow regime. Draining wetlands, channelizing streams, and creating new drainage channels have decreased flow stability by increasing peak flows and diminishing recharge in groundwater tables.

All tributaries to the Huron River suffer from comprehensive channelization, lack of cover, and large flow fluctuations as a result of efforts to accelerate drainage through these streams. Tributaries in the watershed section for this plan show evidence of this altered hydrology in a number of ways. Table 2.2 provides some hydrological statistics and measures to help evaluate the health and stability of flow in watershed tributaries. Most of these statistics are related to peak flows following a "bankfull event," which is a rain storm that causes streams to rise to or just over the tops of their banks and enter the floodplain (in non-incised streams). Such a storm occurs once in about every 1.5 to 2 years in southeast Michigan, and includes 2.25-2.5" of rain.[4] A reference bankfull flow can be determined using a creekshed's drainage area, that is based on an evaluation of natural streams in southern Michigan.[5] All estimates of bankfull flows for watershed tributaries exceed reference flows by more than 100%. In some cases, measured flows exceed reference bankfull flows by more than 10 times (1000%). This degree of altered hydrology is further supported by evaluating the flashiness of tributary stream flows. All tributaries are well above the median flashiness rating[6] for Michigan streams of similar drainage area.

Summer water temperatures have become warmer and more variable due to lower base flows, channel widening and clearing of shading stream-side vegetation. Landscape alterations and increased peak flows have accelerated erosion within the basin and increased the sediment load to the river.[7]

Flow is also recorded on Mallets Creek (#04174518) at Chalmers Road since 1999. Malletts Creekshed is highly impervious and the effects of development described above can be seen in the sharp increases and declines of the creek's 2019 hydrograph (Figure 2.9).

Additional factors important in reviewing and understanding the hydrology of the watershed are direct drainage, depth to groundwater, soil permeability, and groundwater recharge that indicate the infiltration potential of groundwater.

Direct drainage areas (Figure 2.10) are areas that have significant spatial and temporal influence on the quantity and quality of water entering the river system via groundwater or surface water flows (all green areas on map). Much of this flow may come from direct flow from impervious surfaces. Excluded from direct drainage are portions of the landscape that form depressions where the dominant flow of water reaches the groundwater directly through infiltration (red areas on map). The map presented in Figure 2.10 is derived from a model that calculates flow accumulation based, in part, on the amount of imperviousness in each area.

Dams and Impoundments

Another attribute contributing to the hydrology of the Middle Huron Watershed is the presence of dams and impoundments. According to the National Inventory of Dams, 17 dams are located in the Watershed (Figure 2.11 and Table 2.3).[8] Dams may be constructed for uses such as hydropower, recreation, or stormwater and flood control. Most of the dams in the Middle Huron were developed for recreational purposes, though several significant dams continue to be used for active hydropower or flood control. Dams that were previously useful can outlive their intended purposes and become hazards and ecological detriments to the river. Dams can create hazards by collecting debris or simply by requiring recreationalists to circumnavigate them. They act as ecological detriments by holding back silt and nutrients, altering river flows, decreasing oxygen levels in impounded waters, blocking fish migration and eliminating spawning habitat, increasing nuisance plant growth in impoundments, altering water temperatures, and injuring or killing fish.

Three of the dams in this Watershed are on the main branch and considered major, large dams. The other 14 dams are on smaller tributaries and serve as storm water retention or in many cases are very old and have no current purpose.

Table 2.2 Estimated Bankfull Flows for Watershed Tributaries

Tributary Creek	Drainage Area (mi^2)	Reference Flow (cfs)	Measured Flow (cfs)	Storm precip-itation (in)	Modeled Flow (cfs)	Surveyed Flow (cfs)	Flashiness Index	R-B Index Rating (4=worst 1=best)
Allens	5.21	56	1350	2.0	1198	NA	0.71	4
Traver	6.83	67	660	2.73	196	313	0.44	3
Millers	2.41	33	490	2.63	134	361	NA	NA
Malletts	11.05	93	1050	2.0	499	1007	0.64	4
Swift Run	4.65	52	273	2.6	189	398	0.82	4
Fleming	31.79	191	1177	2.73	NA	NA	0.43	4

Reference Flow is based on regional reference curves for southern Michigan.
Measured flow is the peak flow measured by HRWC or USGS for a rain event similar in size to a 2-year return, 24-hour event. Precipitation provides the actual size of the storm.
Modeled flow is from the City of Ann Arbor's SWMM model projected flow from a 2.35" 24-hour event.
Surveyed flow is a flow estimate from bankfull surveys conducted near the mouth of the tributaries
Flashiness Index (R-B Index) and ratings are based on the Richards-Baker Flashiness methodology and analysis of Michigan streams.

Table 2.3. Inventoried Dams in the Watershed

Dam Name	Waterway	Community	Downstream Hazard Potential	Purpose	Date Built	Dam Height (Feet)	Pond Area (acres)
Barton	Huron River	City of Ann Arbor	High	Hydropower	1915	24	302
Argo	Huron River	City of Ann Arbor	High	Retired Hydropower, Recreation	1920	18	92
Geddes	Huron River	Ann Arbor Twp.	High	Retired Hydropower, Recreation	1919	25	261
Fishbeck	Fleming Creek	Superior Twp.	Low	Recreation	1973	15	6
Upper Geddes Lk	Millers Creek	City of Ann Arbor	Low	Flood & Storm	NA	13	4
Lower Geddes Lk	Millers Creek	City of Ann Arbor	Low	Flood & Storm	NA	9	4
Pittsfield-Ann Arbor #1	Malletts Creek	City of Ann Arbor	Low	Unknown	1978	10	3
Pittsfield-Ann Arbor #2	Malletts Creek	City of Ann Arbor	Low	Unknown	1978	10	4
Traver Creek #1	Traver Creek	City of Ann Arbor	Low	Unknown	NA	NA	2
Traver Creek #2	Traver Creek	City of Ann Arbor	Low	Unknown	NA	NA	2
Traver Creek #3	Traver Creek	City of Ann Arbor	Low	Unknown	NA	1	2
Traver Creek #4	Traver Creek	City of Ann Arbor	Low	Unknown	NA	NA	2
Traver Creek #5	Traver Creek	City of Ann Arbor	Low	Unknown	NA	NA	2
Traver Creek #6	Traver Creek	City of Ann Arbor	Low	Unknown	NA	6	5
Traver Creek Retention	Traver Creek	Ann Arbor Twp.	Low	Unknown	1981	13	2
Traver Lake #5	Traver Creek	City of Ann Arbor	Low	Unknown	1971	34	2
Whittaker and Gooding	Fleming Creek	Superior Twp.	Low	Unknown	NA	6	10
Waterway Trucking Service	Fleming Creek	Superior Twp.	Low	Unknown	NA	NA	2

Figure 2.7. Average Annual Discharge of the Huron River at Wall Street, from water year 1915-2018. The red line indicates an increasing linear trend over time.

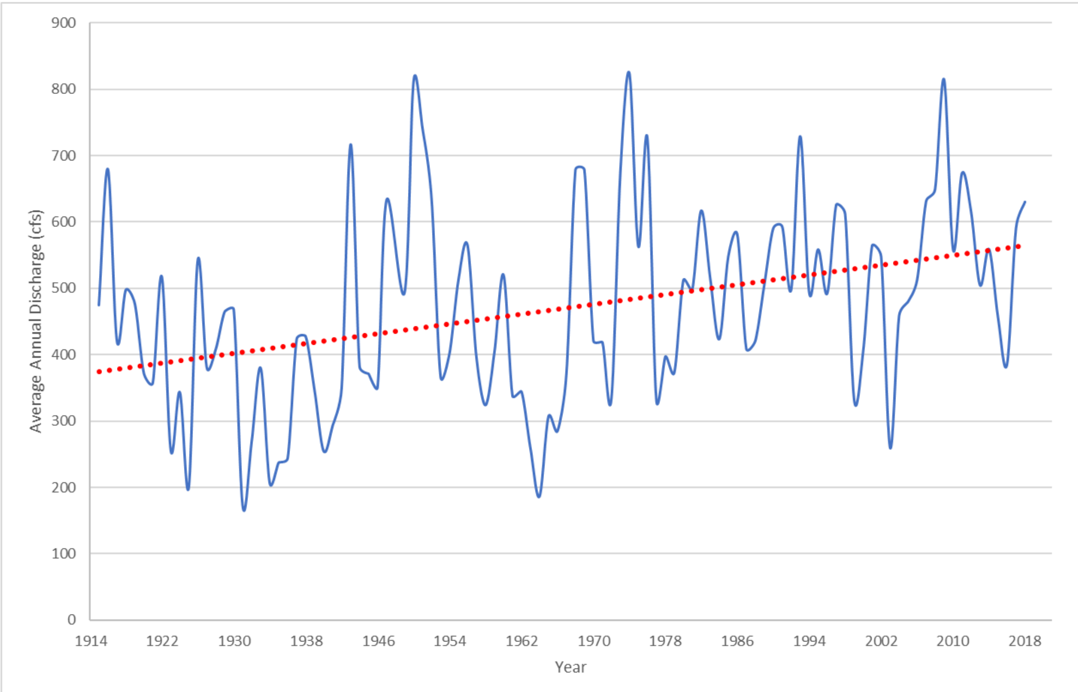


Figure 2.8. Variety of monthly flow conditions over the flow data on record for the Huron River, Wall Street. (USGS station #041744500).

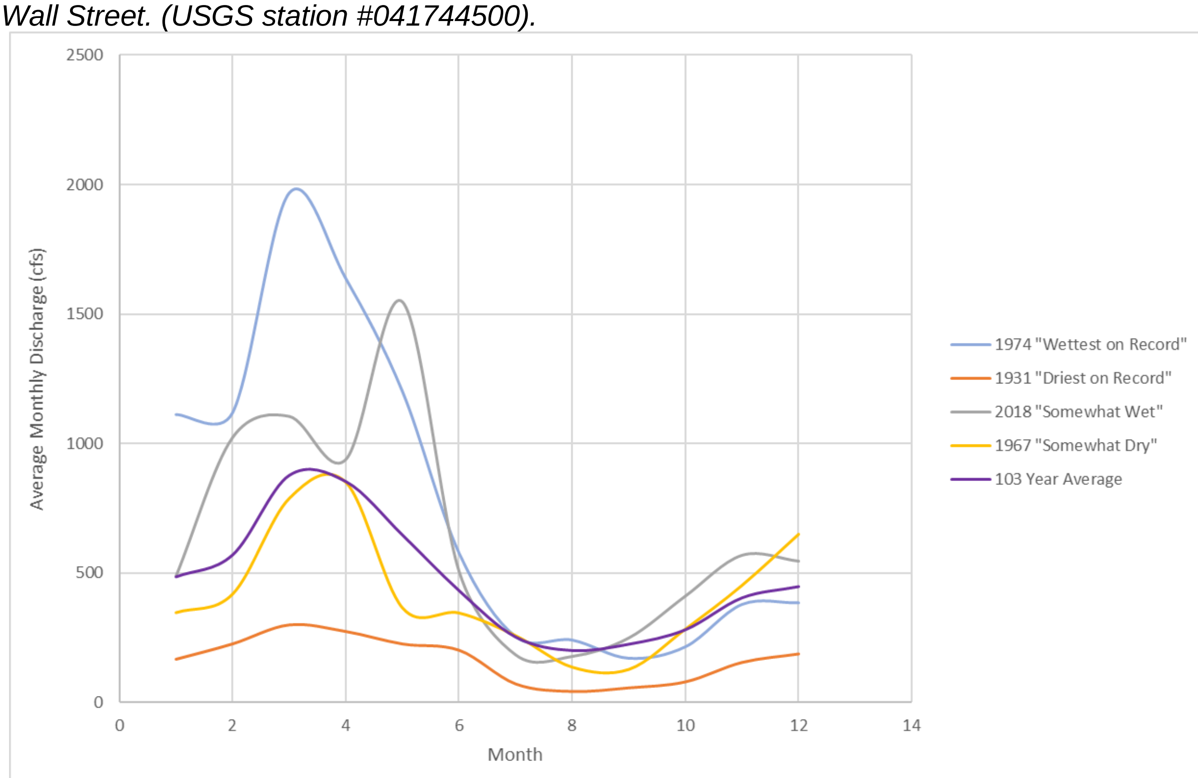


Figure 2.9. Flow at Mallett's Creek: Chalmers Road (USGS station #(#04174518) for the 2019 calendar year.

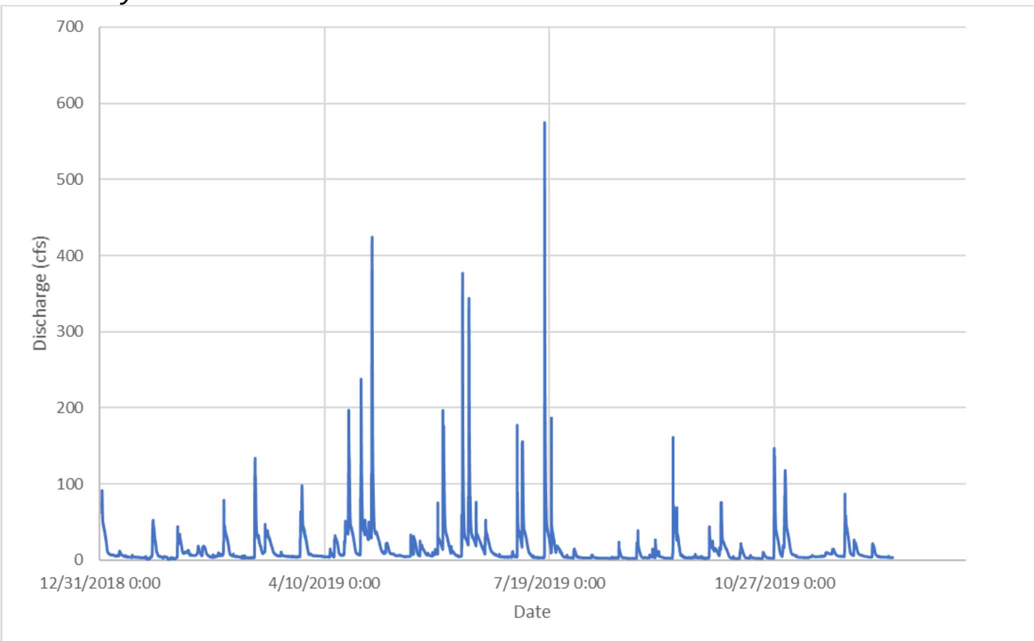


Figure 2.10. Land that drains directly to the river (green) and land that drains to groundwater). (pink)

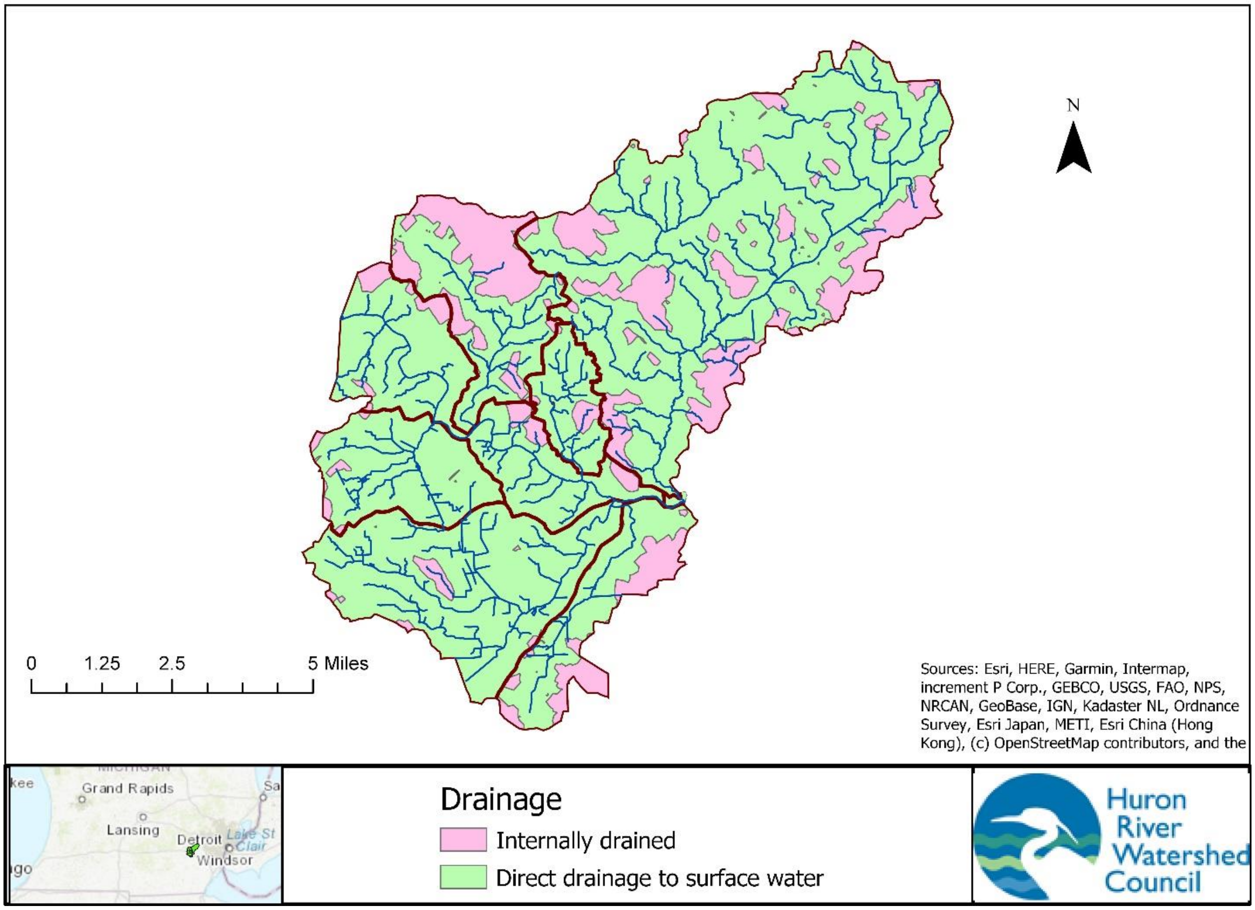
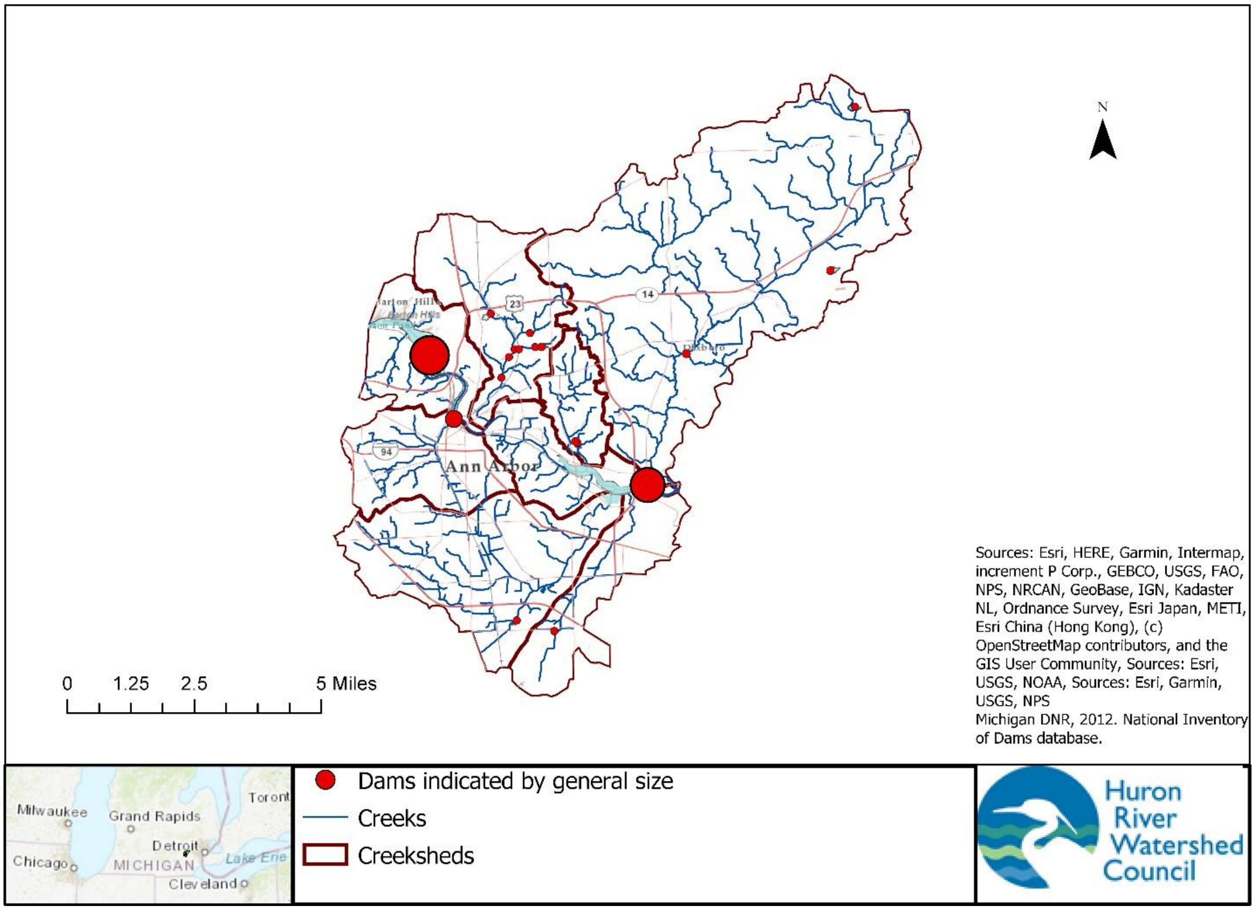


Figure 2.11. Seventeen dams are located in the Watershed. Locations are shown with the size of the dot indicating size of the dam as reflected by the amount of water impounded behind it.



[1] Michigan Features Natural Inventory, 2019. https://mnfi.anr.msu.edu/species/explorer
[2] Olsson, K. 2002. Conservation Planning in the Huron River Watershed Final Report submitted to the U. S. Environmental Protection Agency Great Lakes National Program Office. Ann Arbor, MI: HRWC.
[3] USGS National Water Information System. https://waterdata.usgs.gov/mi/nwis/inventory/?site_no=04174500&agency_cd=USGS. Accessed September 2019.
[4] National Oceanic and Atmospheric Administration. 2013. Atlas 14, Volume 8. Precipitation-Frequency Atlas of the United States, Midwestern States.
[5] Stantec Consulting, Ltd. 2015, Revised Bankfull Discharge for Selected Michigan Rivers and Regional Hydraulic Geometry Curves for Estimating Bankfull Characteristics in Southern Michigan Rivers Study. Project Number: 2011-0100.
[6] Fongers, D., et al, Michigan Department of Environmental Quality. 2012. Application of the Richards-Baker Flashiness Index to Gaged Michigan Rivers and Streams.
[7] Michigan Department of Natural Resources. 1995. Huron River Assessment. Fisheries Special Report No. 16
[8] Michigan Department of Natural Resources. 2000. National Inventory of Dams database. Lansing, MI: MDNR.

2.2 Communities and Current Land Use

2.2.1. Political Structure

With an area of 81 square miles, the Watershed encompasses portions of 10 communities, of which the largest portions are within the city of Ann Arbor, and the townships of Ann Arbor, Salem, Superior, and Pittsfield. The townships of Northfield, Lodi, Ypsilanti and Scio hold very small edge sections of the Watershed. 100% of the Watershed is located in Washtenaw County, the State of Michigan, and the United States.

Political jurisdictions regarding the Huron River and its tributaries, riparian zones, and land are controlled by federal and state laws, county and local ordinances, and town by-laws. Regulatory and enforcement responsibility for water quantity and quality regulation often lies with the EPA and EGLE. Major activities regulated by the state, through EGLE, are the alteration/loss of wetlands, pollutant discharges (NPDES permits), control of stormwater, and dredging/filling of surface waters.

The State of Michigan maintains that:

> "'Surface waters of the state' means all of the following, but does not include drainage ways and ponds used solely for wastewater conveyance, treatment, or control:
>
> (i) The Great Lakes and their connecting waters.
>
> (ii) All inland lakes.
>
> (iii) Rivers.
>
> (iv) Streams.
>
> (v) Impoundments.
>
> (vi) Open drains.
>
> (vii) Wetlands.
>
> (viii) Other surface bodies of water within the confines of the state."[9]

County government assumes responsibility for carrying out certain state policies. In most cases, county governments enforce the state erosion control policy, under the Michigan Soil Erosion and Sedimentation Control Act 347 of 1972 and Part 91 of Act 504 of 2000, although local governments may also administer this program, and county road commissions typically self-regulate their erosion control. At the time of this publication the City of Ann Arbor was the only local government in the Watershed known to administer its own soil erosion and sediment control program.

Designated county drains are maintained by the Washtenaw County Office of the Water Resources Commissioner. Figure 2.12 indicates the stream channels that are designated county drains in the watershed which may be open ditches, streams or underground pipes, retention ponds or swales that convey stormwater. These systems are designed to provide storm water management, drainage, flood prevention, and stream protection for urban and agricultural lands. The Drain Code gives the Water Resource Commissioner authority for construction or maintenance of designated county drains for flood control and water management.

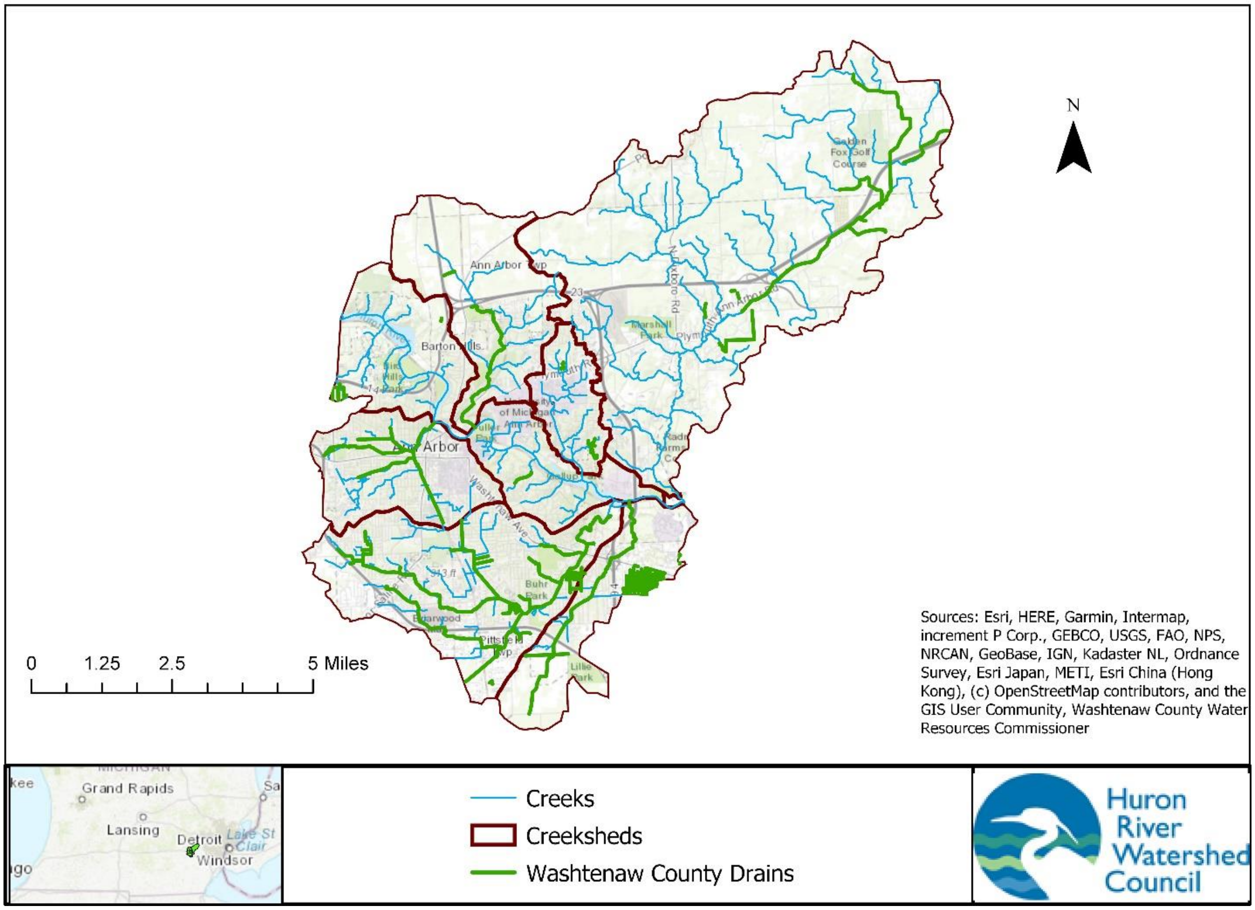
In addition to oversight of these drains, in Washtenaw County the Water Resource Commissioner is required to maintain established lake levels throughout the county. Through the Inland Lake Level Act (Act 146, P.A. of 1961), a board of commissioners may file a petition in circuit court to establish a special assessment district to pay the costs of establishing and maintaining a lake level. The Water Resource Commissioner must determine the apportionment of costs incurred and assess for maintenance of the lake level. Section 24 of the Inland Lake Level Act requires inspection of all lake level control structures on all inland lakes that have normal levels established under this Act to be completed once every three years by a licensed professional engineer.

Drains including roadside ditches, pipes, bridges, and culverts under state highways and county roads that are not designated county drains are maintained by the Washtenaw County Road Commission.

Each local government in the watershed has a zoning code and holds regularly scheduled meetings where rulings are made on policy additions and changes, budgets, land use issues, and other important local business. Working with the guidance of statewide procedures, townships and other local governments have power to formulate land use and development policy, among other important activities. The city of Ann Arbor also has jurisdiction over and management responsibility for sewers and stormwater infrastructure, such as gutters, catch basins, pipes and outlets.

While state and county governments take an active role in many relevant watershed or water quality regulations and policies, local governments assume much leadership in land and water management by passing and enforcing safeguards. These local ordinances can be more protective than state laws, though state regulations set minimum protections that cannot be violated. Working under numerous established procedures, local governments may enact ordinances to control stormwater runoff and soil erosion and sedimentation; protect sensitive habitats such as woodlands, wetlands and riparian zones; and establish watershed-friendly development standards and lawn care and landscaping practices, among other options. Local governments oversee enforcement of their policies.

Figure 2.12. Designated County Drains within the Watershed area (Marked as green and thicker lines). The high density of Drains in the southeast run through a residential neighborhood.



2.2.2. Growth Trends

Prior to European settlement, the region around the watershed was occupied by Chippewa and Potawatomi Native American tribes who had long used the land for farming. Despite an unfavorable report by the U.S. Surveyor-General in 1815 that characterized the soils in the area as being unsuitable for farming, European settlers soon began to recognize the area's agricultural potential, which subsequently became an important area for livestock and grain in the 19th century. This agricultural trend thrived until, in the wake of World War II, growth in southeast Michigan was catalyzed by the baby boom, increased automobile ownership, and establishment of better road systems. As a result, the influence of agriculture began to diminish as land was transferred to suburban uses in a trend that continues today.

A discussion of growth trends in the Watershed is challenged by the fact that readily available demographic data is based on political, rather than hydrologic boundaries. Furthermore, for several of the Watershed's 10 communities, only small portions of their areas are located in the watershed. As such, growth trends in these peripheral communities are not necessarily indicative of growth trends in the Watershed as a whole. Therefore, this section focuses on the City of Ann Arbor, and the townships of Ann Arbor, Salem, Superior, and Pittsfield, which all together make up the vast majority of the Watershed.

Federal decennial census data shows the historical rate of growth in the Watershed area, and then a SEMCOG model predicts future growth (Table 2.3)[10] Not surprisingly, the urbanized area in the City of Ann Arbor shows a small projected population gain and projected population loss respectively through 2030 because it has less land available for new development and more people moving into suburban areas. Pittsfield township nearly doubled in population from 1990-2010, while Superior and Salem both increased by 50%.

All of the areas are expected to grow in population by 2030, but SEMCOG notes that the recession in the circa-2010 timeframe contributed to a slowing growth period and that in general the rate of growth is predicted to be slower from 2010-2030 than it was from 1990-2010. The exception to this is Ann Arbor township which is predicted to have a greater than 100% growth rate but the reason for this is not clear and may be a model artifact.

Changes in total housing also reflect the changing population throughout the Watershed. The largest growth in housing occurred in Pittsfield township from 1990-2010, followed by Salem and Superior Townships (Table 2.4).

Table 2.3. 1990-2030 Population Changes for Core Communities in the Watershed[11]

	1990 Census	2000 Census	2010 Census	% change 1990-2010	2030 SEMCOG forecast	% change 2010-2030
Ann Arbor City	109,608	114,024	113,934	4%	129,114	13%
Ann Arbor Twp.	3,463	4,385	4,067	17%	8,323	105%
Pittsfield Twp.	17,650	30,167	34,663	96%	47,019	36%
Salem Twp.	3,734	5,562	5,627	51%	7,661	36%
Superior Twp.	8,720	10,740	13,058	50%	16,285	25%
TOTAL	143,175	164,878	171,349	20%	208,402	22%

Table 2.4. Housing Units and Densities for Communities in the Watershed[12]

	Housing Units in 1990	Housing Units in 2000	Housing Units in 2010	Increase in Housing Units, 1990-2010	Average Density of Housing in 1990 (units per acre)	Average Density of Housing in 2010 (units per acre)
Ann Arbor City	43075	47,218	49,789	15.59%	5.15	5.95
Ann Arbor Twp.	1464	1,893	1,826	24.73%	0.81	1.01
Pittsfield Twp.	7787	12,337	14,808	90.16%	1.62	3.07
Salem Twp.	1258	2,031	2,209	75.60%	0.35	0.62
Superior Twp.	3156	4,097	5,322	68.63%	0.87	1.47

2.2.3. Land Use and Development

As the Watershed's communities develop, the potential increases for negative environmental impacts, including water quality impacts from erosion, sedimentation, and increased inputs of stormwater pollutants. Potential impacts on water quantity also increase as wetlands, woodlands, floodplains and other natural features that regulate water quantity are altered or replaced with impervious surfaces.

Prior to permanent European settlement, grasslands of oak barrens and forests of several species of oak and hickory dominated the landscape of the Watershed. This dominant landscape was interspersed with patches of wetlands, such as lowland hardwood. (Figure 2.13).

Upon permanent settlement, the land began to be used for human benefit. Initial activities on the land centered on the clearing of grasslands for agricultural production and the use of forested areas for wood and wood by-products.

The most recent land use data, produced by SEMCOG for the year 2015, indicates the significant changes to the landscape that have occurred since settlement. (Figure 2.14)[13]. The Watershed is a highly urbanized land area, with 36% of the land containing housing, university and medical campuses, offices, and retail areas. (Table 2.5). Outside of the urban areas, in Fleming and Traver Creeks particularly, agriculture is dominant, and comprises 45% of the total land area. Natural lands (forests, wetlands, open fields), comprise 17% of the land area.

Figure 2.13. Watershed's Ecosystems, circa 1830's.

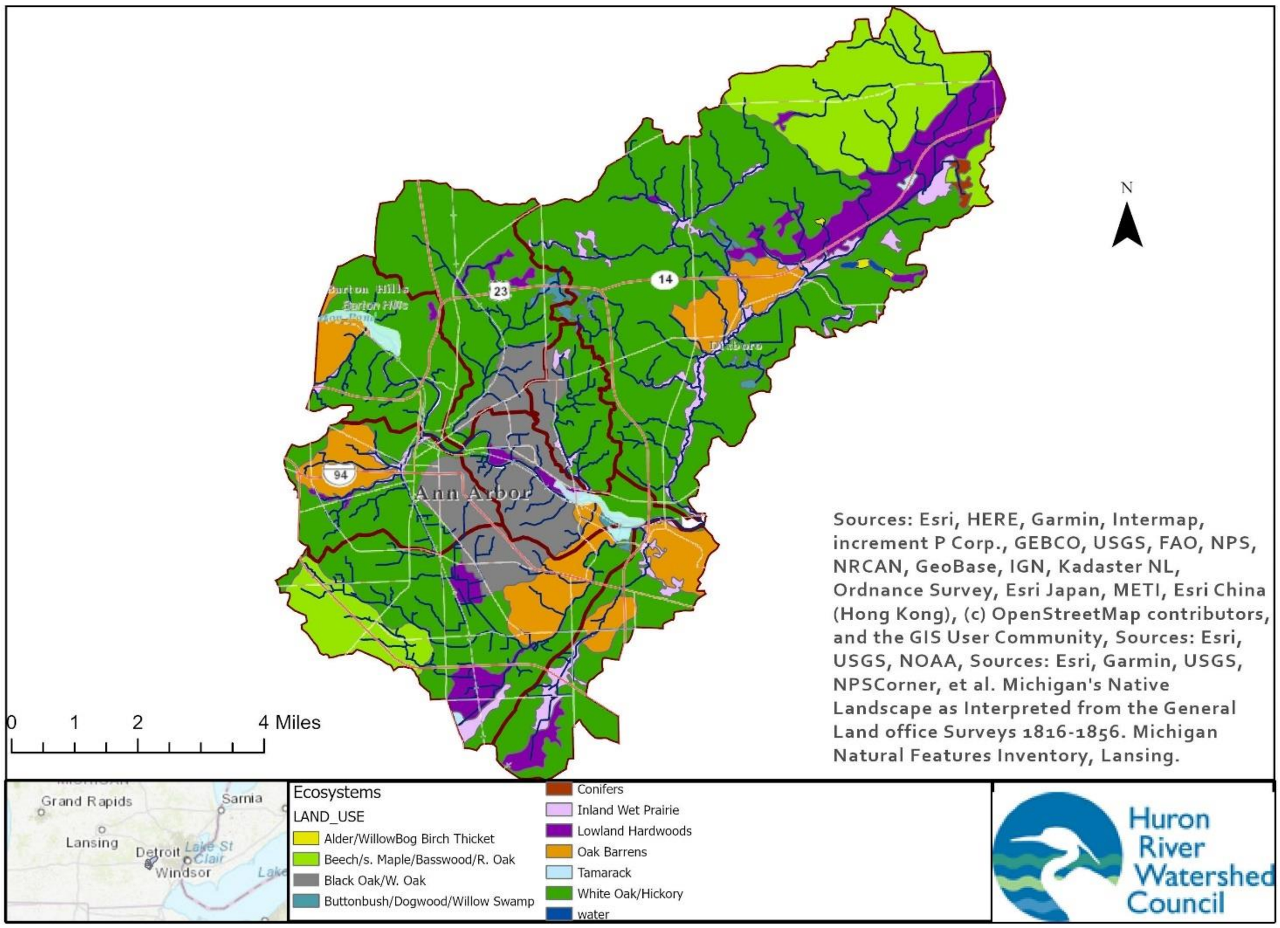


Figure 2.14. Current Land use-2015.

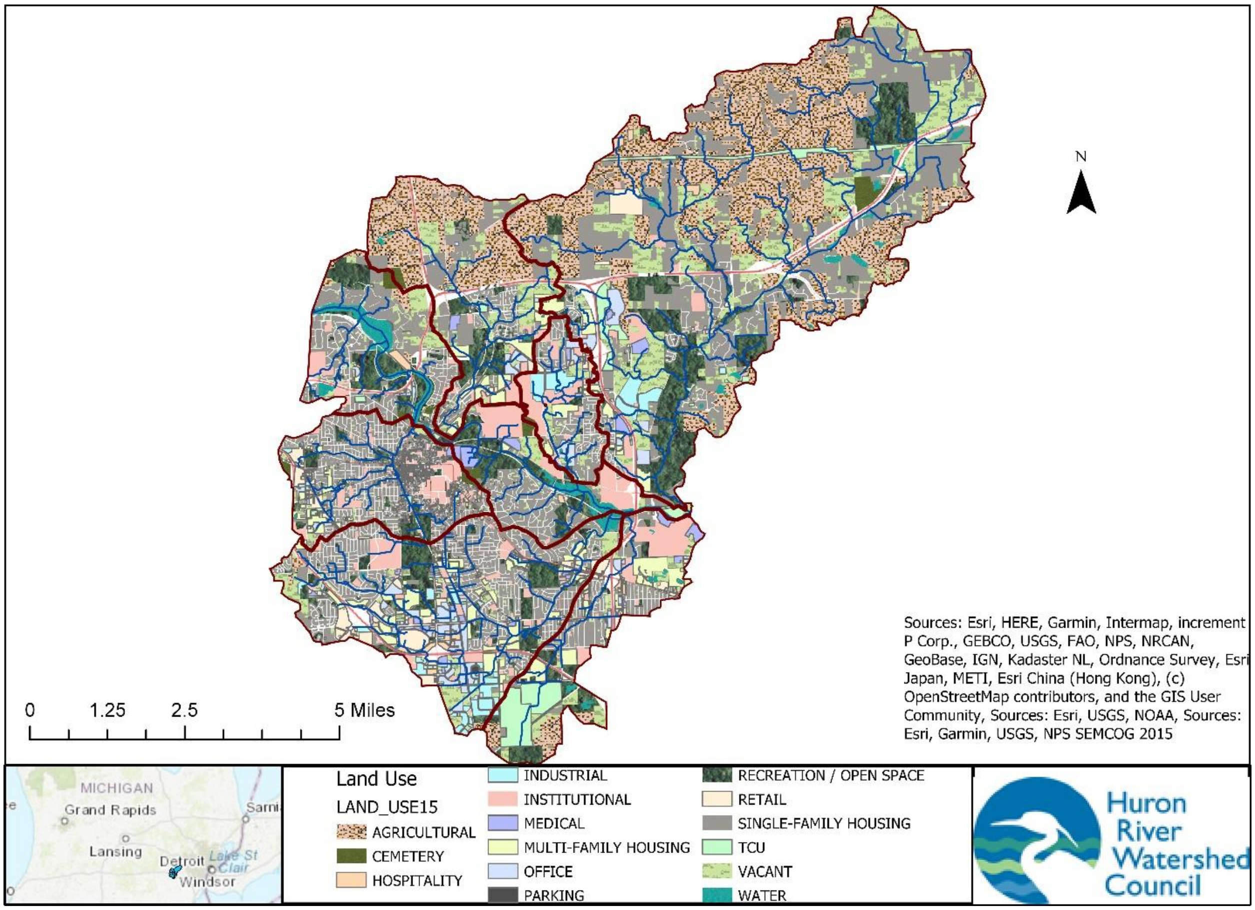


Table 2.5. 2015 Land use in the Watershed, by percentage of creekshed and area in acres (in parentheses).

Creekshed	Water	Agriculture	Open/Natural Lands			
			Total	Cemetery	Vacant	Parks/forest
Allens	0% (2)	0% (0)	17% (531)	3% (78)	3% (96)	12% (356)
Millers	0% (5)	0% (0)	16% (347)	2% (39)	11% (223)	4% (85)
Huron	9% (733)	16% (1403)	32% (2723)	2% (169)	7% (569)	23% (1985)
Fleming	0% (155)	65% (28787)	13% (5635)	0% (108)	7% (3118)	5% (2409)
Malletts	2% (198)	2% (131)	23% (1841)	0% (0)	9% (727)	14% (1115)
Swift Run	5% (227)	9% (412)	32% (1571)	0% (0)	12% (602)	20% (970)
Traver	0% (16)	62% (5654)	13% (1168)	1% (65)	8% (695)	4% (408)
Total	2% (1334)	45% (36388)	17% (13816)	1% (459)	8% (6030)	9% (7327)

(table 2.5, continued)

Creekshed	Urban										
	Total	Single family housing	Multi-family housing	Hospitality	Industrial	Institutional	Medical	Office	Parking	Retail	Utilities
Allens	83% (2524)	45% (1389)	9% (269)	3% (89)	1% (20)	12% (353)	3% (99)	3% (99)	2% (48)	5% (143)	1% (17)
Millers	83% (1757)	20% (431)	9% (186)	1% (29)	7% (144)	33% (706)	0% (10)	8% (163)	0% (0)	2% (34)	3% (55)
Huron	43% (3689)	28% (2353)	2% (141)	1% (53)	0% (10)	11% (906)	2% (140)	0% (24)	0% (4)	0% (3)	1% (55)
Fleming	22% (9900)	18% (7972)	1% (246)	0% (88)	0% (179)	1% (323)	0% (80)	1% (232)	0% (0)	0% (170)	1% (612)
Malletts	73% (5735)	29% (2306)	9% (692)	1% (102)	5% (378)	7% (558)	1% (99)	5% (429)	0% (14)	6% (476)	9% (681)
Swift Run	54% (2628)	14% (695)	12% (569)	1% (47)	1% (65)	8% (371)	5% (235)	1% (55)	0% (0)	3% (142)	9% (449)
Traver	25% (2245)	13% (1205)	4% (368)	0% (5)	0% (4)	6% (507)	0% (33)	1% (73)	0% (4)	0% (28)	0% (19)
Total	36% (28480)	20% (16351)	3% (2472)	1% (412)	1% (799)	5% (3723)	1% (696)	1% (1075)	0% (69)	1% (996)	2% (1888)

2.2.4. Existing Point Sources

There are several point source facilities in the watershed that hold NPDES permits issued by the State of Michigan (Figure 2.15). The number of permitted point sources is not static due to expiring old permits and activation of new permits. As of the October 2019 update on the EGLE website, forty-nine permits were in issuance[14]. Receiving waters for the discharges include direct drainage to the Huron River, all major tributaries, numerous secondary streams or drains, and impoundments along these water bodies.

Two of the permits are Individual Permits, the Ann Arbor Waste Water Treatment Plant and the Ann Arbor MS4 (stormwater discharge from municipal sources)

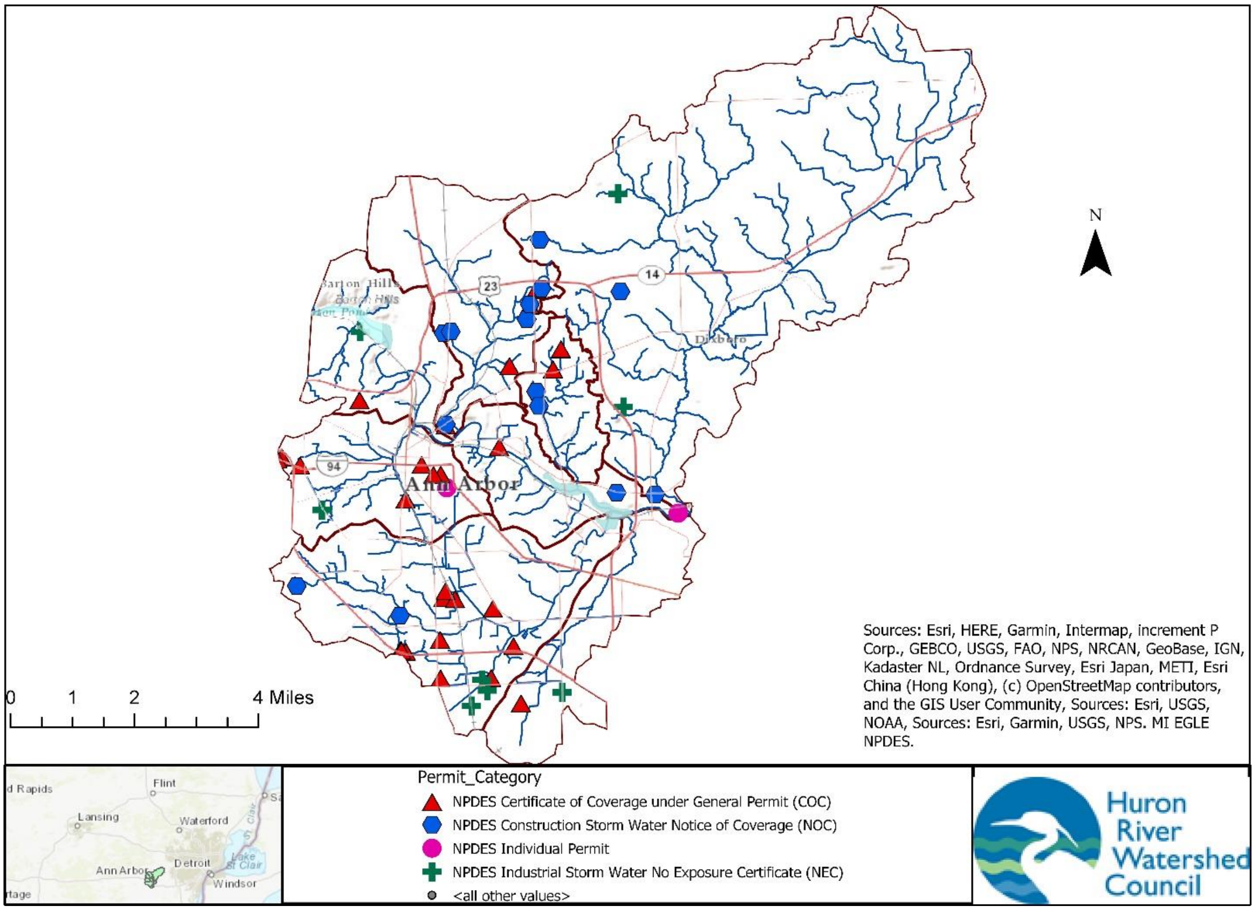
Twenty-five of the permits are for NPDES Certificate of Coverage under General Permit (COC).

Eight of the permits are issued for the purpose of conveying stormwater to local waterways (NPDES Construction Storm Water Notice of Coverage).

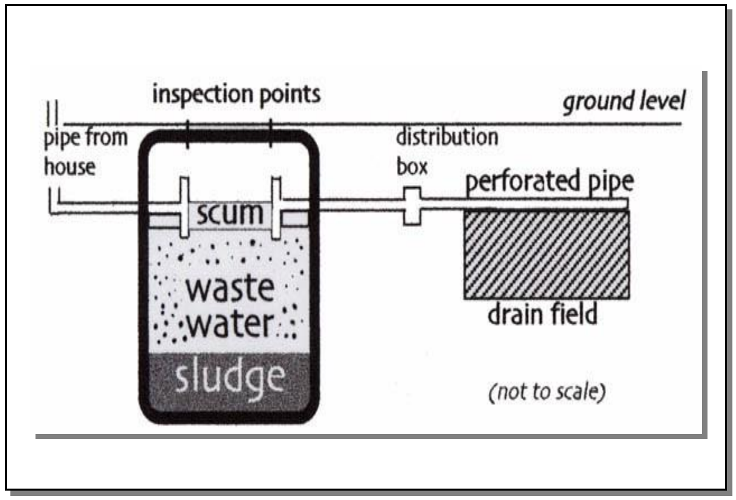
Fourteen are for discharge of various types of industrial wastewater (NPDES Industrial Storm Water No Exposure Certificate).

Due to the nutrient TMDLs in Ford and Belleville Lakes, waste load allocations for phosphorus contributions from permitted point sources have been established in all upstream contributing portions of the Huron River watershed. These waste load allocations set goals on the maximum amount of phosphorus that should be discharged into waters flowing to these TMDL areas. These limits are considered when determining the amount of phosphorus that may be discharged by existing NPDES permittees. The TMDL may also factor into determining whether additional phosphorus-discharging facilities may be permitted to locate in a TMDL area, and what their discharge limits may be.

Figure 2.15. NPDES permits in the Watershed, as of October 2019.



2.2.5. Sanitary Sewer Service Areas and Privately-Owned Septic Systems



The Watershed has a mix of households whose waste discharges are treated by publicly owned wastewater treatment plants (WWTP) or on-site decentralized wastewater systems (privately-owned septic systems). Sanitary sewers rely on the connection of pipes from residential, commercial, and industrial sites that ultimately are received at a wastewater treatment plant where treatments are applied before discharge. Privately owned on-site septic systems, or septic tanks, allow wastewater from a single (sometimes multiple) entity to be treated via biological and infiltration processes. Both technologies are effective methods of wastewater treatment if maintained and operated properly; however, impairments do occur. Households currently served by sanitary sewers are located in the urbanized areas of the watershed, while remaining areas are served by on-site septic systems (Figure 2.16).

Improperly functioning sewer systems and privately-owned septic systems can have a profound impact on the water quality. By carrying nutrients (phosphorus and nitrogen), bacteria, pharmaceutical agents, and other pollutants to waterbodies with little or no treatment, impaired systems can result in unhealthful conditions to humans (i.e., bacterial contamination) and to aquatic organisms (i.e., low dissolved oxygen from plant growth).

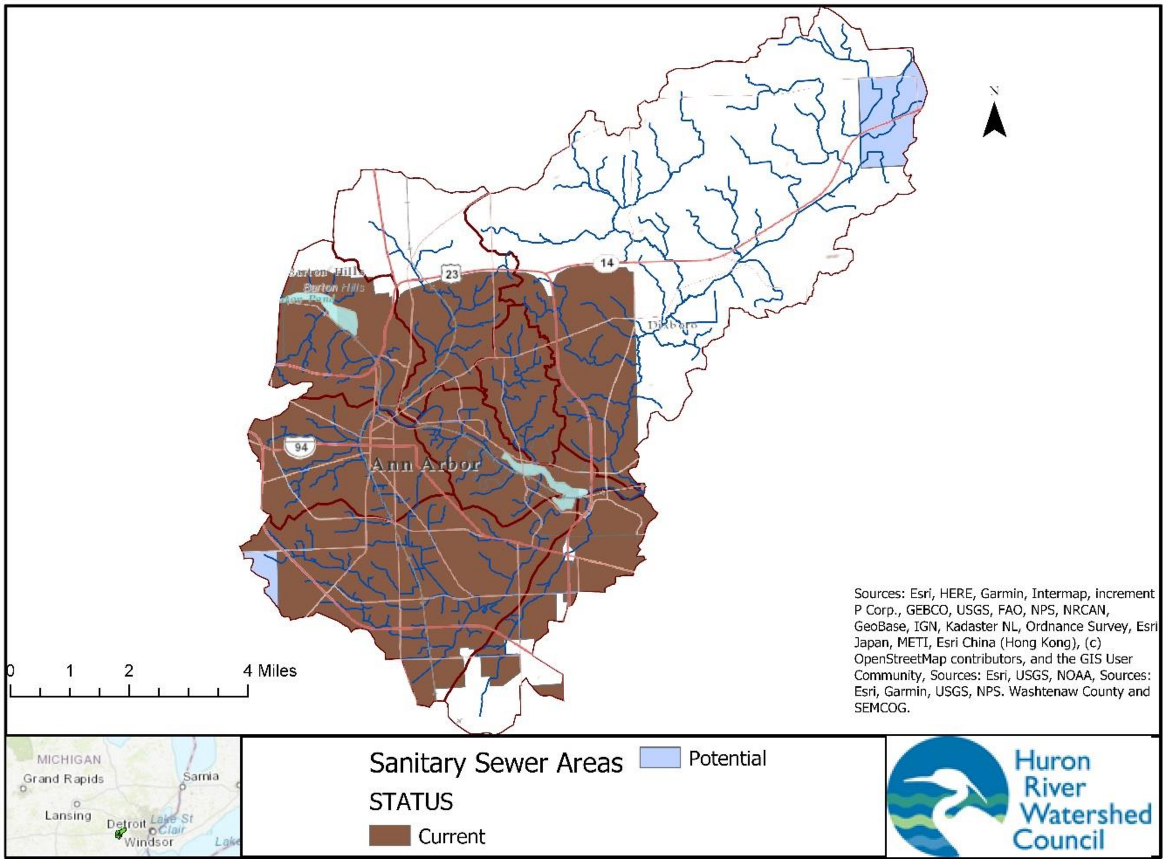
If either system is designed, constructed, or maintained improperly, it can be a significant source of water pollution and a threat to public health. The Washtenaw County Health Department regulates the design, installation, and repair of privately-owned septic systems. Washtenaw County currently requires regular maintenance and inspection to assure proper functioning of these systems, which occurs at the time the property is sold.

Sanitary sewer systems can suffer from improper installation and maintenance. For instance, in many older developments sanitary sewer pipes can be inadvertently connected to stormwater drainage systems, causing what is termed an “illicit discharge.” These discharges can have an even greater impact on water quality than impaired septic systems, depending on the type, volume, and frequency of the activity. Both county and local units of government covered by Phase II stormwater permits are required to identify and eliminate illicit discharges in their communities through an Illicit Discharge Elimination Program (IDEP).

Development projects can utilize community wastewater systems, also known as decentralized wastewater systems, which provide on-site wastewater treatment for multiple homes much like a giant septic system. Community wastewater systems are increasingly being used to build high density developments in un-sewered areas where soils are not suitable for individual septic systems. A drawback of these large septic systems is the potential discharge of large quantities of septic waste into a localized groundwater area. Conversely, community wastewater systems can also be a tool for mitigating the impacts of individual septic systems over a larger area; rather than locating several individual septic systems in close proximity to a lake or waterway where they could pose a greater risk to surface waters or groundwater, a community wastewater system could allow the homes to be built near the waterbody, while the community septic system would be located at a greater distance from the waterbody. Due to the potential impacts of community wastewater systems, communities should be aware of their complexities and plan accordingly for their location, construction, and operation.

Two stream sections have been identified as impaired by pathogens in the Middle Huron Watershed. The Huron River mainstem between Argo and Geddes Dams has exhibited periodic high *E. coli* counts. Lower Geddes Pond has consistently exhibited the highest bacteria concentrations among all Huron River reaches in the Ann Arbor area. Geddes Pond is also the receiving water for three direct tributaries (Millers Creek, Malletts Creek and Swift Run Creek), plus Traver Creek and Allens Creek that enter immediately upstream. Historic data indicate that each of these tributaries exceed the WQS for pathogens as well.

Figure 2.16. Sanitary Sewer Areas in the Watershed



2.3 Water Quality Parameters

This section provides a synopsis of water constituents and how they make up and affect the aquatic ecosystems of the Watershed. Many of these parameters are also indicators for gauging water quality. A general discussion of basic limnology (lake behavior) is also presented. While these parameters are important and useful in evaluating overall water quality, data for all of them were not readily available for all creeks in the Watershed. For the data that is available, it has been broken down to the creekshed level and presented in Section 2.4.

2.3.1. Chemical and Physical Parameters

Stream Morphology and Substrate

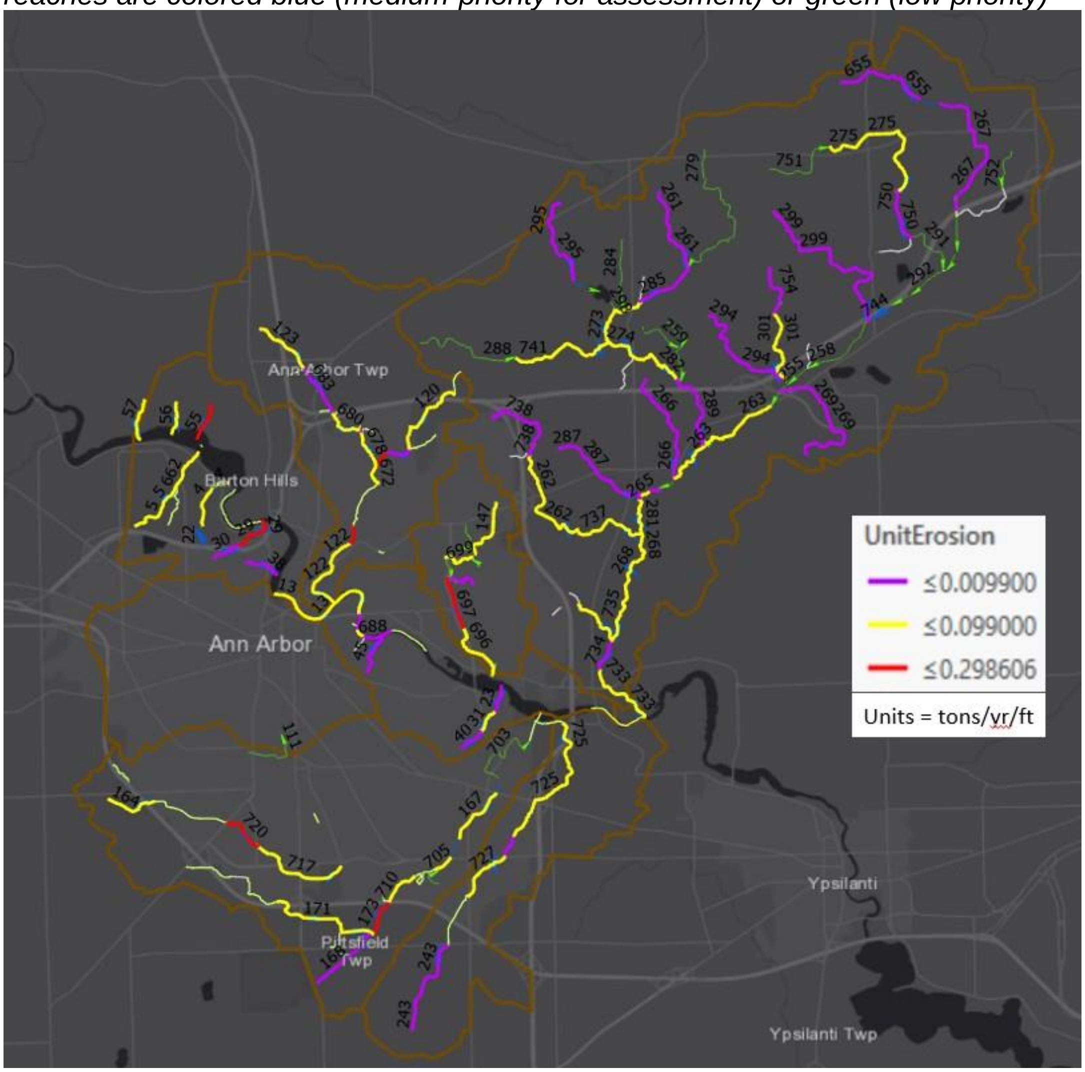
Stream channels provide a diversity of habitats for aquatic life and each serves a different function for the stream ecosystem. Most natural stream channels alternate through a pattern of riffles (small rapids), runs, glides and pools. The specific shape and pattern is controlled by the underlying geology (bedrock, rocks and soils) and hydrology (pattern and size of stream flow). Natural streams can take on a variety of forms along the journey from headwaters to confluences, and these forms are generally dynamic – changing somewhat following each major storm. If the stream has a good connection to its floodplain, it might meander from one channel to another and back again over the years. As this movement occurs, the stream lifts, transports and deposits sediment into its channels or floodplains, creating new aquatic and upland habitat. As hydrology is altered (e.g. through artificial channelization or upland urbanization and disconnection to groundwater), storm flows increase, and the erosion rates of stream banks and beds increase as well. This can result in homogenization of channel type, habitat destruction, and loss of important sediment and chemical processing functions. Phosphorus can be exported with higher erosion, and stagnant, low oxygen pools can form that promote bacterial growth. Highly altered streams of this type produce biological communities with very low diversity.

Stream bottoms or substrate can be composed of a number of different materials, depending on the geology of the stream bed and surrounding drainage area. This substrate can vary from a predominance of large particles such as gravel, cobble or even bedrock to moderately sized sands to fine organic particles in silt and clay. Silt, which is the fine-grained particulate matter that results from eroded soil, can be deposited in streams over substrate composed of larger particles. Silt in riffles can limit the number of creatures living in a creek because it fills the spaces between surfaces and reduces oxygen in the substrate. Eroded silt also degrades water quality because soil binds pollutants, like phosphorus, which helps to create nuisance algae blooms. Many streambeds in the Huron River system are naturally sand or gravel bottoms. When fine sediments build up too fast, the natural aquatic ecology cannot rapidly adapt and the biotic diversity may be degraded. Erosion is a natural process, but dramatic increases in fine sediment suggest unnaturally high erosion rates upstream. Evaluation of stream banks can help determine the need for bank and channel restoration.

For this plan, HRWC employed a new method to evaluate the stability of representative stream reaches (i.e. segments) throughout the watershed. The BANCs (Bank Assessment for Non-point source Consequences of Sediment) methods and complete results are described in Appendix E. In summary, the rapid evaluation method assesses the erodibility of a stream reach's banks and the hydraulic forces impacting those banks to estimate erosion rates for each bank. These bank assessments can then be compiled into an overall erosion rate for the stream reach or average rates for all evaluated streams within a tributary creekshed. The erosion estimates individually should only be used to get a general sense of the scale of erosion relative to other streams in the system (rather than taken as precise estimates of sediment load), as the techniques are designed for a rapid and broad assessment. Results for each creekshed are presented in section 2.4, but Figure 2.17 shows the evaluated stream reaches and their erosion rates. Within the watershed, there are a small number (7) of stream reaches with high erosion rates. The majority of streams (54 of 94 evaluated reaches) fall within a moderate erosion rate.The remaining reaches (24%) have stable banks with little evidence of active erosion.

Erosion rates:
High: >0.1 and <=0.30 tons/yr/ft. Marked Red
Moderate: 0.01 to 0.099 tons/yr/ft. Marked Yellow
Low: <0.01 tons/yr/ft. Marked Purple.

Figure 2.17 Estimated Unit Erosion Rates for Evaluated Stream Reaches. Note: unassessed reaches are colored blue (medium-priority for assessment) or green (low priority)



Phosphorus

Phosphorus and nitrogen are nutrients essential for the growth of aquatic plants. Phosphorus is needed for plant growth and is required for many metabolic reactions in plants and animals. Generally, phosphorus is the limiting nutrient in freshwater aquatic systems. That is, if all phosphorus is used up, then plant growth will cease no matter how much nitrogen is available. Phosphorus is the main parameter of concern that causes excessive plant and algae growth (eutrophication) in lakes and impoundments. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient-poor or low plant productivity), mesotrophic (moderate nutrient levels and moderate plant productivity), eutrophic (nutrient-rich, high plant productivity) and hypereutrophic (excessive plant productivity and excessive nutrients). Eutrophic and hypereutrophic conditions are characterized by depletion of dissolved oxygen in the water. Low levels of dissolved oxygen adversely affect aquatic animal populations and can cause fish kills. High nutrient concentrations interfere with recreation and aesthetic enjoyment of waterbodies by causing reduced water clarity, unpleasant swimming conditions, foul odors, blooms of toxic and nontoxic organisms, and interference with boating.

Phosphorus enters surface waters from point and nonpoint sources, with nonpoint sources accounting for the vast majority of phosphorus loading in the Watershed. Wastewater treatment plants are the primary point sources of the nutrient. Additional phosphorus originates from the use of industrial products, such as toothpaste, detergents, pharmaceuticals and food-treating compounds. Tertiary treatment of wastewater, through biological removal or chemical precipitation, is necessary to remove more than 30% of phosphorus.

Nonpoint sources of phosphorus include human, natural, and animal sources. Because phosphorus has a strong affinity for soil, stormwater runoff from activities that dislodge soil or introduce excess phosphorus (such as conversion of land to urban uses and over-fertilization of lawns) is frequently considered the major nonpoint source of phosphorus contribution to waterbodies. Eroded sediments from agricultural areas carry phosphorus-containing soil to surface waters. Septic system failures and illicit connections also are routes for phosphorus introduction. Domesticated animal and pet wastes that enter surface waters comprise another nonpoint source of phosphorus. Natural sources include phosphate deposits and phosphate-rich rocks that release phosphorus during weathering, erosion and leaching; and sediments in lakes and reservoirs that release phosphorus during seasonal overturns. EGLE considers total phosphorus concentrations higher than 0.03 mg/L (parts per million) to have the potential to cause eutrophic conditions.

Due to the persistent and systemic presence of high concentrations of phosphorus in Ford and Belleville Lakes, as well as the Huron River and tributaries upstream in the watershed, high nutrient loading is the top challenge identified in this Plan. A TMDL for excessive phosphorus loading from point and nonpoint sources has been established for Ford and Belleville Lakes and their contributing waters. While the flowing Huron River and its tributaries do not generally show signs of excessive phosphorus concentrations, the impoundments along these waterways tend to act as sinks for phosphorus loading, which can lead to eutrophic conditions.

Nitrogen

Nitrogen is also considered essential in determining algae growth in lakes and is found in a number of forms, including molecular nitrogen, ammonia, nitrates, and nitrites. Nitrogen is often found in waterbodies at higher concentrations than phosphorus. Consequently, nitrogen is often not considered the limiting nutrient to detrimental growth. Additionally, unlike phosphorus loading, nitrogen loading is often difficult to reduce due to the high water solubility of nitrogen. Therefore, concerns regarding nitrogen and its role in eutrophication often are considered secondary to phosphorus in southeast Michigan. However, studies have shown that high nitrate concentrations, even without phosphorus limitations, can promote eutrophication. In addition, studies also reveal that dual control on nitrogen and phosphorus result in short term reductions in eutrophication.. Typical sources of nitrogen in surface waters include human and animal wastes, decomposing organic matter, and runoff from fertilizers. Improperly operated wastewater treatment plants and septic systems, as well as sewer pipeline leaks also can act as additional sources of nitrogen to waterbodies. EGLE considers total nitrogen levels greater than 1 to 2 mg/L to have the potential to cause eutrophic conditions. Nitrate levels above 10 mg/L are considered unsafe for drinking water[15].

Salts, Conductivity, and Total Dissolved Solids

Salts typically enter waterways from road salting (de-icing) operations or from water softener backwash discharge into the environment. De-icing products, primarily sodium chloride, are used locally by MDOT, county road commissions, homeowners, and business/commercial establishments. Salts are highly soluble in water and easily wash off pavement into surface waters and leach into soil and groundwater. High concentrations of salt can damage and kill vegetation, disrupt fish spawning in streams, reduce oxygen solubility in surface water, interfere with the chemical and physical characteristics of a lake, and pollute groundwater making well water undrinkable.

A study by the USGS in Oakland County on the effects of urban land use change on streamflow and water quality showed a strong positive correlation between salt ions (sodium, potassium, and chloride) and residential and commercial landcovers, as well as overall percentage of the watershed built, and population density.[16] These ions were negatively correlated with agriculture, open space, forest, and wetland land covers. While it may be reasonably stated that the rapid urbanization in the Watershed has led to increased salt concentrations in the water, the extent to which this is occuring and the impacts of these salt concentrations requires additional monitoring data and studies.

Michigan has a relatively new water quality standard for chloride concentration. Chloride is the most persistent and harmful component of most salts. Based on this standard, the chronic and acute impacts on aquatic wildlife occur at relatively high chloride concentrations – approaching sea water concentrations.

Best management practices to reduce salt inputs may include the use of alternative road de-icers such as calcium carbonate, magnesium chloride or calcium acetate that are not as detrimental to water quality. In addition to salt alternatives, proper calibration of salt dispensing equipment and optimizing the timing of de-icing applications can reduce over-use of salt and alternative de-icers.

Conductivity, a broad indicator of general water quality, increases with the amount of dissolved ions, such as salts or metals. There is some evidence that average conductivity measured at a site over 800 microsiemens (µS) can be correlated with lower stream biodiversity.[17] Conductivity over 800 µS may indicate the presence of toxic substances, but it can also be high due to naturally occurring ions. Many toxins are also not detected by conductivity measures. A high conductivity measurement signals a need for further investigation to better determine the cause and potential sources.

Since 2002, conductivity has been recorded at sites in the Watershed through the Chemistry and Flow Monitoring Program. Monitoring data is collected twice monthly from April through September. In addition, conductivity is monitored by HRWC's River Roundup program when the volunteer teams sample for macroinvertebrates.

Conductivity is also highly correlated with Total Dissolved Solids (TDS), which include anything dissolved in water including minerals, salts, metal, cations, anions and organic molecules. Though a more accurate measurement for expressing the chemical constituents of water, TDS is a more expensive and complicated measurement to make, and thus often Conductivity is often used in lieu of TDS.

Organic Compounds and Heavy Metals

Organic compounds (PCBs, PFAS, PAHs, DDT, etc.) and heavy metals (lead, copper, mercury, zinc, chromium, cadmium, etc.) can potentially cause adverse impacts on river ecosystems. These chemicals and metals can disrupt the physiology of aquatic organisms and can accumulate in their fatty tissues. Organic chemicals such as PCBs are by-products of manufacturing processes and the combustion of fossil fuels. They are also present in automobile fluids such as gasoline and oils. Other organic chemicals are found in pesticides and herbicides. Heavy metals are also a common by-product of manufacturing, but these contaminants are also common in agricultural and road runoff.

In the Watershed, potential sources of organic compounds and heavy metals include urban areas, roads, permitted industries, existing in-stream contamination from historic activities, chemicals from lawns, and runoff from agricultural operations.

Coal tar sealcoats are incredibly high in polycyclic aromatic hydrocarbons (PAHs). PAHs are of concern because many of these compounds have been identified as toxic, mutagenic, teratogenic (causing birth defects) and/or probable human carcinogens. Coal tar sealants contain 1000 times more PAHs than asphalt-based sealants (a readily available alternative) and are the number one source of PAHs in lake sediments.[18] PAHs from coal tar sealcoat are released into the environment in several ways. When applied, these compounds volatilize into the air, affecting air quality. As the sealcoat weathers, dust from the pavement makes its way into homes on shoes and clothing. When it rains, loose particles move into soils, stormwater catch basins, lakes, and rivers.

HRWC has done significant work on PAHs in the last decade. HRWC conducted PAH sampling in several detention ponds in Fleming, Mallets, and Traver Creeksheds (section 2.4). Results show that the Watershed has elevated PAH levels; and since studies indicate that 50-75% of PAHs found in sediments in the Great Lakes Region come from coal tar sealants[19], HRWC has worked with municipalities to pass ordinances restricting use. Within the Watershed, the City of Ann Arbor, Ann Arbor Township, and Pittsfield Township have now adopted ordinances that make it illegal to sell or apply high PAH pavement sealers.

Polyfluoroalkyl substances (PFAS) are a family of manmade organic molecules that were revealed to be a problem in the Huron River Watershed in August 2018, after EGLE reported high levels in the tissues of fish from Kent Lake. In 2018, the Michigan Department of Health and Human Services has issued a “Do Not Eat Fish” advisory for most of the Huron River from the crossing at North Wixom Road in Milford all the way to Lake Erie. This includes the Huron River section contained in the Watershed of this Management Plan.

PFAS pollution in drinking water is not regulated by federal law. The State of Michigan is currently in the process of establishing drinking water standards, and EGLE established a cleanup criteria of 70 ppt for groundwater used as drinking water in 2018.[20]

A number of international, national and regional studies over the past two decades have documented the presence of pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in surface waters. PPCPs include substances such as drugs and cosmetics. EDCs are any chemicals that have been shown to interfere with the normal function of the human endocrine system. Both types of compounds have potential human health and wildlife impacts. Researchers are currently working to evaluate the effects of environmental exposure to PPCPs and EDCs.

These substances can enter the environment through a number of routes including: wastewater treatment discharge, industrial discharge, runoff from confined animal feeding operations, and land application of animal waste. The U.S. Geological Survey conducted a national study of 139 streams in 30 states and found that 80% of those streams contained at least one of the 95 compounds they targeted.[21]

In 2004, a more targeted study conducted for the City of Ann Arbor assessed city waters for 22 compounds of concern.[22] The researchers in that study found that ten of the 22 compounds were present in the source water in Barton Pond, with four remaining in finished drinking water; and 17 of the 22 compounds were found in wastewater influent, with 15 compounds making their way into the effluent discharged to the Huron River. The existing treatment processes for both drinking water and wastewater reduced the concentrations for most, but not all the target compounds.

Acidity (pH)

Measuring pH provides information about the H+ concentration in the water. pH is measured on a logarithmic scale that ranges from 0-14, so river water with a pH value of 6 is 10 times more acidic than water with a pH value of 7. Organisms that live in rivers and streams can survive only in a limited range of pH values. In Michigan surface waters, most pH values range between 7.6 and 8.0. Michigan Water Quality Standards require pH values to be within the range of 6.5 to 9.0 for all waters of the state. The pH of rivers and streams may fluctuate due to natural events, but humans also can cause unnatural fluctuations in pH. For example, chemical contamination from spills can cause short-term pH changes.

Turbidity and Suspended Sediments

While some sedimentation in a river system is natural, when streambanks in one area erode and the soil is deposited downstream, the Watershed experiences heavy sedimentation on the Huron River, its tributaries, and lakes and impoundments. Impacts of soil erosion and sedimentation on downstream water resources include decreased aesthetic quality with increased turbidity, decreased light penetration and decreased plant growth, and decreased aquatic habitat quality with sediment covering and clogging gills of fish and aquatic insects. In addition, nutrients and other pollutants often bond with soil particles, increasing the detrimental impacts of sedimentation on water resources.

Many streambeds in the Huron River system are naturally composed of sand, gravel, and cobble. However, a problem arises when a dramatic shift from these coarse materials to more fine sediments occurs. Excessive deposits of fine sediment are known to impair macroinvertebrate communities. This is occurring in a number of locations in the Middle Huron, including lower Millers Creek, Malletts Creek, and Swift Run. TMDLs for macroinvertebrate habitat degradation have been established for Malletts Creek and Swift Run (Chapter 2.5).

Increased stormwater flows result in increased sediment loadings for a variety of reasons. Soil particles are picked up by stormwater as it flows over roads, through ditches, and off of bridges into surface waters. Increased flows from stormwater runoff or dam discharge have enough energy to scour soils and destabilize stream banks, carrying bank sediments downstream. In addition, runoff from some construction sites can be sources of sediment. This problem arises if proper soil erosion and sedimentation controls are not in place on bare soil that has been exposed during the construction process. Sediment enters the water at bridges as a result of inadequate construction and maintenance practices, and via road ditches, which convey sediment from unpaved roads into the stream. Other sources of sediment include wash-off from paved streets and parking lots. Active agricultural land may be a source of concern in the rural areas of the watershed since traditional farming practices leave soil bare and tilled at certain times of the year, which leaves soil vulnerable to wind and water erosion.

Turbidity is the measure of the relative clarity of water and is an approximation of suspended solids in the water that reduce the transmission of light. This relationship depends on several factors including the size and shape of the suspended particles along with their density in the water, as well as the degree of turbulence at the sample site. Turbidity should not be confused with color since darkly colored water can still have low turbidity or high relative clarity. Total suspended solids (TSS) include all particles suspended in water that will not pass through a filter of a specified size. Suspended solids are any particles/substances that are neither dissolved nor settled in the water. A third measure, suspended sediment concentration (SSC) is now being promoted by EGLE, USGS and EPA as a more accurate measure for open channel monitoring. SSC differs from TSS in the methods of calculation. Both express the amount of sediments suspended in a sample of water.

High turbidity and TSS/SSC result from soil erosion, stormwater runoff, algal blooms and bottom sediment disturbances. Turbid water absorbs heat from the sun. Warmer water holds less oxygen than cooler water, resulting in less oxygenated water. Water with high turbidity loses its ability to support diverse aquatic biology. Suspended solids can be diverse in composition, including clay, silt and plankton as well as industrial wastes and sewage or other components. High amounts of suspended solids can clog fish gills, reduce growth rates and disease resistance in aquatic organisms, decrease photosynthesis efficiency, reduce dissolved oxygen (discussed in a later section) levels, and prevent egg and larval development. Settled particles can accumulate on the stream bottom and smother fish and amphibian eggs and aquatic insects including larvae of benthic macroinvertebrates.

Michigan Water Quality Standards set a narrative standard that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. Most observers consider water with a TSS concentration less than 20 mg/l to be relatively clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary.[23] Standards have not been established for turbidity, but levels for turbidity have been set for stream segments that have been listed for impairment of biota.

Stormwater carries sediment directly into the nearest waterway.
Photo: HRWC files

A simple, though somewhat subjective, method of measuring water clarity in lakes uses a Secchi disk, which is an 8-inch diameter plate with alternating quadrants painted black and white. The observer lowers the disk into water until it disappears from view and then raises it until it becomes just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. Nearly all Secchi disc measurements on Michigan inland lakes will be between one and forty feet, and this score is also an indicator of nutrient levels in the lake. EGLE classifies Secchi disk readings greater than 16 feet as indicative of oligotrophic (low nutrient) conditions. Secchi disk readings between 6.5 and 16 feet indicate mesotrophic conditions, and Secchi disk readings less than 6.5 feet indicate eutrophic (high nutrient) or hypereutrophic conditions.[24]

Temperature

Water temperature directly affects many physical, biological, and chemical characteristics of a river. Temperature affects the amount of oxygen that can be dissolved in the water, the rate of photosynthesis by algae and larger aquatic plants, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic wastes, parasites, and diseases. These factors limit the type of macroinvertebrate and fish communities that can live in a stream.

An average summer temperature of about 72º F is the warmest water that will support coldwater fish, such as sculpin and trout. Fish that can survive in warmer waters up to 77º F include smallmouth bass, rock bass, sunfish, carp, catfish, suckers, and mudminnows. Average summer temperatures above 77º F exclude many fish and cool water insects[25]. Fluctuations in temperature also affect biodiversity. Extreme fluctuation in summer temperature, as defined by a difference of more than 18º F between the average maximum and average minimum stream temperature, have been found to decrease fish diversity at warm sites.[26]

Thermal pollution—the discharge of heated water from industrial operations, dams, or stormwater runoff from hot pavement and other impervious surfaces—often causes an increase in stream temperature. The Michigan Water Quality Standards specify that the Great Lakes and connecting waters and inland lakes shall not receive a heat load that increases the temperature of the receiving water more than 3º F above the existing natural water temperature (after mixing with the receiving water). Rivers, streams and impoundments shall not receive a heat load that increases the temperature of the receiving water more than 5º F for warmwater fisheries. These waters shall not receive a heat load that increases the temperature of the receiving water above monthly maximum temperatures (after mixing).[27]

All waters in the Watershed are warmwater fish streams. However, coldwater fish species are found occasionally in the Watershed, and the presence of EPT and sensitive aquatic insect families at many monitoring sites is an indication of adequately cool stream temperatures. Low flows below impoundments, removal of streambank vegetation, and inputs of stormwater runoff (which are typically substantially warmer than base stream flows) are all potential contributing factors to elevated water temperatures.

Dissolved Oxygen

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water.
DO is essential for fish and is an important component in the respiration of aerobic plants and animals, photosynthesis, oxidation-reduction processes, solubility of minerals, and decomposition of organic matter. Aquatic plants, algae and phytoplankton produce oxygen as a by-product of photosynthesis. Oxygen also dissolves rapidly into water from the atmosphere until the water is saturated. Dissolved oxygen diffuses very slowly and depends on the movement of aerated water. DO levels fluctuate on a diurnal basis. They rise from morning through late afternoon as a result of photosynthesis, reach a peak in late afternoon, then drop through the night as a result of photosynthesis stopping while plants and animals continue to respire and consume oxygen. DO levels fall to a low point just before dawn.

The amount of oxygen an organism requires varies according to species and stage of life. DO levels below 1-2 mg/L do not support fish. DO levels below 3 mg/L are stressful to most aquatic organisms. Minimal DO levels of 5-6 mg/L usually are required for growth and activity. Low DO levels encourage the growth of anaerobic organisms and nuisance algae. The accumulation of organic wastes and accompanying aerobic respiration by microorganisms as they consume the waste depletes DO in freshwater systems. High levels of bacteria from sewage pollution and high levels of organic matter can lead to low DO levels. Michigan Water Quality Standards states that surface waters protected for warmwater fish and aquatic life must meet a minimum dissolved oxygen standard of 5 mg/l.[28]

Bacteria

Bacteria are microorganisms that are found everywhere. Coliform is a group of bacteria that includes a smaller group known as fecal coliforms, which are found in the digestive tract of warm-blooded animals. Their presence in freshwater ecosystems indicates that pollution by sewage or wastewater may have occurred and that other harmful microorganisms may be present. A species of fecal coliform known as *Escherichia coli* or *E. coli* is analyzed to test for contamination. *E. coli* counts are used as a measure of possible drinking water contamination, as high concentrations can result in serious illness. The potential sources of *E. coli* in surface waters are varied and difficult to pinpoint. They include human sources such as failed septic fields, but also wildlife sources such as geese and raccoons and pet or feral sources as well.

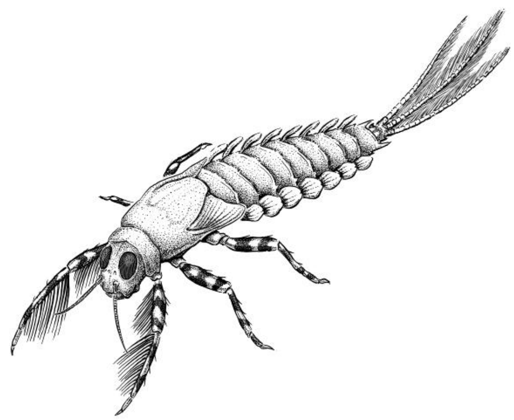
Rule 62 of the Michigan Water Quality Standards (Part 4 of Act 451) limits the concentration of microorganisms in surface waters of the state and surface water discharges. Waters of the state that are protected for total body contact recreation must meet limits of 130 *Escherichia coli* (*E. coli*) per 100 milliliters (ml) water as a monthly geometric mean of five sampling events (3 samples per event) and 300 *E. coli* per 100 ml water for any single sampling event during the

May 1 through October 31 period. The limit for waters of the state that are protected for partial body contact recreation is a geometric mean of 1000 *E. coli* per 100 ml water for any single sampling event at any time of the year.[29]

2.3.2 Aquatic Biological Communities

Macroinvertebrates

Insects living in the creek compose the benthic macroinvertebrate (no backbone) population, along with clams and other mollusks, crayfish, and other taxa. Typically, monitoring focuses on insects (in aquatic stages of development) as they are representative of a variety of trophic levels, are sensitive to local environmental conditions and are easy to collect. Since the macroinvertebrate population depends on the physical conditions of the stream as well as water quality, its composition indicates the overall stream quality. Insect diversity indicates good stream quality and is measured by the number of different insect families. 87 benthic insect families are found in the Huron River Watershed.[30]



*Brush-legged Mayfly (*Ephemeroptera isonychiidae*) drawing: Matt Wimsatt*

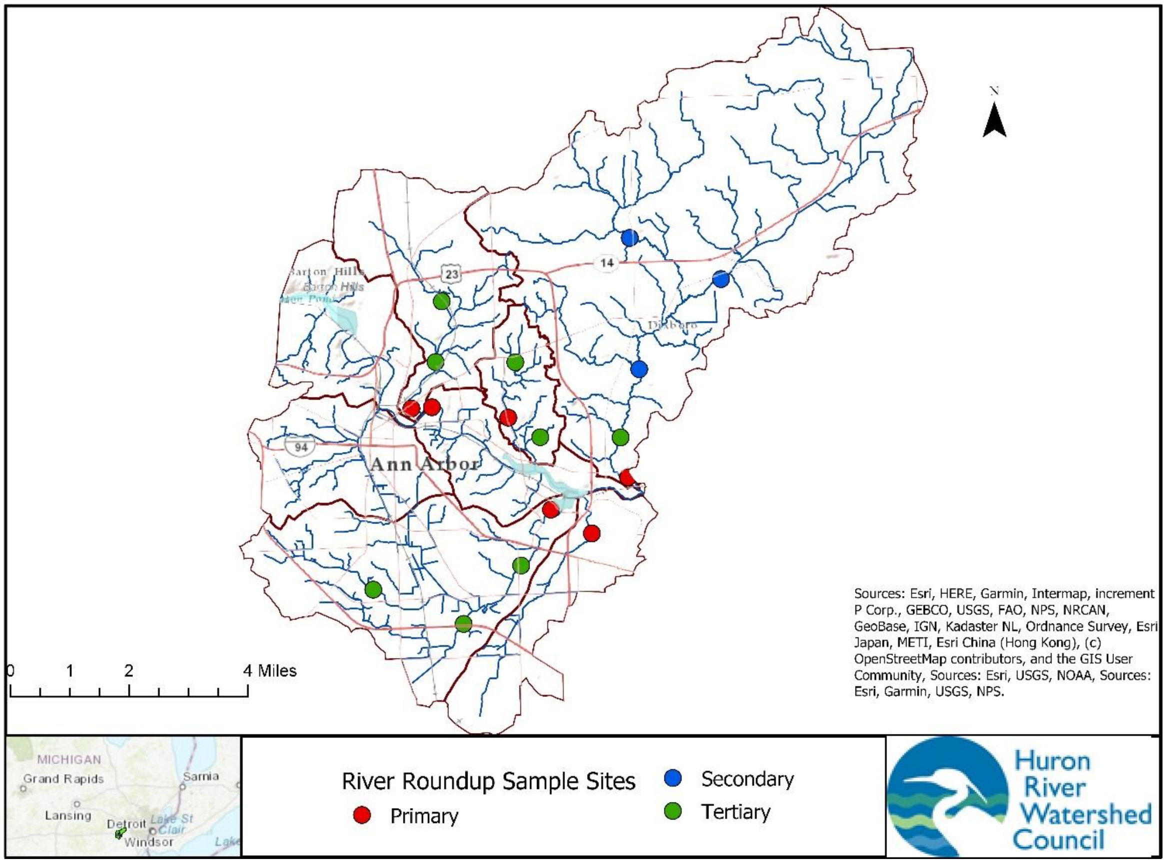
Macroinvertebrate data is collected through HRWC River Roundup event, which relies on trained volunteers to monitor more than 80 sites in the watershed, including 15 in the Watershed. Monitoring data has been gathered since as early as 1992 at some sites through annual spring and fall collection days, and a winter stonefly search each January. Six sites in the Watershed are considered primary sites, on the Huron main branch and the mouths of the main creeks. Collections are taken at primary sites in nearly every event unless volunteer labor force is low enough to prevent that. Three sites in the Watershed are secondary sites and collected every other year. There are also 6 tertiary sites that are only sampled occasionally, and given the low frequency of sampling, the tertiary sites are not included in this WMP (Figure 2.18).

Insect families belonging to the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are known as the EPT families, which are indicators of alterations in stream flow, temperature, oxygen and other changes that raise metabolic rates.

Sensitive insect families, such as Perlidae (Perlid stonefly) and Brachycentridae (log-cabin caddisfly), are highly sensitive to organic pollution. William Hilsenhoff's conducted a study that ranked macroinvertebrates on a scale of 0-10 in terms of pollution sensitivity and organisms ranked 0, 1, or 2 are considered sensitive in HRWC's protocols.[31] 19 of the 87 benthic insect families living in the Huron River Watershed are sensitive.[32]

The presence of winter stoneflies, which are active in January and require high levels of oxygen, are indicators of good stream quality. Absence of winter stoneflies suggests that toxic pollutants may be present. Since there is usually little or no stormwater runoff in January, there is a greater likelihood that any pollutants in the stream are persistent toxic substances present in the bottom of the streambed. Conversely, at a site where insect diversity is lower than expected but winter stoneflies are present, pollutants connected or related to stormwater runoff (i.e. nutrients or sediment) are more likely to be the problem.

Figure 2.18. Sample sites for HRWC's River Roundup (Benthic Macroinvertebrates monitoring).



Fish

Fish depend upon aquatic insects for food, and they also need good quality stream habitats and free-flowing reaches for all life cycle phases. More than 90 species of fish are native to the Huron River Watershed, however at least 99 species now live in its waters due to human-induced changes to the river's fish communities. Many native species still are present and abundant, yet many have declined to the point of rarity and are considered threatened or endangered. Increased peak flows, reduced summer base flows, increased and more varied temperatures, and increased turbidity and sediment loads have negatively affected critical fish habitat requirements, particularly as they relate to spawning and survival of young fishes. Dams have also affected fish populations by altering temperature and flow patterns, as well as inundating more high-gradient reaches and blocking migrations among critical seasonal habitats within the river.[33]

No information is available on the pre-European settlement fish community in the Middle Huron system. The headwaters and most tributaries of the Huron River had fairly stable flows. Summer water temperatures remained cool due to substantial water volumes, shaded banks, and local inflow of additional groundwater. Diverse habitats existed, including extensive gravel and cobble riffles, deep pools with cover, channel-side marshes, and flood plain wetlands. A 1938 survey of the headwaters and tributaries upstream of Ann Arbor found about 25 species.[34]

Higher-gradient stretches with extensive gravel riffles and pools held mudminnow, hornyhead chub, silver shiner, rosyface shiner, common shiner, lake chubsucker, northern hog sucker, golden redhorse, black redhorse, yellow bullhead, stonecat, tadpole madtom, brindled madtom, longear sunfish, rock bass, smallmouth bass, rainbow darter, fantail darter, and greenside darter.

Vegetation-dependent mud pickerel, northern pike, blackstripe topminnow, and least darter were also present.

Most common in the faster flowing, low gradient stretches connecting natural lakes were white sucker, largemouth bass, bluegill, pumpkinseed, Johnny darter, logperch, and yellow perch.

Neither muskellunge nor walleye were found in the 1938 survey. These may have been originally present but extirpated during early settlement.

The Huron River and its tributaries in the Watershed are considered warmwater fish habitat, mostly of second quality. Second quality warmwater feeder streams (tributaries of the mainstem of the Huron River) are those that contain significant populations of warmwater fish, but game fish populations are appreciably limited by such factors as pollution, competition, or inadequate natural reproduction. Small streams are often difficult to fish because of their small size; typically less than 15 feet wide.[35]

2.3.3. Lake Behavior (Limnology)

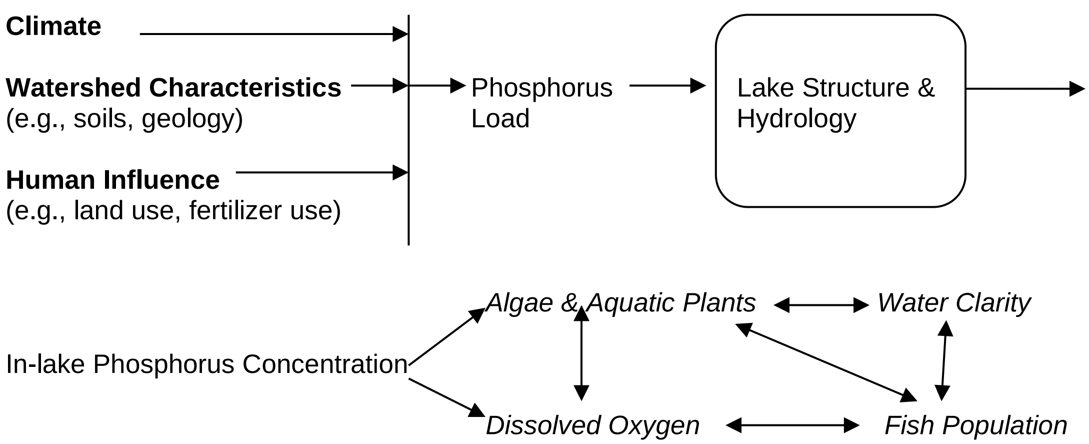
Limnology is the physical, chemical, and biological science of study of freshwater systems, including lakes. The Watershed includes several significant impoundments. A general review of lake behavior in response to nutrients is useful for understanding how lake and river system dynamics differ.

While numerous water quality parameters are studied to determine the trophic status and water quality status of lakes, in-lake phosphorus concentrations are often the determining factor. Trophic status is a useful means of describing the water quality of a lake since it defines the expected productivity and biotic composition of the system. While many factors influence the overall trophic status of a lake, the interaction of climate, watershed characteristics (e.g., soils), and human influences are the most dominant (Figure 2.19).[36]

Generally, a lake with concentrations of phosphorus less then 0.01 mg/L will be considered oligotrophic. A lake will be considered mesotrophic at concentrations of 0.01 mg/L to 0.02 mg/L and eutrophic to hypereutrophic at or greater than 0.02 mg/L or 0.03 mg/L.[37] Oligotrophic and mesotrophic lakes normally support cold- or cool- water fisheries (e.g., trout, some species of bass) and numerous recreational activities. The water in these lakes is also often suitable for drinking water supply. Eutrophic lakes often support warm water fisheries (e.g. bass, bluegill, catfish, carp, etc.) and have a more limited recreational value compared to oligotrophic or mesotrophic lakes because of periodic nuisance algal blooms and aquatic macrophyte growth. Hypereutrophic lakes, which experience frequent and intense nuisance algal blooms, do not ordinarily support cold or warm water fisheries and offer little or no recreational value. In addition, these lakes often exhibit decrease in open water surface areas because of layers of algal and aquatic plant masses.

Temperate zone lakes, like those in the watershed, experience changes in water chemistry and biology throughout the year. As winter ice thaws in the spring, winds and temperature changes in surface waters cause mixing within the water column. The result is water with temperature, dissolved oxygen, and other variables that are essentially equal at all depths This event is often referred to as a spring turnover. In the summer months, warm air temperatures interact with surface waters causing stratification or layering of lake water due to water temperature and density relationships. During this time of thermal stratification, little mixing of lake water occurs. Lakes that receive increased pollutant loading can exhibit quantifiable reductions in water quality at this time because of the lack of oxygen in the bottom water. As fall approaches, cooler air temperatures increase surface water density and mixing establishes uniformity within the water column in what is termed as fall turnover. During the winter months, the lake may stratify again.

Figure 2.19. Illustrative Schematic of Phosphorus Load Determinants and Lake Response.



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2.4. Creekshed Current Conditions

In order to gain a perspective on the past and present general water quality conditions in the Watershed, efforts were made to compile and summarize relevant and readily available existing water quality data. This effort included but was not limited to acquisition of studies conducted by state researchers, as well as requests to Advisory Committee members and researchers in the area.

Numerous studies and datasets of relevance were obtained in this process; however, spatial and temporal data may be somewhat limited in certain areas, especially for areas of the Watershed drained by minor tributaries. Due to these limitations, the following narrative should be considered a snapshot of water quality in the Watershed rather than a comprehensive review.

Seven hydrologically distinct drainage areas, or creeksheds, were delineated and their water quality summaries are reviewed below.

2.4.1 Huron River Direct Drainage

Hydrology

The hydrology of the Huron River through this section of the Watershed is discussed and evaluated in section 2.1.4, along with general conclusions about hydrology in all of the tributaries. The hydrology in the many, small direct drainages to the river has not been measured nor evaluated. Given the size of their drainage areas, direct drainage streams will have little impact on the overall river flow. However, as discussed in the Morphology section below, the flow dynamics in these streams cause significant erosion and may contribute a significant sediment load to the river.

Morphology

Recent conditions:
HRWC evaluated stream morphology for a number of direct drainages to the Huron River, along with the river itself. The terrain along the Huron River can be quite diverse in these tiny tributary drainages. While there is quite a bit of development along the river, some stretches have good riparian cover with a well-connected floodplain. Some slopes down to the river are quite steep, however, and this leads to high erosion rates in some places. The stream reaches in the Watershed have erosion rates that reflect this diversity. Most direct drainages and river reaches have low to moderate levels of erosion, but a couple reaches with steep slopes are highly eroded. The Huron River itself has a unit erosion rate of 0.038 tons/year per linear foot of stream, which is just a bit above the average rate of 0.029 tons/yr/ft across all of the Watershed.

None of the river reaches had erosion rates in the highest priority category, however, only a limited section of the river between Argo and Geddes Ponds could be evaluated. Combined, the direct drainages had an average unit erosion rate of 0.051 tons/yr/ft. This mean rate was pulled up by two high-erosion reaches. One small reach drains an extremely steep section of Barton Hills. This stream reach has high banks and a steep valley with high walls. It has the highest erosion rate in the Watershed at 0.30 tons/yr/ft. The other small reach cuts through very soft, erodible spoil material in the Kuebler-Langford and parts of Bird Hills Parks. It has a rate of 0.11 tons/yr/ft. The high priority sites are included in restoration recommendations in Chapter 4. Overall, the evaluated section of the Huron River generates an estimated total of 526 tons/year in eroded soil, while the direct drainages erode a combined 1,417 tons/year.

Erosion rates (Figure 2.17).
High: >0.1 and <=0.30 tons/yr/ft. Marked Red
Moderate: 0.01 to 0.099 tons/yr/ft. Marked Yellow
Low: <0.01 tons/yr/ft. Marked Purple.

Phosphorus and Suspended Solids

Recent conditions
HRWC does not collect samples for chemical analysis at any river sites within this Watershed, so it is difficult to determine phosphorus or suspended solid concentrations in the river or the direct drainages. However, based on the phosphorus load analysis discussed in section 2.5.2.1 and Table 2.11, it was estimated that a four-year (2014-18) mean daily phosphorus load at the USGS gage station was 160.4 lbs/day. Given that the average river discharge over that period was 522 cfs, the mean total phosphorus concentration at the gage is estimated to be 57 µg/L.

The City of Ann Arbor's Water and Waste Water Laboratory sampled two sites in the Watershed through 2019, one site at the Fuller Road crossing just downstream of the USGS gage, and one just upstream of the WWTP and downstream of the Geddes Dam (Figure 2.20). The most recent 3-year average TP concentrations for those sites were 27 µg/L at Fuller Rd. and 35 µg/L at the WWTP. Both concentrations are quite low. Directly comparing the same time period as the model run, TP concentrations over the 2014-18 period were 48 µg/L at Fuller Rd. and 52 µg/L at the WWTP. Those figures are closer to the model estimate due to higher concentrations in 2014 and 2015, both of which had higher intensity storms. Regardless, river concentrations are very close to, if not below the original TMDL target level of 50 µg/L, but above the current lake concentration target of 30 µg/L.

Further, the load models estimate that direct drainages and impoundments between the gage station at Wall St. and Ford Lake actually decrease phosphorus loading by 184.8 lbs/day. Essentially, this means that the impoundments behind Geddes, Superior and Peninsula Paper dams capture and settle that much phosphorus as a daily average, over and above any amount of phosphorus sourced from direct drainages.

Since load estimates were not calculated for Total Suspended Solids, no equivalent load-based analysis can be performed for TSS concentrations in the river. Sampling by the Ann Arbor lab, however, show very low TSS concentrations. Over the most recent three years, the site at Fuller Rd. had a mean concentration of 4 mg/l and the site at the WWTP was 5 mg/l. Means over the four-year 2014-18 period were 5 mg/l at Fuller Rd. and 6 mg/l at the WWTP. The maximum TSS concentrations for both of the sites were below 20 mg/l. These figures suggest that there is not a substantial erosion problem in the river, and methods controlling sediment-bound phosphorus may be maximized at this point.

Historic data (>10 years old):
In the 1990's and 2000s, MDEQ collected annual water quality data at monthly intervals for two sites on the Huron River upstream of Ford and Bellville Lakes to determine the progress toward meeting the phosphorus goal established for the lakes' TMDL. The target for total phosphorus concentrations was not to exceed 50 µg/L in the Huron River, just upstream of Ford Lake, in order to meet the goal of 30 µg/L for total phosphorus in Belleville Lake. Data was collected from April to September during the years 1994-1999, 2001-2003, and 2004-2006 at a site located at Bandemer Park, just downstream from Barton Pond. Total phosphorus concentrations at the Bandemer Park station remained at or below 40 µg/L over the years of monitoring, with a few exceptions when spikes were observed in August 1996 and July 1998.[38, 39, 40, 41, 42, 43] The City of Ann Arbor Water and Waste Water Laboratory also sampled several sites in the river on a monthly basis for a period of time in the early 2000's. The Fuller Road bridge and Waste Water Treatment Plant are two of these locations in the Watershed (Figure 2.20). Looking at the three most recent years with samples from April through September, the Fuller Road location (2002-2004) had a mean TP concentration of 77 µg/L and a median of 42 µg/L. One sample in May 2003 drove the high average. At the WWTP site (2006-08), the mean *and* median TP concentration were both 43 µg/L. For TSS, the Fuller site had a very low average concentration of 5.2 mg/L and the WWTP mean concentration was 8.1 mg/L.

Conductivity
Recent conditions and historic data (>10 years old):
Conductivity in the Huron is monitored at Island Park in Ann Arbor during the HRWC River Roundup events. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. The Island Park site has an average conductivity level of 774 µS from 2000-2019 with no indication of a significant change over that time period.

Temperature

Recent conditions:
In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. On August 17,24, and 25, 2016, volunteers walked the section of the Huron River from Argo Dam to Island Park, recording about 40 temperature readings that all ranged from 75-77 degrees Fahrenheit. The temperatures were all recorded late morning through early afternoon.

Historic data (>10 years old):
In 2001, HRWC had a min/max thermometer installed at the Huron River: Island Park location. The minimum and maximum temperatures were checked every week from the end of June through the beginning of September. Through this time, the temperature ranged from 70.1 to 87.4 degrees Fahrenheit, with an average minimum 72.5 of and an average maximum of 81.8.

Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions:

HRWC does not monitor river sites in the target Watershed. However, the City of Ann Arbor samples several bridge crossing locations. Two sites are in the Watershed: the Fuller Rd. crossing and at the WWTP. In 2019, samples from the Fuller Rd. site were all below the single sample full-body contact standard of 300 CFU per 100 mL, except for a single sample (sampling was not done in triplicate[1]) in June, which was 727 MPN/100 ml. The site at the WWTP had two samples above the threshold in 2019 at 1,733 MPN/100 ml in June, and 548 MPN/100 ml in August. The recent three-year means for those sites were 110 MPN/100 ml for Fuller Rd., and 229 MPN/100 ml upstream of the WWTP.

Historic data (>10 years old):

MDEQ collected *E. coli* data in 2001 and 2002 for Geddes Pond and its tributaries in support of the development of the Geddes Pond *E. coli* TMDL. The *E. coli* water quality standard of 130 *E. coli* per 100 mL as a 30-day geometric mean for Geddes Pond was exceeded in 2001. The results of routine monitoring conducted from May to October of 2002 indicated that Geddes Pond exceeded the water quality standard during the second half of July, all of August, and during one sampling event in September.[44]

The Washtenaw County Drain Commission (WCDC) coordinated a research project to identify agents causing high bacterial levels (>10,000 CFU/100 ml) during both wet and dry weather in Geddes Pond. Sampling took place at Sheridan Road and Buckingham Road. Researchers employed library-based genotypic bacteria source tracking (BST) to match bacterial strands with specific species. Storm sewer samples validated 2003 data, indicated seasonal differences (Spring had greater levels than Fall), and displayed climatic differences (wet weather had greater levels than dry weather). BST analysis indicated that the primary culprits were raccoons and pets – cats to a greater extent than dogs. Unknown bacterial strands may be attributed to rats or deer.

Macroinvertebrates

Recent conditions:

As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and the number of pollution sensitive families. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality.

The Adopt a Stream Program monitors the Huron River at Island Park in Ann Arbor. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples. For this sample site, diversity averages were calculated for 2015-2017 since high water had prevented sampling in 2018 and 2019. An average of 12.0

[1] Michigan's bacteria standard is based on a geometric mean of 3 samples from the same site for a single event. HRWC and partners draw single samples for each event at each site, thus single results are not directly comparable to the single event standard, but means of multiple samples should be more comparable to the standard.

insects, including 5.0 EPT families and 1.2 sensitive families were found at Island Park (Table 2.6).

Historic data (>10 years old):
HRWC has sampled the Huron River: Island Park location since 2000. From the time period of 2000-2017, the three insect metrics have averaged 12.8, 5.8, and 1.6 for the total insect, EPT, and sensitive families respectively, with respective standard deviations of 3.1, 1.7, and 0.9. The data does not show a macroinvertebrate population that is statistically significantly changing over time.

Fish

Recent conditions:
Michigan DNR sampled Barton Pond on April 28, 2010 with boom shocking equipment. The purpose was not to conduct a general sample but to collect samples for viral hemorrhagic septicemia (VHS) analysis. A total of 198 fish weighing 34 pounds and made up of 11 species were collected. Panfish comprised 50% of the catch and 33% of the weight. Larger game fish such as small and largemouth bass comprised 12% of the catch and 64% of the weight. All VHS test results were negative for the three fish species submitted (60 bluegill, 60 bluntnose minnow, and 36 largemouth bass).

Historic data (>10 years old):
As part of the DNR Water Survey of the Huron River, from 1996-2000, DNR sampled Argo Pond, Geddes Pond, and Barton Pond for their fish populations.

From May 3-5, 2000, DNR researchers trapped fish two consecutive nights on the 86.5 acre impoundment of Argo Pond. Four trap nets at five locations were used. Eighteen different species of panfish, large gamefish, rough fish and others were caught. Panfish were in the greatest abundance, with blue gills totaling 23.8 fish per net lift. Bluegills yielded a 2.75 Schneider Index rating, which put their population levels as poor to acceptable.[45]. Of the large gamefish, channel catfish were the most abundant, with poor showings of largemouth bass and walleye. No northern pike were observed, but no deep water sampling took place either. Suckers, white and shorthead redhorse, dominated the rough fish category. The DNR recommended that channel catfish yearling stockings continue, and that Argo dam be removed to create better habitat for smallmouth bass and restore riverine mussel populations. [46]

The Geddes Pond study took place on June 20, 1996. Trapping took place at four different locations using trap nets. Since 1980, Geddes Pond has been stocked with tiger muskellunge, largemouth bass, and, most recently, channel catfish. Channel catfish are relatively old and large in size, because they were stocked from 1987 to 1991. However, limited reproduction has led to homogeneity in fish age, with few small catfish. The DNR has recommended future stockings of channel catfish. The pond also has a large number of carp, which accounted for 40% of the catch by weight. Anglers use the pond in the Spring, Summer and Fall to catch smallmouth bass, largemouth bass, black crappie, channel catfish, and carp. [47]

The Barton Pond study was conducted from June 18-19, 1996. Testing of the 302 acre impoundment took place at four different locations along the river using trap nets. Carp and white and redhorse suckers accounted for 75% of the catch by weight. Two channel catfish and seven walleye were also caught. While anglers typically find walleye, largemouth and smallmouth bass, crappie and channel catfish, the timing, duration of study and weather hindered the monitoring at this site at the conclusion was that the sample may not be representative of true conditions. [48]

Additional Data – Macrophytes

Recent conditions:

There are no known recent efforts (within the last decade) to study or characterize the macrophyte population in the Huron River.

Historic data (>10 years old):

Limno-Tech, Inc. conducted a survey of aquatic macrophytes on Barton, Argo, Geddes, and South Ponds in 2006.[49] Areas of dense vegetation have been noted by residents and staff of the City of Ann Arbor and have interfered with recreational use of the impoundments, degraded aesthetic value, and disrupted the City of Ann Arbor water intake and treatment operations on Barton Pond. Over 600 sites in total on the four impoundments were surveyed over a two week period in September. Each species was recorded as well as its density, distribution, and relative height in the water column. These data were used to analyze percent occurrence of each species, community biodiversity, and community quality.

The data suggest that the total number of species observed in each of the ponds is similar to conditions that would be expected in an impoundment. However, these totals are lower than would be expected in a relatively undisturbed lake system in southeast Michigan. Moreover, the biodiversity scores are indicative of disturbed conditions, meaning that the plant communities are in an unstable state. Such a state can allow for the establishment and proliferation of invasive species and a variety of nuisance conditions.

The most commonly observed density patterns of macrophytes in the impoundments were "common" and "present". These patterns indicate that most of the plant species are capable of inhabiting many areas of the pond as opposed to narrowly defined habitats in which rare species would be found. Additionally, the mixtures of distribution types observed during the survey are representative of systems with fairly good habitat complexity.

Overall, the plant communities surveyed are indicative of disturbed conditions with a predominance of opportunistic species such as Eurasian watermilfoil and coontail. Density and distribution observations indicate moderately good habitat structure complexity in each of the systems.

The results of the aquatic macrophyte survey were used to develop a preliminary review of aquatic plant management alternatives for each of the impoundments. The main objectives for aquatic plant management are to reduce nuisance plant growth in order to minimize or eliminate interference with recreational use and improve aesthetics, prevent disruption of City of Ann Arbor water intake and treatment operations on Barton Pond, and support economical, ecologically-protective, and sustainable management of the impoundments.

MDEQ collected qualitative habitat data including substrate and instream cover, channel morphology, and riparian and bank structure for one applicable site on the Huron River during the 2002 survey. Habitat condition at Forest Street was considered slightly impaired due to low availability of epifaunal substrate, bank instability, and high stream flashiness.[50]

Additional Data – Dams

Recent conditions:

There are no known recent studies on Barton, Argo, or Geddes Dams.

Historic data (>10 years old):

A feasibility study was conducted in 2002 by Barr Engineering, Co. for the removal of Argo Dam on the Huron River in Ann Arbor[51]. The study sought to identify whether significant contaminated sediment or soil exists in Argo Pond and to obtain a rough estimate of the magnitude of the volume of sediments at the pond site. Sediment samples were collected from three representative sites within the pond and were analyzed for concentrations of nutrients, pesticides, and metals. A series of soundings at 15 sections throughout the pond was performed to obtain a rough estimation of volumes and locations of sediments in the pond. Results indicated that the sediments do not appear to be significantly contaminated and that they may be acceptable as vegetated soils at the surface if Argo Pond were to be drained. The study also found that there are approximately 184,000 CY of sediment deposited in the pond.

2.4.2 Allens Creek

Allens Creek consists of a piped stormwater sewer system that drains a large section of Ann Arbor's streets and parking lots. The primary outflow pipe drains into the Huron River below Argo Dam. Chemistry and bacteria measurements are taken from the outflow pipe, but morphological and biological parameters are not considered for Allens Creek.

Creekshed Natural Areas

Forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from the creek, and provide wild-life habitat and beautiful places for us all to enjoy. Allens Creek is within the City of Ann Arbor and therefore mostly consists of neighborhoods, businesses, and institutional uses. In fact, only about 50 acres still consist of intact natural areas (in parks like Eberwhite Woods and Miller Nature Area). In this urban creekshed, it will be important to maintain natural features like trees, pocket parks, plantings, riparian buffers throughout the community to help soak up rainwater.

Hydrology

Recent conditions:

Due to the highly urbanized and pipe-controlled alterations of the Allens Creek watershed, the hydrology is highly variable. At the outflow pipe into the Huron River, Allens Creek varies from zero flow a majority of the time to over 2,000 cfs during and following larger storms. A reference creek with a drainage area the size of Allens Creek would be expected to have a stream flow of 56 cfs following a 50% (2-year return interval) storm of 2.35". The USGS station at the outflow recorded a peak flow of 1,350 cfs following a 2-inch storm. A modeled hydrograph of the Allens Creek outflow during a 50%, 24-hour event shows a rapid rise to almost 1,200 cfs and fall back to nearly 0 cfs within a matter of hours resulting in an uninhabitable environment both within the storm pipe system itself, as well as in the Huron River downstream. In fact, the effect of Allens

Creek storm flows can be observed in the flow record from the Huron River at Wall Street. Taking all this fluctuation into account, Allens Creek has one of the highest flashiness index ratings at 0.71.

Morphology

Recent conditions:
As described in the introduction, Allens Creek has been highly altered. Over 90% of the stream channels in the system have been urbanized with the storm flow redirected to underground pipes. Very little exposed surface water or aquatic habitat remains in the system. Insufficient stream channel was available to evaluate.

Phosphorus and Suspended Solids
Recent conditions:
Since 2003 HRWC's Chemistry and Flow Monitoring Program has monitored the primary outflow pipe right below the Argo Dam twice monthly during the growing season. In the most recent 10 years, data indicate improvements in water quality at Allens Creek. Total phosphorus and total suspended solids concentrations have both seen statistically significant declines. From 2010 to 2019, HRWC observed a statistically significant decrease (p=0.015) in total phosphorus (TP) and total suspended solids concentrations at Allens Creek. Nonetheless, mean and median TP concentrations are still above the TMDL target level. Mean TP from 2010 to 2019 was 0.08 mg/l (s=0.07) with a median of 0.06 mg/l, both above the TMDL target for Ford and Belleville Lakes of 0.03 mg/l. Mean and median total suspended solids concentrations at Allens Creek are well below the single sample standard of 80 mg/l. Between 2010 and 2019, average TSS was 12.3 mgl/l (s=25.1) and the median was 5.6 mg/l.

Nitrate and Nitrite
Recent conditions and historic data (>10 years):
Since beginning collection of nitrate and nitrite data in 2003, HRWC's Chemistry and Flow Monitoring Program has seen a decline in concentrations at Allens Creek. While no statistically significant trend is evident, nitrite at Allens Creek appears to be declining, especially over the past ten years. Nitrate at Allens Creek has seen a statistically significant decline since 2003 ($p=9.67e^{-8}$). Over the entire monitoring period, nitrite concentrations at Allens Creek ranged from 0.003 to 0.500 mg/l with a median of 0.014 mg/l and a mean of 0.022 mg/l (s=0.041). From 2003-2019, nitrate averaged 0.66 mg/l (s=0.31) with a median of 0.60 mg/l and values ranging from 0.0 to 2.00 mg/l. These nitrate and nitrite ranges are within the normal range for surface waters and below the EPA's Maximum Contaminant Levels.

Conductivity
Recent conditions:
During its twice monthly monitoring outings to Allens Creek, HRWC's Chemistry and Flow Monitoring Program also measures in-stream conductivity. From 2010 to 2019, mean conductivity was 944 µS/cm (s=340) and median conductivity was 919 µS/cm, both of which are over HRWC's 800 µS/cm threshold. These data indicate that stormwater runoff from Allens Creek is a likely source of nonpoint source pollution in the Middle Huron River.

pH
Recent conditions:
HRWC's Chemistry and Flow Monitoring program has monitored pH at Allens Creek since 2002 at the outflow pipe below Argo Dam in Ann Arbor. pH values at Allens Creek fall within the

prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 7.10 and a maximum value of 8.40. From 2010 to 2019, the average pH value at Allens Creek was 7.94 (s=0.28) with a median of 8.01.

Temperature

Recent conditions:

Since 2014, HRWC's Chemistry and Flow Monitoring Program has collected temperature data bimonthly from April through September. The six-year data record indicates a range of 41.0 to 79.3 degrees Fahrenheit with a mean and median of 60.8 degrees (s=8.0). During the monitoring period, there are no statistically significant trends in temperature at Allens Creek.

Dissolved Oxygen

Recent conditions:

Dissolved oxygen at the Allens Creek outflow, as measured by HRWC's Chemistry and Flow Monitoring Program, is consistently above the state standard of 5 mg/l with a range of 6.50 to 12.55 mg/l. Dissolved oxygen measured at Allens Creek between 2014 and 2019 averaged 9.33 mg/l (s=1.31) with a median of 9.10 mg/l. During this period, there has been a statistically significant increase in dissolved oxygen (p=0.055).

Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions:

Recently, *E. coli* at Allens Creek has shown trends towards lower bacteria counts. *E. coli* data from 2010 to 2019 at Allens Creek have shown a statistically significant decline (p=0.07). However, the median and mean *E. coli* counts are still above the total and partial body contact standards. The average *E. coli* value from 2010-2019 was 3669 counts per 100 ml (s=5458) with median counts of 1273 counts per 100 ml.

Historic data (>10 years old):

MDEQ collected *E. coli* data in 2001 and 2002 for Geddes Pond and its tributaries in support of the development of the Geddes Pond *E. coli* TMDL. Water quality standards of 300 *E. coli* per 100 mL in Allens Creek were exceeded in 2001 and remained elevated in 2002. There was also visual evidence of illicit connections in Allens Creek. Additional *E. coli* sampling in 2006 for the Middle Huron Stream Monitoring Program demonstrated that E. coli again exceeded the water quality standard each month from June through September, ranging from 2000 to 7200 *E. coli* per 100 mL. [52]

Additional Data

In 2005 and 2006, the Washtenaw County Drain Commissioner's office made rain garden assistance grants available to Allens Creek residents through State Non-Point Source Pollution funding. Grants provided interested homeowners with rain garden design plans. Over the course of the two year program, nineteen homeowners installed rain gardens in their yards. As a result, an estimated 25,000 gallons of rainfall flow into and through the created rain gardens during each 1-inch rain event. [53]

No biological monitoring is conducted in Allen's Creek.

Further information about Allens Creek can be found in the Allens Creek Watershed Plan in Appendix C.

2.4.3 Fleming Creek

Creekshed Natural Areas

Fleming creekshed's forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from runoff, and provide wildlife habitat and beautiful places for us all to enjoy. About 23% of the creekshed has natural areas. However, only a small fraction of these areas are protected from development (about 3% of the creekshed, including Matthaei Botanical Gardens and Parker Mill County Park). Twenty percent of the creekshed is made of natural areas that face an uncertain future; they are privately owned and likely will not remain natural in the long term. They face conversion from forest and wetlands to paved surfaces, parking lots, and lawns; not immediately, but over the course of time. It is important to keep these lands natural, so they can continue to help keep the creek healthy.

Hydrology

Recent conditions:
Fleming Creek has the lowest flashiness index in the Watershed at 0.43, but given the size of the Watershed (32 mi^2), that is still very flashy. A natural creek with a drainage area of that size would be expected to have a stream flow of 191 cfs following a 50% (2-year return interval) storm of 2.35". HRWC recorded a peak flow of 1,177 cfs following a 2.73-inch storm. Hydrographs of Fleming Creek during and after high rain events show discharge rising quickly to the peak flow, but returning to baseflow over a period of several days. The rapid rise in flow is certainly damaging to aquatic habitat. However, the slow return and relatively high baseflow provide for long-term conditions that may allow for more diverse aquatic biota to repopulate the system as compared to streams that both rise and fall quickly, such as Swift Run and Millers.

Morphology

Recent conditions:
Within the Watershed, the Fleming Creek drainage area offers the largest total area and proportion of undeveloped land. The drainage also has a relatively lower slope than the rest of the Watershed. Because of these factors and a good proportion of protected floodplain, the tributary streams within the Fleming Creekshed have the lowest overall unit erosion rate by far at 0.014 tons/year per linear foot of stream, or less than half the average rate of 0.029 tons/yr/ft across all Watershed drainages. None of the evaluated streams in Fleming Creek had erosion rates in the highest priority category of > 0.099 tons/yr/ft, and the worst stream reach is ranked number 10 out of 95 evaluated reaches, with a unit erosion of 0.086 tons/yr/ft. Despite the low erosion rates in the Creekshed, Fleming Creek has the largest drainage area, and, as a consequence, produces the greatest total amount of eroded soil in the system at an estimated

1,864 tons/year. Overall, the Fleming Creekshed is a better candidate for protection than restoration.

Phosphorus and Suspended Solids

Recent conditions:

The Chemistry and Flow Monitoring Program monitors water quality twice monthly during the growing season at the Parker Mill County Park. Growing season samples and chemistry measurements have been collected since 2003. Total phosphorus concentrations at Fleming Creek are maintaining and demonstrate no observable or statistically significant trend. Mean and median TP concentrations from 2010 to 2019 are 0.06 mg/l (s=0.05) and 0.05 mg/l respectively, both above the TMDL target of 0.03 mg/l.

Total suspended solids concentrations at Fleming Creek also illustrate no observable trend. Average TSS concentrations at Fleming Creek from 2010 to 2019 are 25.6 mg/l (s=97.1) with a median of 6.4 mg/l. Both concentrations report below the 80 mg/l threshold, with only 4 samples during the 10-year period exceeding that standard.

Historic data (>10 years old):

MDEQ conducted a survey of the Huron River and its tributaries from July to September of 1997 and 2002. MDEQ measured conductivity, Kjeldahl nitrogen, total phosphorus, and total suspended solids in 2002 for Fleming Creek at a site in the Matthaei Botanical Gardens. These measurements fell within the range of reference sites for the region. [54]

Nitrate and Nitrite

Recent conditions and historic data (>10 years):

HRWC's Chemistry and Flow Monitoring Program has monitored nitrate and nitrate during the growing season since 2003. Over that period there has been a statistically significant decline in nitrite (p=0.057). From 2003 to 2019, nitrite values at Fleming Creek ranged from 0.000 to 0.044 mg/l, with an average concentration of 0.007 mg/l (s=0.006) and a median of 0.005 mg/l. Nitrate values averaged 0.35 mg/l (s=0.17) and ranged from 0.0 to 1.30 mg/l with a median value of 0.30 mg/l/. The nitrate and nitrite ranges at Fleming Creek are below the EPA's Maximum Contaminant Levels.

Conductivity

Recent conditions and historic data (>10 years old):

Since the mid-1990s, HRWC has tested conductivity at four Fleming Creek locations during the HRWC River Roundup events (Parker Mill County Park, Botanical Gardens, Galpin Road, and Warren Road). HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. All four sample locations average less than 800 µS for the time period and no statistically significant changes have occurred over time. Occasional spikes in the data record do occur (ranging from 1026-1440), though these only happen in January samples when road salt run-off can cause higher readings.

In addition to the River Roundup Program, HRWC's Chemistry and Flow Monitoring Program also measures in-stream conductivity during outings. From 2010 to 2019, mean conductivity was 726 µS/cm (s=149) and median conductivity was 737 µS/cm. Mean and median conductivity values are both below the 800 µS/cm threshold used by HRWC, indicating lesser concern of salt and metal pollutants at Fleming Creek. There is no observable trend in conductivity values from Fleming Creek, as there is a high degree of seasonal variability in values.

pH

Recent conditions:

HRWC's Chemistry and Flow Monitoring program has monitored pH at Fleming Creek since 2002 at Parker Mill County Park in Ann Arbor. pH values at Fleming Creek fall within the prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 7.26 and a maximum value of 8.90. From 2010 to 2019, the average pH value at Fleming Creek was 8.08 (s=0.30) with a median of 8.17.

Temperature

Recent conditions:

In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the May-August months in 2013-2018, volunteers walked portions of Fleming Creek and made 350 temperature measurements. The measurements range from 58.7 through 80.6 degrees Fahrenheit, with an average of 69.5 and a standard deviation of 4.5. The temperatures were all recorded late morning through early afternoon.

Temperature data has been collected by HRWC's Chemistry and Flow Monitoring Program since 2014. Over the six years since beginning temperature data collection at Fleming Creek, measurements ranged from 42.4 to 74.1 degrees Fahrenheit during the six-month annual monitoring season. Average temperature at Fleming Creek were 63.5 degrees Fahrenheit (s=7.2) with a median of 64.4 degrees Fahrenheit.

Historic data (>10 years old):

In the early 2000s, HRWC installed min/max thermometers at four locations in Fleming Creek. The minimum and maximum temperatures were checked every week from July through August. The below temperatures are in degrees Fahrenheit.

Site (Year)	Range	Avg Min	Avg Max
Parker Mill (2009)	60.0-72.0	62.5	69.7
Botanical Gardens (2000)	53.9-73.2	59.0	70.9
Warren Road (2000)	57.0-75.0	61.1	72.3
Galpin Road	58.0-74.0	59.6	67.8

DO

Recent conditions:

Dissolved oxygen at Fleming Creek, as measured by HRWC's Chemistry and Flow Monitoring Program, is consistently above the state standard of 5 mg/l with measured values ranging from 5.64 to 14.59 mg/l. Dissolved oxygen measured at Fleming Creek between 2014 and 2019 averaged 9.77 mg/l (s=1.6) with a median of 9.48 mg/l. While not statistically significant, trends in DO values at Fleming Creek appear to be slightly increasing.

Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions and historic data (>10 years old):

HRWC's Chemistry and Flow Monitoring Program has been collecting samples to be analyzed for bacteria, specifically *E. coli* since 2006. Over the past ten years, *E. coli* counts from Fleming

Creek have been maintaining and illustrate no statistically significant trend. However, most *E. coli* counts collected by HRWC are below both the partial body contact and full body contact standards. Annually, only a few samples, usually those collected following or during storm events, exceed the full body contact standard of 300 *E. coli* counts per 100 ml. Between 2010 and 2019, the average *E. coli* value at Parker Mill County Park was 448 counts per 100 ml (s=842). This average value is skewed by the high counts measured during or post storm events, which are as high as 5,400 counts per 100 ml. The median *E. coli* value at Fleming Creek during the same period was 131 counts per 100 ml, which is well below both state standards.

Macroinvertebrates

Recent conditions:

As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and the number of pollution sensitive families. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality.

The Adopt a Stream Program monitors the Fleming Creek at 4 locations. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples. For these sample sites, diversity averages were calculated for 2017-2019 samples. The results are given in Table 2.6.

Historic data (>10 years old):

HRWC has sampled macroinvertebrates in Fleming Creek since 1993, with the exception of the Galpin Road site which started in 2004. Over that time period, the overall insect diversity has remained steady across the sites. In recent years, HRWC has noted an increase of sensitive families at Parker Mill, the Botanical Gardens, and the Warren Road sites which have contributed to a statistically significant increase of the sensitive family diversity at these sites. (Table 2.6)

The 1997 and 2002 MDEQ Huron River Surveys also found the macroinvertebrate community in Fleming Creek at the Matthaei Botanical Gardens and Geddes Road to be in acceptable condition. [55, 56]

Fish

Recent conditions:

Fleming Creek is home to smallmouth and largemouth bass and northern pike, but the stream is not known for great sport fishing. Smaller species and suckers compose most of the fish community. Also, the creek is presumably home to a State endangered species, the redside dace, though there has not been a confirmed sighting in about twenty years.

On October 11, 2011, the MDNR conducted a 325 minute electroshocking sample to find the redside dace and otherwise record the fish population at Matthaei Botanical Gardens. The redside dace was not found. Exact species found and counted were as follows: 8 American brook lamprey, 33 blacknose dace, 1 bluntnose minnow, 17 central stonerollers, 7 common shiners, 45 creek chubs, 1 grass pickerel, 120 mottled sculpin, 2 northern hog suckers, 12 rainbow darter, 12 spotfin shiners, and 2 white suckers.

Historic data (>10 years old):

MDNR conducted a 120 minute electroshocking full fish survey of Fleming Creek at Ford Road on August 8, 2001. The species found were primarily small minnows, darters, sculpin, and moderately sized creek chubs and white suckers. Exact species found and counted were as follows: 20 American brook lamprey, 246 blacknose dace, 1 bluntnose minnow, 28 central stonerollers, 3 common shiners, 124 creek chubs, 4 fathead minnow, 1 green sunfish, 2 greenside darters, 255 mottled sculpin, 2 northern hog suckers, 1 pumpkinseed, 10 rainbow darter, 3 smallmouth bass, and 42 white sucker.

Additional Data

Recent conditions:
In 2015 HRWC conducted polycyclic aromatic hydrocarbon (PAH) sampling in three detention pond sediments, including one in Fleming Creek (PAH1, Figure 2.20). The goal of this study was to locally confirm what was seen in the broader scientific literature, that detention ponds sediments have very high levels of PAHs, most of which are sourced from coal-tar driveways sealants. While HRWC did not try to establish the coal-tar cause, sampling did indicate very high levels for a number of PAH compounds. The Fleming Creek detention pond contained PAHs at levels above the Probable Effect Concentration (PEC) for:

- Benz[a]anthracene (1.5 times the PEC)
- Benzo(a)pyrene (2.2 times the PEC)
- Chrysene (2.6 times the PEC)
- Fluoranthene (2.3 times the PEC)
- Phenanthrene (1.8 times the PEC)
- Pyrene (2.2 times the PEC)

Historic data (>10 years old)
MDEQ collected qualitative habitat data including substrate and instream cover, channel morphology, and riparian and bank structure for two sites on Fleming Creek during the 2002 survey. Habitat condition was rated as slightly impaired at both the Matthaei Botanical Gardens and Geddes Road due to low availability of epifaunal substrate, bank instability, and high stream flashiness.[57]

2.4.4 Malletts Creek

Creekshed Natural Areas
Forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from runoff, and provide wildlife habitat and beautiful places for us all to enjoy. As most of Malletts creekshed is developed, it has very little natural lands left. Only 8% of the creekshed are natural areas. Half of that are publicly owned, like Mary Beth Doyle and County Farm parks.

Hydrology

Recent conditions:
Malletts Creek has a high flashiness index at 0.64, but the rating has trended down since 2010. Year to year, it currently ranges between 0.51 and 0.71, but before 2010, the index was generally above 0.70. This is likely due to the moderating effect of the regional wetland restoration and detention project in Mary Beth Doyle Park. Malletts Creek also has one of the larger drainage areas in the Watershed (11 mi^2). A natural creek with a drainage area of that size would be expected to have a stream flow of 93 cfs following a 50% (2-year return interval) storm of 2.35”. The modeled flow for Malletts Creek following a storm of this size is 499 cfs, and the estimate from survey data is 1,007 cfs. Both estimates are several times greater than peak flows expected in a natural creek. USGS recorded a peak flow of 1,050 cfs following a 2-inch storm. The flow rate (discharge) rises quickly to the peak flow, but it returns to baseflow over a period of several days. Prior to the restoration project, the discharge would return to baseflow over a much shorter period of time. The rapid and extreme rise in flow is likely damaging to aquatic habitat. However, the slow return and relatively high baseflow provide for long-term conditions that may allow for diverse aquatic biota to repopulate the system.

Morphology

Recent conditions:
The Malletts Creek drainage area is one of the most developed in the entire Huron River Watershed. Much of the drainage area is in underground storm pipes. However, most of the stream reaches that are accessible only show moderate levels of erosion. The tributary streams within Malletts Creekshed have a moderate unit erosion rate at 0.043 tons/year per linear foot of stream, but greater than the average rate of 0.029 tons/yr/ft across all Watershed drainages. Two of the evaluated streams in Malletts Creek had erosion rates in the highest priority category of > 0.099 tons/yr/ft. One reach, just upstream of the I-94 crossing is the fourth most erosive in the Watershed at 0.13 tons/year/ft, and the other reach has an estimated erosion rate of just over 0.1 tons/year/ft. These sites are highlighted for restoration in Chapter 4. Overall, thanks to the size of the drainage area and the high to moderate erosion rates, Malletts Creek produces the third greatest total amount of eroded soil in the system at an estimated 1,196 tons/year.

Phosphorus and Suspended Solids

Recent conditions:

HRWC's Chemistry and Flow Monitoring Program has collected bimonthly samples at Malletts Creek at Chalmers Drive since 2003. Over the past 10 years, total phosphorus concentrations ranged from 0.015 mg/l to 1.00 mg/l, with mean and median concentrations of 0.09 mg/l (s=0.11) and 0.06 mg/l respectively. Both the mean and median remain above the TMDL target for phosphorus of 0.03 mg/l. When analyzing all data points from 2010 to 2019, there is no statistically significant trend. Upon removing outliers, specifically data from samples collected during or after storm events, there is a statistically significant decline in total phosphorus concentrations (p=0.008). This indicates that urban stormwater runoff is still the primary contributor of nutrient runoff into Malletts Creek.

Save for a few samples over the past 10 years, most all samples from Malletts Creek have had total suspended solids concentrations below the 80 mg/l threshold. Nonetheless, during and following large storm and bankfull events, TSS concentrations tend to exceed the 80 mg/l threshold. From 2010 to 2019, Malletts Creek had an average TSS concentration of 21.6 mg/l (s=59) and a median concentration of 8.8 mg/l. Both the mean and median are well within the target threshold. While there is no statistically significant trend in TSS at Malletts, most concentrations seem to be moving in the downward direction.

Historic data (>10 years old):

MDEQ conducted a biological survey of the Huron River and its tributaries from July to September of 1997 and 2002. Water quality parameters such as conductivity, Kjeldahl nitrogen, total phosphorus, and total suspended solids were measured in 2002 for Mallets Creek at Chalmers Road and Scheffler Park. These measurements fell within the range of reference sites for the region. [58, 59]

Nitrate and Nitrite

Recent conditions and historic data (>10 years old):

HRWC's Chemistry and Flow Monitoring has evaluated nitrate and nitrate concentrations at Malletts Creek from April through September since 2003. Nitrite concentrations at Malletts Creek during that period saw a statistically significant decline (p=0.04). From 2003 to 2019, nitrite concentrations ranged from 0.001 to 0.250 mg/l, with a mean of 0.015 mg/l (s=0.020) and a median of 0.010 mg/l. Over this monitoring period, nitrate concentrations at Malletts Creek averaged 0.37 mg/l (s=0.19) and ranged from 0.0 to 1.30 mg/l with a median concentration of 0.40 mg/l. The ranges seen at Malletts Creek are below the EPA's Maximum Contaminant Levels for nitrate and nitrite.

Conductivity

Recent conditions and historic data (>10 years old):

Conductivity in the Huron is monitored at Chalmers Drive in Ann Arbor during the HRWC River Roundup events. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. The Island Park site has an average conductivity level of 1942 µS from 1995-2019, with a range between 747 and 5,030. The consistently high conductivity level indicates a water pollution problem, as in urban environments conductivity is often correlated with other harder to measure pollution issues such as sedimentation, sewage, oils, and heavy metals. There is no indication of a statistically significant change over the 1995-2019 period.

HRWC's Chemistry and Flow Monitoring Program has collected conductivity data at the Malletts Creek Chalmers Drive site since 2003. During the entire sampling period, there has been seasonal variability of conductivity values during the monitoring season. Nonetheless, conductivity values at Malletts Creek since 2003 have risen ($p=0.0097$), revealing increased pollutant loading into the creekshed. Between 2014 and 2019, average conductivity at Malletts Creek was 1,538.92 µS/cm ($s=410.91$) and median conductivity was 1613 µS/cm. As previously stated, these consistently high conductivity values at Malletts Creek indicate water quality impairments due to urban sources.

pH

Recent conditions:

HRWC's Chemistry and Flow Monitoring program has monitored pH at Malletts Creek since 2002. pH values at Malletts Creek fall within the prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 7.20 and a maximum value of 8.50. From 2010 to 2019, the average pH value at Malletts Creek was 8.00 ($s=0.25$) with a median of 8.06.

Temperature

Recent conditions:

In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the May-August months in 2014-2018, volunteers walked portions of Malletts Creek and made 135 temperature measurements. The measurements range from 51.7 through 74.0 degrees Fahrenheit, with an average of 66.7 and a standard deviation of 5.0. The temperatures were all recorded late morning through early afternoon.

Temperature data collected at Malletts Creek through HRWC's Chemistry and Flow Monitoring Program between 2010 and 2019 ranged from 43.7 to 86.4 degrees Fahrenheit with an average value of 68.0 degrees Fahrenheit ($s=8.8$) and a median of 70.0 degrees Fahrenheit. There appear to be no statistically significant trends in temperature at the Malletts Creek monitoring site as changing seasons results in variability of values.

Historic data (>10 years old)

In the early 2000s, HRWC installed min/max thermometers at three locations in Malletts creek. The minimum and maximum temperatures were checked every week from July through August. The below temperatures are in degrees Fahrenheit.

Site (Year)	Range	Avg Min	Avg Max
Chalmers Drive (2011)	66.0-80.0	69.5	75.3
Scheffler Park (2001)	62.8-82.8	66.6	79.8
S. Main Street (2011)	62.0-88.0	62.6	74.6

DO

Recent conditions:

Dissolved oxygen measurements from Malletts Creek, collected twice monthly from April through September through HRWC's Chemistry and Flow Monitoring Program, consistently met and exceeded Michigan's standard of 5 mg/l over the past 10 years. Except for two measurements during at ten-year period, measurements were within the range of 6.55 mg/l to 17.57 mg/l, Average dissolved oxygen value at Malletts Creek was 9.63 mg/l ($s=2.45$) and the median value was 9.60 mg/l, indicating the general aquatic livability of Malletts Creek.

Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions:

Since 2006, HRWC's Chemistry and Flow Monitoring Program has collected samples from Malletts Creek at Chalmers Drive for *E. coli* analysis. *E. coli* counts from Malletts Creek are consistently high but appear to be decline, nonetheless, this trend is not statistically significant. Over the past 10 years, the average *E. coli* value at Malletts Creek was 1,011.6 counts per 100 ml (s=4,733) with a median of 332 counts per 100 ml. While the median is below the state partial body contact standard of 1,000 *E. coli* per 100 ml, the mean value still exceeds this standard but only by a small margin.

Historic data (>10 years old):

MDEQ collected *E. coli* data in 2001 and 2002 for Geddes Pond and its tributaries in support of the development of the Geddes Pond *E. coli* TMDL. Water quality standards of 130 *E. coli* per 100 mL in Mallets Creek were exceeded in 2001 and remained elevated in 2002. Data collected from July through October of 2002 at the Eisenhower Commerce Park site showed high spikes in three of the six samples collected. [60]

Macroinvertebrates

Recent conditions:

As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and the number of pollution sensitive families. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality.

The Adopt a Stream Program monitors the Malletts Creek at the crossing of Chalmers Road. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples. For these sample sites, diversity averages were calculated for 2017-2019 samples. The results are given in Table 2.6.

Historic data (>10 years old)

HRWC has sampled macroinvertebrates in Malletts Creek since 1993. Over that time period, the overall insect diversity and EPT families have statistically significantly increased. The total increase has been small—an average of 3 total families have been gained, which includes an average of 1 EPT family—but this is good news for a creek that has historically had a poor macroinvertebrate community. (Table 2.6). Winter stoneflies have never been found at this location.

The 2002 MDEQ Huron River Survey found the macroinvertebrate community in Malletts Creek at Scheffler Park to be in acceptable condition. The survey also indicated that the macroinvertebrate community at the Chalmers Drive site improved from good condition in 1997 to excellent condition in 2002.[61]

Fish
There are no known fish surveys conducted in Mallett's Creek.

PAH

Recent conditions:

In 2015 HRWC conducted polycyclic aromatic hydrocarbon (PAH) sampling in three detention pond sediments, including one in Malletts Creek (PAH2, Figure 2.20). The goal of this study was to locally confirm what was seen in the broader scientific literature, that detention ponds sediments have very high levels of PAHs, most of which are sourced from coal-tar driveways sealants. While HRWC did not try to establish the coal-tar cause, sampling did indicate very high levels for a number of PAH compounds. The Malletts Creek detention pond contained PAHs at approximately many times the Probable Effect Concentration (PEC) for

- Anthracene (4.6 times the PEC)
- Benz[a]anthracene (2.9 time the PEC)
- Benzo(a)pyrene (29 times the PEC)
- Chrysene (44 times the PEC)
- Dibenz[a,h]anthracene (188 times the Threshold Effects Concentration) (there is no PEC)
- Fluoranthene (27.8 times the PEC)
- Phenanthrene (18 times the PEC)
- Pyrene (27 times the PEC)

Additional Data

The MDEQ-collected qualitative habitat data including substrate and instream cover, channel morphology, and riparian and bank structure for Malletts Creek at Chalmers Drive and Scheffler Park during the 2002 survey. Habitat condition was rated as slightly impaired due to low availability of epifaunal substrate, bank instability, and high stream flashiness. [62]

The U.S. Geological Survey maintains a gage station at Chalmers Drive near the mouth of Malletts Creek. This gage has been in place since 1999. Figure 2.27 shows four separate years of monthly mean flows along with the 7-year average. On a monthly basis, there is little consistent seasonal pattern. However, flows on average are higher in the late spring months, and much lower in late fall to early winter.

Combining flow and nutrient data (i.e. phosphorus, nitrate/nitrite, and total suspended solids) can yield estimates of loading of these compounds to the main river system. Malletts Creek was determined to be one of the highest phosphorus-loading tributaries in the Middle Huron system (second only to Mill Creek), when a full analysis was conducted in 1996 for the development of the Ford and Belleville Lakes phosphorus TMDL. The annual total phosphorus loading at that time was estimated at 3,945 pounds. The load curve for Malletts Creek shows the highest slope at more than twice that of the next highest tributary. This indicates that much of the phosphorus load is flushing out of the Malletts system during larger rain events. When combined with historical discharge data, a seasonal load duration curve can be plotted. This indicates that Malletts Creek exceeds target phosphorus levels during high and low flow periods, but the exceedances are greater during high flow and storm conditions. This further suggests loading from nonpoint source runoff.

Using the sampling data along with the long-term flow data from the gage station, a new loading estimate was calculated for Malletts Creek for the April to September growing season. This new phosphorus load estimate is 2,863 pounds over the growing season. This suggests a larger annual load than was originally estimated in 1996, and much greater than that calculated from field measurements at that time. This estimate is similar to the one calculated for the TMDL study in 2001 (see Appendix B1). Note that the method used was a rough estimate and should be refined and extended to generate a more accurate annual load estimate.

Older information about Malletts Creek can be found in the Malletts Creek Watershed Plan in Appendix B.

2.4.5 Millers Creek

Creekshed Natural Areas

Forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from the creek, and provide wild-life habitat and beautiful places for us all to enjoy. Millers is within the City of Ann Arbor and therefore mostly consists of neighborhoods, businesses, and institutional uses. In fact, only 10% of the creekshed (about 148 acres) still consists of intact natural areas. 9 of those acres are protected from development (Ruthven Park). In this urban creekshed, it will be important to maintain natural features like trees, pocket parks, plantings, and riparian buffers throughout the community to help stabilize flashy stream flows.

Hydrology

Recent conditions:
HRWC was not able to collect a sufficient amount of continuous flow data with acceptable quality needed to compute a multi-year flashiness index for the monitoring station in Millers Creek. A single-year index was calculated to be 0.54, which is quite flashy. Millers Creek also has the smallest drainage area (11 mi^2) of all the evaluated tributaries in the Watershed. It also has the highest gradient or slope. A natural creek with a drainage area of that size would be expected to have a stream flow of 33 cfs following a 50% (2-year return interval) storm of 2.35". The modeled flow for Millers Creek following a storm of this size is 134 cfs, and the estimate from survey data is 361 cfs. Both estimates are multiple times greater than peak flows expected in a natural creek. After a 2.63" rain event, the measured peak flow during was 490 cfs. This is a high enough flow to tumble cobble sized rocks in the creek. The flow rate (discharge) rose quickly to the peak flow, and it returned rapidly to baseflow over a period of only a few hours. Most of the time Millers Creek discharges at a very low baseflow level. The rapid rise and fall in flow is certainly damaging to aquatic habitat.

Morphology

Recent conditions:
The Millers Creek drainage area is highly developed. Some of the drainage area is in underground storm pipes, but much of it is accessible in steep channels. The main branch Millers Creek stream reaches show moderate to high levels of erosion. The tributary streams within Millers Creekshed have the highest unit erosion rate in the Watershed at 0.062 tons/year per linear foot of stream; more than twice the average rate of 0.029 tons/yr/ft across all Watershed drainages. One of the evaluated streams in Millers Creek had an erosion rate in the highest priority category of > 0.099 tons/yr/ft. That reach, which runs along Huron River Parkway in Ann Arbor is the second most erosive in the Watershed at 0.19 tons/year/ft. A bankpin study by HRWC in 2006 estimated erosion rates in this reach to by 0.14 ft/year. In 2013, the City of Ann Arbor funded a study of sediment erosion and accumulation in Millers Creek.[63] The study also listed the highlighted reach as one of the highest eroding reaches in the Millers Creekshed. The study estimated an erosion rate of 0.028 – 0.041 tons/yr/ft. This range is a bit lower than the rapid assessment, so rapid assessment estimates may be a bit elevated overall. The high priority site is highlighted for restoration in Chapter 4, as are recommendations from the Sediment Accumulation Study. Overall, due to the small size of the drainage area Millers Creek produces the fifth greatest total amount of eroded soil in the system at an estimated 921 tons/year.

A MDEQ cross section study conducted by Rathbun and Vincent[64] in April and October 2016 showed BEHI ratings of "Very High" at the Baxter Road cross-section, ranging from "Moderate" to "Very High" at two upstream Glazier Road cross-sections, and a "Moderate" and "Low" at the downstream Glazier Way cross-section.

Phosphorus and Suspended Solids

Recent conditions:
Through its Chemistry and Flow Monitoring Program, HRWC has collected data on phosphorus and suspended solids from Millers Creek at Huron Parkway since 2003. Millers Creek total phosphorus concentrations have moved in the downward direction over the past 10 years, but there is no statistically significant trend. During this period, Millers Creek saw a mean TP concentration of 0.06 mg/l (s=0.07) and a median of 0.04 mg/l/. In 2019, the most recent monitoring year, Millers Creek had an average and mean TP concentration of 0.03 mg/l

(s=0.02), which is right at the TMDL target for phosphorus. While there is no statistically significant trend, recent data reveals improvements in nutrient runoff in Millers Creek

Total suspended solids concentrations at Millers Creek ranged from 0.80 mg/l to 256 mg/l over the span of the most recent ten years. During this period, both mean and median TSS values of 18.33 mg/l (s=33.7) and 7.2 mg/l respectively are below the state standard of 80 mg/l. Only five samples out of 120 during the ten-year period exceeded the state standard, despite Millers Creek being one of the more severely eroded creeks in the Middle Huron. These concentrations over 80 mg/l occur during or following significant storm or bankfull events. No statistically significant trend in TSS is apparent at Millers Creek as most data varies annually.

Nitrate and Nitrite

Recent conditions and historic data (>10 years old):

Nitrogen compounds nitrate and nitrite have been monitored at Millers Creek since 2008. During the entire monitoring period (2008-2019) there has been no statistically significant trends in either compound at Millers Creek. Nitrite has ranged from 0.001 to 0.287 mg/l, with a mean of 0.010 mg/l (s=0.024) and a median of 0.005 mg/l. Meanwhile, nitrate from 2008 to 2019 averaged at 0.50 (s=0.23) and ranged from 0.02 to 2.10 mg/l with a median of 0.40 mg/l. These ranges are below the EPA's Maximum Contaminant Levels for nitrate and nitrite.

Conductivity

Recent conditions and historic data (>10 years old):

Conductivity in Millers Creek is monitored at Glazier Way in Ann Arbor during the HRWC River Roundup events. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. The Glazier Way site has an average conductivity level of 2,348 µS from 1993-2019, with a range between 820 and 6,040. The consistently high conductivity level indicates a water pollution problem, as in urban environments conductivity is often correlated with other harder to measure pollution issues such as sedimentation, sewage, oils, and heavy metals. There is no indication of a statistically significant change over the 1993-2019 period.

Since 2008, HRWC's Chemistry and Flow Monitoring Program has measured the conductivity of Millers Creek at Huron Parkway twice monthly from April to September. Conductivity at Millers Creek ranged from 513 to 2,722 µS/cm. Values averaged 1,646 µS/cm (s=396) with a median of 1,731 µS/cm, both of which are above the 800 µS threshold. These data are indicative of salt, metal, and/or mineral pollution at Millers Creek. Over the entire sampling period, from 2008 to 2019, there have been a statistically significant increase (p=0.006) in conductivity at Millers Creek, which is evidence of increasing issues regarding these pollutants.

EGLE conducted conductivity measurement on June 21, 2017, with results supporting the ranges seen by HRWC in their long-term monitoring (ranging from 1102 to 3173 at 9 locations).[65]

pH

HRWC's Chemistry and Flow Monitoring program has monitored pH at Millers Creek since 2008. pH values at Millers Creek fall within the prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 7.19 and a maximum value of 8.29. From 2010 to 2019, the average pH value at Millers Creek was 7.94 (s=0.25) with a median of 8.01.

Temperature

Recent conditions:

In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the May-August months in 2014-2018, volunteers walked the entire length of Millers Creek and made 174 temperature measurements. The measurements range from 52.0 through 72.7 degrees Fahrenheit, with an average of 66.3 and a standard deviation of 4.2. The temperatures were all recorded late morning through early afternoon.

During its annual, six-month monitoring season, HRWC's Chemistry and Flow Monitoring Program measures stream temperature. Over the six years since HRWC began collecting routine temperature data at Millers Creek, measurements ranged from 41.0 to 72.3 degrees Fahrenheit. The average temperature during that period was 59.9 degrees Fahrenheit (s=6.7) with a median of 60.0 degrees Fahrenheit. Millers Creek has seen a statistically significant increase in temperature (p=0.027) since 2014. While no analyses have been conducted, one likely driver of this trend is rising air temperatures as influenced by climate change.

Historic data (>10 years old):

In the early 2000s, HRWC installed min/max thermometers at 4 locations in Millers Creek. The minimum and maximum temperatures were checked every week from July through August. The below temperatures are in degrees Fahrenheit.

Site (Year)	**Range**	**Avg Min**	**Avg Max**
Hubbard Road (2001)	56.0-75.0	59.2	69.3
Glazier Way (2009)	54.0-74.0	56.1	70.1
Huron Parkway (2009	55.0-70.0	58.4	66.8
Narrow Gauge Way	48.0-57.0	48.6	53.0

DO

Recent conditions:

Dissolved oxygen at Millers Creek, as measured bimonthly by HRWC's Chemistry and Flow Monitoring Program, is consistently above the state standard of 5 mg/l with measured values ranging from 5.2 to 14.59 mg/l. Between 2014 and 2019, dissolved oxygen measured at Millers Creek averaged 9.70 mg/l (s=1.66) with a median of 9.45 mg/l. When all measured dissolved oxygen concentrations were above the state standard, there are no apparent trends in dissolved oxygen at Millers Creek.

Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions:

Bacteria at Millers Creek, represented by *E. coli*¸ has been measured by HRWC's Chemistry and Flow Monitoring Program since 2008. Over the twelve years of bacteria monitoring in Millers Creek, there has been a statistically significant decline in *E. coli* (p=0.007). Despite these significant improvements in bacteria, *E. coli* counts at Millers Creeks are still above the partial body and full body contact standards set by EGLE. Looking at data from 2010 to present, both the mean (763.9 *E. coli* per 100 ml) and median (425.6 *E. coli* per 100 ml) are below the partial body contact standard but above the full body contact standard. However, this most recent year of data from 2019 saw the single-year median (218.9 *E. coli* per 100 ml) slip below the full body contact standard.

Historic data (>10 years old):
MDEQ collected *E. coli* data in 2001 and 2002 for Geddes Pond and its tributaries in support of the development of the Geddes Pond *E. coli* TMDL. Water quality standards of 130 *E. coli* per 100 mL in Millers Creek were exceeded in 2001 and remained elevated in 2002. Concentrations in 2002 at the east and west branches of Millers Creek at Plymouth Road were higher than concentrations at other locations. [66]

Macroinvertebrates
Recent conditions:
As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and the number of pollution sensitive families. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality.

The Adopt a Stream Program monitors Millers Creek at the crossing of Glazier Way. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples. For these sample sites, diversity averages were calculated for 2017-2019 samples. The results are given in Table 2.6.

MDEQ sampled Millers Creek at Glazier Way in 7/12/2016 and found largely oligochaetes (worms) and Ceratopogonidae (biting midges) and Chironomidae (midges). The stream was ranked as Poor.

Historic data (>10 years old):
HRWC has sampled macroinvertebrates in Millers Creek since 1993. Over that time period, the insect metrics HRWC examines have largely remained unchanged, and generally low. One statistically significant change is that from 1994-1996, one sensitive family was found in autumn samples and then sensitive families have not been seen here since. Winter stoneflies have never been found at this location (Table 2.6). Millers Creek along with Swift Run are the worst streams for insect life in entire Huron River Watershed.

Fish
There are no known fish surveys conducted in Millers Creek.

Additional Data
MDEQ assessed stream habitat in Millers Creek at Glazier Way in 7/12/2016 and found low bank stability, lower than average riparian widths, and high evidence of stream flashiness. The overall habitat was rated as marginal.

HRWC has also conducted a flow study of Millers Creek at a number of locations in the early 2000s. Millers Creek is a highly flashy creek, with rapid spikes in discharge during rain events that quickly dissipate to baseflow (or no flow). The high peak flows and low base flows likely have lead to the observed erosion of the stream channels and low amount of aquatic diversity.

Older information about Millers Creek can be found in the Millers Creek Action Plan in Appendix A.

2.4.6 Swift Run

Creekshed Natural Areas

Forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from the creek, and provide wild-life habitat and beautiful places for us all to enjoy. About 16% of the creekshed still consists of intact natural areas. About half of these areas are protected from development (including Southeast Area, Pittsfield Preserve and Lillie parks). Protecting these remaining natural lands as well as maintaining natural features such as trees, pocket parks, plantings, and riparian buffers throughout the community is important for stabilizing the flashy flows of Swift Run.

Hydrology

Recent conditions:
Swift Run has the highest flashiness index rating of all the tributaries in the study Watershed. At 0.82, the stream flow of Swift Run is among the flashiest of all streams evaluated in the Michigan study. Swift Run has a small drainage area (4.7 mi^2) and is highly built-out. Only one major stream channel is evident in the creekshed. Much of the creek either runs dry in mid-summer or has a mostly stagnant flow in the dry months. Little groundwater flow appears to enter the creek. A natural creek with a drainage area similar to Swift Run would be expected to have a stream flow of 52 cfs following a 50% (2-year return interval) storm of 2.35". The modeled flow for Swift Run following a storm of this size is 189 cfs, and the estimate from survey data is 398 cfs. Both estimates are multiple times greater than peak flows expected in a natural creek, but the differences are not as big as some of the other tributaries. HRWC measured a peak flow of 273 cfs during a 2.6" rain event, which is consistent with these estimates. A modeled hydrograph of Swift Run during a 2.35" rain event reflects the flow rate (discharge) rising quickly to the peak flow, and it returning rapidly to baseflow over a period of only a few hours. The rapid rise and fall in flow, combined with a stagnant baseflow in dry condition are certainly damaging to aquatic habitat and inhospitable to life.

Morphology

Recent conditions:
The Swift Run drainage area is highly developed with little stormwater treatment infrastructure in place. Some of the drainage area is in underground storm pipes, but much of the main channel is accessible. The main branch stream reaches in the Swift Run creekshed show low to moderate levels of erosion, though small sections are highly eroded. The tributary streams within the Swift Run creekshed have a unit erosion rate of 0.041 tons/year per linear foot of stream, which is very similar to its neighboring Malletts Creek. That erosion rate is above the average rate of 0.029 tons/yr/ft across all watershed drainages. None of the evaluated streams in Swift Run had an erosion rate in the highest priority category of > 0.099 tons/yr/ft. This is partly due to the long run of the creek with no additional stream inputs. A smaller section of Swift Run had erosion rates above 0.1 tons/yr/ft, but the reach as a whole had an average rate of 0.085 tons/yr/ft, which is at the high end of the moderate range. Sections of that reach, which runs through the US-23-Washtenaw Avenue exit cloverleaf, should also be considered for

restoration. The high priority site is included in restoration recommendations in Chapter 4. Overall, Swift Run generates an estimated total of 759 tons/year in eroded soil.

Phosphorus and Suspended Solids

Recent conditions and historic data (>10 years old):

HRWC's Chemistry and Flow Monitoring Program has been monitoring Swift Run at Shetland Drive in Ann Arbor from April through September for over 16 years. Since monitoring began in 2003, Swift Run has had consistently high total phosphorus and total suspended solids concentrations. Over the most recent ten years, total phosphorus concentrations at Swift Run ranged from 0.01 mg/l to 1.8 mg/l with a mean of 0.13 mg/l (s=0.19) and a median of 0.10 mg/l. Most measured concentrations during this period have been beyond the TMDL target of 0.03 mg/l, with only 0.3% of samples at or below that target. More recently, data has been closer to the TMDL target, with a 2019 average concentration of 0.13 mg/l (s=0.19) and a median of 0.10 mg/l. Nonetheless, these values are still over double the TMDL target. When considering all data from 2010 to 2019, there is no statistically significant trend in total phosphorus at Swift Run. However, similar to Malletts Creek, when samples from or following three bankfull or storm events are removed from the analysis, there is a statistically significant decline in phosphorus (p=0.05). Despite its high phosphorus levels, large precipitation events are the primary driver of extreme nutrient runoff from Swift Run.

Swift Run has also been analyzed for total suspend solids since 2003. During this time, there has been no observable trends in TSS concentrations at Swift Run. Since 2010, TSS concentrations at Swift Run have been as low as 1.8 mg/l up to 930 mg/l, which is over 11 times the sample standard of 80 mg/l. However, the mean and median are both below the sample standard at 35 mg/l (s=96) and 10 mg/l respectively. Additionally, most samples are below the sample standard, with only 10% of samples during the ten-year period exceeding 80 mg/l.

Nitrate and Nitrite

Recent conditions and historic data (>10 years old):

From 2003 through the present, HRWC has monitored nitrate and nitrite twice monthly at Swift Run. Interestingly, over the 16 year monitoring period Swift Run saw statistically significant but inverse changes in nitrogen compounds; nitrate at Swift Run increased (p=0.015), whereas nitrite decreased ($p=1.06e^{-5}$). From 2003 to 2019, nitrate ranged from 0.0 to 0.90 mg/l, with a mean of 0.34 mg/l (s=0.17) and a median of 0.30 mg/l. Nitrite concentrations at Swift Run during that period ranged from 0.001 to 0.082 mg/l and saw an average value of 0.014 mg/l (s=0.014) and a median of 0.009 mg/l. These ranges at Swift Run are below the EPA's Maximum Contaminant Levels for nitrate and nitrite.

Conductivity

Recent conditions and historic data (>10 years old)

Conductivity in Swift Run is monitored at Shetland Drive in Ann Arbor during the HRWC River Roundup events. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. The Shetland Drive site has an average conductivity level of 1763 µS from 1996-2019, with a range between 618 and 5,020. The consistently high conductivity level indicates a water pollution problem, as in urban environments conductivity is often correlated with other harder to measure pollution issues such as sedimentation, sewage, oils, and heavy metals. There is no indication of a statistically significant change over the 1996-2019 period.

On top of the conductivity data collect by HRWC's River Roundup, their Chemistry and Flow Monitoring Program also measures conductivity of Swift Run at Shetland Drive twice monthly from April to September. Since 2010, there has been no statistically significant trend in conductivity at Swift Run. Conductivity values have been wide-ranging, from a minimum value of 328 µS/cm to a maximum value of 3,037.00 µS/cm. The mean and median during the ten-year period have both been above the 800 µS threshold at 1,432.39 µS/cm (s=764.75) and 1,191.50 µS/cm respectively. Given these routinely elevated conductivity levels, it is likely there are salts, metals, and other naturally occurring minerals impairing the water quality of Swift Run.

pH

Recent conditions and historic data (>10 years old):
HRWC's Chemistry and Flow Monitoring program has monitored pH at Swift Run since 2003. pH values at Swift Run generally fall within the prescribed range under the Michigan Water Quality Standards for surface waters, save for one measurement at 9.05. pH values at Swift Run over the past 10 years range from 7.06 to 9.05, with an average of 7.95 (s=0.33) with a median of 7.98.

Temperature

Recent conditions:
In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the May-August months in 2014-2018, volunteers walked the entire wetted length of Swift Run and made 84 water temperature measurements. The measurements range from 59.6 through 78.0 degrees Fahrenheit, with an average of 67.3 and a standard deviation of 5.3. The temperatures were all recorded late morning through early afternoon.

HRWC's Chemistry and Flow Monitoring Program also collects a suite of temperature data annually during the growing season. This data, collected since 2014 at the Shetland Drive monitoring site, reveals a range from 42.8 to 76.8 degrees Fahrenheit, with a mean and median of 64.6 (s=7.6) and 66.7 degrees Fahrenheit respectively. Temperature data from Swift Run does not illustrate any trends, with measurements maintaining at the expected range of values.

Historic data (>10 years old):
In the early 2000s, HRWC installed min/max thermometers at the Swift Run: Shetland Drive site. The minimum and maximum temperatures were checked every week from July through August. The below temperatures are in degrees Fahrenheit.

Swift Run (2001): Range: 58.0-81.0 Avg Min: 60.6 Avg Max: 75.3

DO

Recent conditions and historic data (>10 years old):
Most dissolved oxygen values at Swift Run, as measured by HRWC's Chemistry and Flow Monitoring Program, are above the state standard, with only 5% of recorded values below the state standard of 5 mg/l. DO measurements at Swift Run illustrate the largest range among the tributaries analyzed in this plan, with a minimum value of 2.66 mg/l and a maximum of 19.77 mg/l. Between 2014 and 2019, dissolved oxygen measured at Swift Run averaged 8.57 mg/l (s=3.30) with a median of 7.68 mg/l. While there is no apparent trend in dissolved oxygen at Swift Run, all measured values since 2017 have been above the state standard.

Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions:

Bacteria from Swift Run, in the form of *E. coli*¸ has been analyzed by HRWC's Chemistry and Flow Monitoring since 2006. In this fifteen-year period, *E. coli* counts ranged from 54,750 counts per 100 ml to 13.10 counts per 100 ml. Given these outlier bacteria counts at Swift Run, which range from 15,000 to 54,000 counts per 100 ml, the mean of 2,488 counts per 100 ml (s=7,297) is nearly six times greater than the median of 420 counts per 100 ml. Since 2010, most *E. coli* counts at Swift Run were greater than the state's full body contact sample standard, with 61% of samples exceeding the 300 counts per ml threshold. A little less than a third of samples from Swift Run (28%) exceeded the partial body contact standard. Analysis of the complete set of *E. coli* data at Swift Run from 2010-2019 reveals no statistically significant trend. However, there does appear to be a downward trend in *E. coli.* Like with the phosphorus trends, upon exclusion of four outliers from large storm events, there is a statistically significant (p=0.001) declining trend in *E. coli* at Swift Run. This indicates large precipitation events are responsible for the bacteria runoff into Swift Run.

Historic data (>10 years old):

MDEQ collected *E. coli* data in 2001 and 2002 for Geddes Pond and its tributaries in support of the development of the Geddes Pond *E. coli* TMDL. Water quality standards of 130 *E. coli* per 100 mL in Swift Run were exceeded in 2001 and remained elevated in 2002. Sampling in the early portion of the 2002 monitoring season indicated elevated concentrations at various locations while the last four weeks of the season were dry or stagnant. [67]

Macroinvertebrates

Recent conditions:

As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and the number of pollution sensitive families. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality.

The Adopt a Stream Program monitors Swift Run at Shetland Road Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples. For these sample sites, diversity averages were calculated for 2017-2019 samples. The results are given in Table 2.6.

Historic data (>10 years old):

HRWC has sampled macroinvertebrates in Swift Run since 1992. Over that time period, the insect metrics HRWC examines have largely remained unchanged, and generally low. Winter stoneflies have been found at this location only once, in 2004. (Table 2.6) Swift Run along with Millers Creek are the worst streams for insect life in the entire Huron River Watershed.

Fish

There are no known fish surveys conducted in Swift Run.

Further information about Swift Run can be found in Appendix F.

2.4.7 Traver Creek

Creekshed Natural Areas

The creekshed's forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from runoff, and provide wildlife habitat and beautiful places for us all to enjoy. About 15% of the creekshed remains as intact natural areas. However, only about a third of these areas are protected from development. (including Black Pond and Dhu Varren Woods). Without designated protection, the natural areas of the creekshed face an uncertain future; they are privately owned and likely will not remain natural in the long term. They face conversion from forest and wetlands to paved surfaces, parking lots, and lawns; not immediately, but over the course of time. It will be important to keep these lands natural, so they can continue to help keep the creek healthy by stabilizing flows and filtering polluted runoff before it reaches the creek.

Hydrology

Recent conditions:
Traver Creek has the lowest flashiness index rating of all the tributaries in the Watershed. At 0.44, the stream flow in the creek is still more variable than the average Michigan stream. Traver Creek has a drainage area of 6.8 mi^2 and has a mixture of built, agricultural and natural land covers. A natural creek with a drainage area similar to Traver Creek would be expected to have a stream flow of 67 cfs following a 50% (2-year return interval) storm of 2.35". The modeled flow for Traver Creek following a storm of this size is 196 cfs, and the estimate from survey data is 313 cfs. Both estimates are multiple times greater than peak flows expected in a natural creek, but the differences are not as big as some of the other tributaries. HRWC measured a peak flow of 660 cfs during a 2.73" rain event, which is a bit larger than a bankfull event. A modeled hydrograph of Traver Creek during the 2.35" rain event shows a flow rate (discharge) rising quickly to the peak flow, beginning to fall, but then rising again before returning to baseflow over a period of days. This split hydrograph is likely due to the urbanized lower section of the creek, which generates rapid runoff, followed by the slower addition from the remainder of the creekshed, which is further slowed by several impoundments along its course. The initial rapid rise in flow is likely damaging to aquatic habitat, but good baseflow may be able to protect habitat over the long-term.

Morphology
Recent conditions:
The Traver Creek drainage area is quite diverse. Some stretches are highly developed with development directly adjacent to concrete-armored stream banks, and other stretches have good riparian cover with a well-connected floodplain. The main branch stream reaches in the creekshed have erosion rates that reflect this diversity. Most show low to moderate levels of erosion, though some small sections are highly eroded. The tributary streams within the creekshed have a unit erosion rate of 0.043 tons/year per linear foot of stream, which is the third

highest rate. That erosion rate is above the average rate of 0.029 tons/yr/ft across all watershed drainages. Two of the evaluated streams in Traver Creek had an erosion rate in the highest priority category of > 0.099 tons/yr/ft. One small reach runs through a heavily built-out area downstream of Leslie Park Golf Course. This stream reach has high banks and a heavily confined streambed. It has an erosion rate of 0.13 tons/yr/ft – the third highest rate in the Watershed. The other small reach runs along Foxfire South Park. It has a rate of 0.11 tons/yr/ft. The high priority sites are included in restoration recommendations in Chapter 4. Overall, Traver Creek generates an estimated total of 1,057 tons/year in eroded soil.

<u>Phosphorus and Suspended Solids</u>

Recent conditions:

Traver Creek has been routinely monitored for a suite of chemistry parameters by HRWC's Chemistry and Flow Monitoring Program at the Broadway Avenue since 2003. Total phosphorus concentration at Traver Creek over the past 10 years averaged 0.06 mg/l (s=0.05), with a median of 0.05 mg/l. In 2019, the most recent monitoring year, both the mean and median were 0.05 mg/l, which is right on the previous TMDL target before it was updated in November 2019. During the most recent 10 years of phosphorus data, concentrations ranged from 0.007 to 0.27 mg/l. Since 2010, there has been a statistically significant decline in total phosphorus concentrations (p=0.01), indicating progress on nutrient reduction in the Traver Creekshed.

Since sampling started in 2003, trends in total suspended solids concentrations from Traver Creek at Broadway Avenue have been declining (p=0.045). In the past 10 years, TSS concentrations at Traver Creek ranged between 0 mg/l and 144 mg/l with a mean of 12.65 (s=18.36 mg/l) and a median of 6.8 mg/l. Over this period, only 2% of samples have exceeded the 80 mg/l state single sample standard, indicating less sediment loading into the Middle Huron form Traver Creek as compared to other creeks in this stretch of the river.

<u>Nitrate and Nitrite</u>

Recent conditions and historic data (>10 years old):

HRWC's Chemistry and Flow Monitoring Program has collected data on nitrate and nitrite since 2006. From 2006 to 2019, Traver Creek has seen a statistically significant decline in nitrite (p=0.0036) and a simultaneous increase in nitrate (p=0.0006), which could be due to increased animal waste and fertilizer runoff. Over the entire monitoring period, nitrate at Traver Creek ranged from 0.0 to 1.20 mg/l, with a mean of 0.42 mg/l (s=0.16) and a median of 0.40 mg/l. Nitrite at Traver Creek averaged 0.009 mg/l, with a median of 0.006 mg/l, a minimum value of 0.001 mg/l, and a maximum value of 0.057 mg/l. These ranges are below the EPA's Maximum Contaminant Levels for nitrate and nitrite.

<u>Conductivity</u>

Recent conditions and historic data (>10 years old):

Conductivity in Traver Creek is monitored at Broadway Avenue in Ann Arbor during the HRWC River Roundup events. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. The Broadway Ave. site has an average conductivity level of 1087 µS from 1996-2019, with a range between 388 and 3,290. This is an elevated conductivity level but less than the other Huron River tributaries in the Watershed. There is no indication of a statistically significant change over the 1996-2019 period.

HRWC's Chemistry and Flow Monitoring Program also collects data on conductivity from Traver Creek at Broadway Avenue during its annual, six-month monitoring season. These data indicate no significant trend in conductivity values at Traver Creek. Over the past 10 years, conductivity values at Traver Creek ranged from 331.3 µS/cm to 1,462.0 µS/cm with an average value of 869.7 µS/cm (s=207.5) and a median value of 860 µS/cm. Given both the mean and median are beyond the 800 µS/cm, there is evidence of metal, salt, and/or mineral pollutants in Traver Creek.

pH

Recent conditions and historic data (>10 years old):

HRWC's Chemistry and Flow Monitoring program has monitored pH at Traver Creek since 2002 at Broadway Avenue. pH values at Traver Creek fall within the prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 7.40 and a maximum value of 8.61. From 2010 to 2019, the average pH value at Traver Creek was 8.08 (s=0.26) with a median of 8.17.

Temperature

Recent conditions:

In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the May-August months in 2013-2018, volunteers walked the length of Traver Creek south of US-23/14 and made 132 temperature measurements. The measurements range from 57.1 through 78.7 degrees Fahrenheit, with an average of 68.8 and a standard deviation of 5.8. The temperatures were all recorded late morning through early afternoon.

Temperature data is also collected bimonthly from April through September by HRWC's Chemistry and Flow Monitoring Program. These data, collected from 2014 to 2019, indicate a range of 40.1 to 79.9 degrees Fahrenheit and an average temperature of 64.8 degrees Fahrenheit (s=8.6) and a median of 67.3 degrees Fahrenheit. While not statistically significant, there does appear to be an increase in temperature values over the past six years. This trend is likely driven by increases air temperatures as driven by climate change.

Historic data (>10 years old)

In the early 2000s, HRWC installed min/max thermometers at 2 locations in Traver Creek. The minimum and maximum temperatures were checked every week from July through August. The below temperatures are in degrees Fahrenheit.

Broadway Avenue (2009): Range: 62.0-74.0 Avg Min: 63.6 Avg Max: 70.6
Dhu Varren Road (2009): Range: 62.0-78.0 Avg Min: 65.7 Avg Max: 75.1

DO

Recent conditions and historic data (>10 years old):

Dissolved oxygen has been measured at Traver Creek by HRWC's Chemistry and Flow Monitoring Program since 2002. Between 2002 and 2019, only one value of 4.32 dipped below the state standard of 5 mg/l. Over the past six years, DO at Traver Creek ranged from 4.32 mg/l to 15.04 mg/l, with an average of 9.12 mg/l (s=1.83) and a median of 8.67. There are no observable trends in dissolved oxygen at Traver Creek, as values seasonally fluctuate.

Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions:

Data regarding pathogens, specifically *E. coli*, is collected annually from April through September by HRWC's Chemistry and Flow Monitoring Program. Since the program began analyzing *E. coli* in Traver Creek in 2006, trends in *E. coli* appear to be declining despite the lack of statistical significance. Over the most recent ten years of monitoring at Traver Creek, *E. coli* counts ranged between 2 per 100 ml to 12,000 per 100 ml with an average of 782.5 counts per 100 ml (s=1450.9) and a median of 381.1 counts per 100 ml. Both the mean and median are below EGLE's partial body contact standard of 1,000 counts per 100 ml, but still above the full body contact standard of 300 counts per 100 ml. Continued efforts to reduce *E. coli* pollution into Traver Creek could help continue to advance the declining trend in *E. coli* to a median value below both sample standards.

Historic data (>10 years old):
MDEQ collected *E. coli* data in 2001 and 2002 for Geddes Pond and its tributaries in support of the development of the Geddes Pond *E. coli* TMDL. Water quality standards of 130 *E. coli* per 100 mL in Traver Creek were exceeded in 2001 and remained elevated in 2002. Some of the highest concentrations were found at the mouth of the tributary. [68]

Macroinvertebrates
Recent conditions:
As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and the number of pollution sensitive families. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality.

The Adopt a Stream Program monitors Traver Creek at the crossing of Broadway Avenue. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples. For these sample sites, diversity averages were calculated for 2017-2019 samples. The results are given in Table 2.6.

Historic data (>10 years old)
HRWC has sampled macroinvertebrates in Traver Creek since 1995. Over that time period, the insect metrics HRWC examines have largely remained unchanged, and generally low; however, Traver is more likely to hold EPT families and winter stoneflies than the other urban tributaries entering the Huron in the Watershed (Table 2.6).

Fish
There are no known fish surveys conducted in Traver Creek.

Additional Data

Recent conditions:
In 2015 HRWC conducted polycyclic aromatic hydrocarbon (PAH) sampling in three detention pond sediments, including one in Traver Creek (PAH3, Figure 2.20). The goal of this study was to locally confirm what was seen in the broader scientific literature, that detention pond sediments have very high levels of PAHs, most of which are sourced from coal-tar driveways sealants. While HRWC did not try to establish the coal-tar cause, sampling did indicate very high levels for a number of PAH compounds. The Traver Creek detention pond contained PAHs higher than the Probable Effect Concentration (PEC) for:

- Benzo(a)pyrene (1.4 times the PEC)

- Chrysene (1.6 times the PEC)
- Fluoranthene (1.6 times the PEC)
- Pyrene (1.6 times the PEC).

Table 2.6. Macroinvertebrate Communities at HRWC Adopt-A-Stream Program Monitoring Sites in the Watershed, 2017-2019 unless otherwise noted.

Study Site	Sample Frequency[t]	Population Trends	Avg. Insect Families	Avg. EPT Families	Avg. Sensitive Families	Winter Stonefly
Huron River: Island Park (61) (2015-2017)	Primary	Stable	12	5	1.2	(Sampled 2015, 2018) Present both samples
Fleming Creek: Parker Mill County Park (11)	Primary	Sensitive Families Improving	11.0	3.7	1.0	Sampled 2017, 2018) Present both samples
Fleming Creek: Botanical Gardens (9)	Secondary	Sensitive Families Improving	14.0	5.8	2.0	(Sampled 2017, 2018) Present both samples
Fleming Creek: Warren Road (13)	Secondary	EPT and Sensitive Families Improving	13.7	7.0	2.0	Present all three samples
Fleming Creek: Galpin Road (84)	Secondary	Stable	13.7	6.3	1.3	(Sampled 2018) Present
Malletts Creek: Chalmers Drive (27)	Primary	Total and EPT Families Improving	9.4	2.4	0.0	(Sampled 2019) Not Present[x]
Millers Creek: Glazier Way (35)	Primary	Sensitive Family Decline	7.2	0.6	0.0	(Sampled 2015) Not present[x]
Swift Run: Shetland Drive (41)	Primary	Stable	4.3	0.5	0.0	(Sampled 2017) Not present[x]
Traver Creek: Broadway Avenue (42)	Primary	Stable	5.8	2.0	0.0	(Sampled 2017,2019) Present in both samples

[t] = Weather and volunteer numbers permitting, primary sites are sampled at every River Roundup and Stonefly Search while secondary sites are sampled every event for one year and then get one year off.
[x] = For the creeks indicated, winter stoneflies were not found after numerous years of consistent sampling. In 2016, HRWC decided to only conduct winter stonefly sampling at these creeks once every 5 years to save on volunteer effort.

Table 2.7. Mean and Median Values for Chemistry Parameters Monitored by HRWC's Chemistry and Flow Monitoring Program, 2002-2019[a]

	Allens Creek: Main Street	**Traver Creek: Broadway Street**	**Fleming Creek: Geddes Road**	**Malletts Creek: Chalmers Drive[g]**	**Millers Creek: Huron Parkway[i]**	**Swift Run: Shetland Drive**
TP[b] (mg/l)	0.08 (0.06)	0.06 (0.05)	0.06 (0.05)	0.08 (0.06)	0.06 (0.04)	0.12 (0.09)
TSS[b] (mg/l)	11.5 (5.8)	12.3 (6.8)	22.2 (6.0)	21.1 (9.6)	17.2 (7.2)	30.4 (9.8)
NO2 (mg/l)	0.022 (0.014)	0.009 (0.006)	0.007 (0.005)	0.015 (0.010)	0.010 (0.005)	0.014 (0.009)
NO3 (mg/l)	0.66 (0.60)	0.42 (0.40)	0.35 (0.30)	0.37 (0.40)	0.50 (0.40)	0.34 (0.30)
E. Coli[c] (cfu/100 ml)	3722 (1273)	814 (345)	408 (131)	1285 (350)	787 (411)	2231 (420)
pH[d]	7.92 (7.96)	8.08 (8.14)	8.06 (8.15)	7.98 (8.00)	7.93 (8.00)	7.90 (7.95)
Conductivity[d] (µS)	1008 (1091)	891 (895)	737 (765)	1460 (1553)	1646 (1731)	1429 (1334)
TDS[e] (mg/l)	763 (813)	677 (676)	556 (559)	1095 (1125)	1311 (1411)	1149 (1073)
DO[f] (mg/l)	9.17 (9.06)	8.98 (8.63)	9.61 (9.35)	9.21 (9.30)	9.67 (9.48)	8.1 4 (7.50)
Temperature[e] (°F)	60.80 (60.71)	64.75 (67.28)	63.53 (64.40)	67.22 (68.54)	59.93 (59.99)	64.60 (66.65)

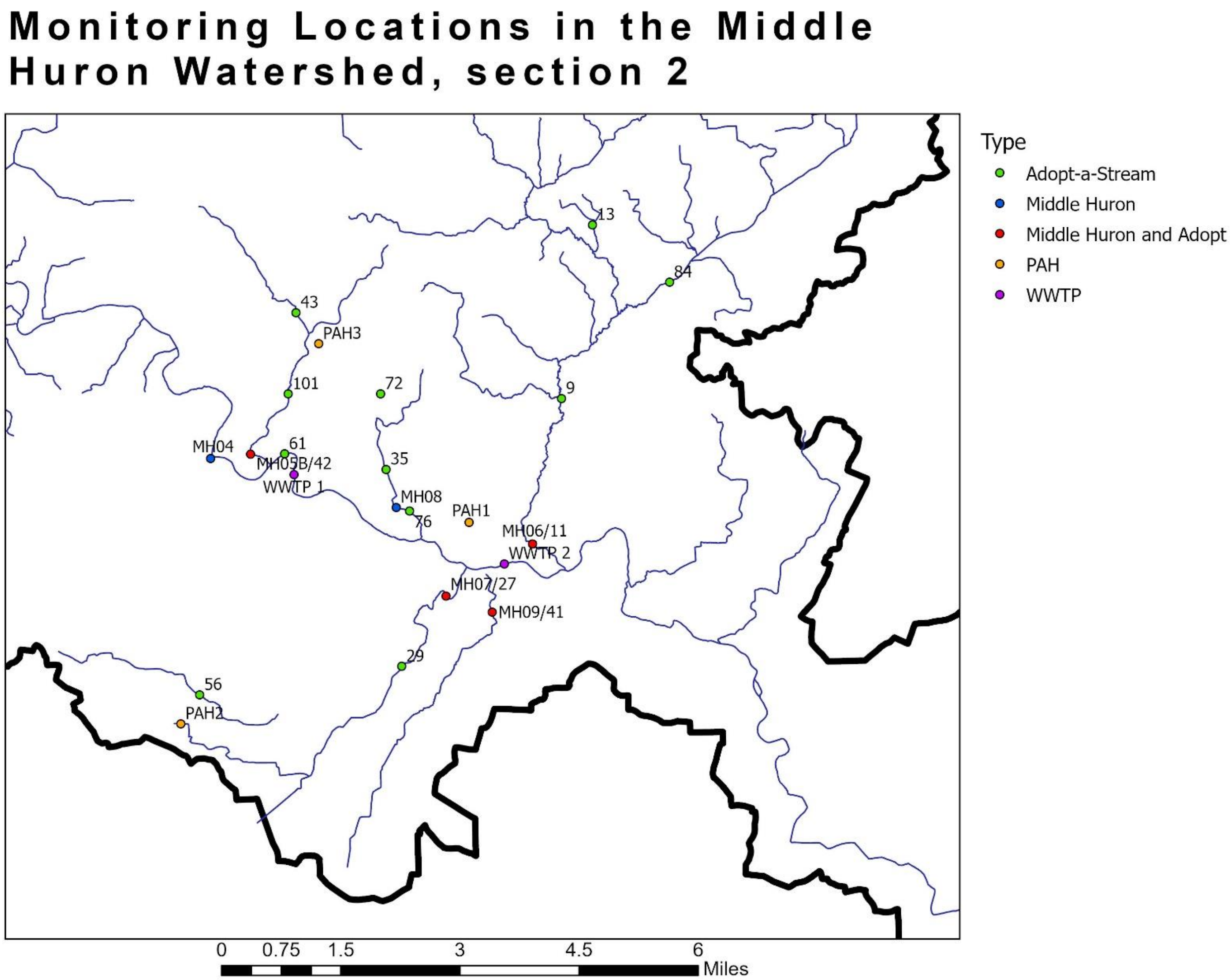
[a] = Mean with median in parentheses; no data for 2007 across all parameters
[b] = Data from 2003 to 2019
[c] = Data from 2006 to 2019
[d] = Data from 2002-2011 and 2014-2019
[e] = Data from 2014-2019
[f] = Data from 2002-2009 and 2014-2019
[g] = No data in 2002
[h] = Includes data from 2003 and 2006-2019
[i] = No data from 2002-2007

Table 2.8. Mean and Median Values for Chemistry Parameters Monitored by HRWC's Chemistry and Flow Monitoring Program, 2010-2019[a]

Parameter	Allens Creek: Main Street	Traver Creek: Broadway Street	Fleming Creek: Geddes Road	Malletts Creek: Chalmers Drive	Millers Creek: Huron Parkway	Swift Run: Shetland Drive
TP (mg/l)	0.08 (0.06)	0.06 (0.05)	0.06 (0.05)	0.09 (0.06)	0.07 (0.04)	0.14 (0.10)
TSS (mg/l)	12.3 (5.6)	12.7 (6.8)	25.6 (6.4)	21.6 (8.8)	18.3 (7.2)	34.9 (10.4)
NO2 (mg/l)	0.022 (0.013)	0.009 (0.006)	0.007 (0.005)	0.015 (0.010)	0.010 (0.005)	0.012 (0.008)
NO3 (mg/l)	0.59 (0.60)	0.43 (0.40)	0.36 (0.30)	0.37 (0.40)	0.50 (0.40)	0.35 (0.30)
E. Coli (cfu/100 ml)	3669 (1273)	783 (381)	448 (131)	1012 (332)	764 (426)	2488 (454)
pH[2]	7.94 (8.01)	8.08 (8.17)	8.08 (8.17)	8.00 (8.06)	7.94 (8.01)	7.95 (7.98)
Conductivity[2] **(µS)**	944 (919)	870 (860)	726 (737)	1492 (1579)	1635 (1721)	1432 (1191)
TDS[3] **(mg/l)**	763 (813)	677 (676)	556 (559)	1095 (1125)	1311 (1411)	1149 (1073)
DO[3] **(mg/l)**	9.33 (9.10)	9.12 (8.67)	9.77 (9.48)	9.63 (9.60)	9.70 (9.45)	8.57 (7.68)
Temperature[3] **(°F)**	60.80 (60.71)	64.75 (67.28)	63.53 (64.40)	68.02 (69.98)	59.93 (59.99)	64.60 (66.65)

[1] = Mean with median in parentheses
[2] = Only data for 2010, 2011, and 2014-2019
[3] = Only data from 2014-2019

Figure 2.20. Location of HRWC and WWTP monitoring sites in the Watershed.



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[56] MDEQ, Water Bureau. February, 2005. A Biological Survey of the Huron River Watershed: Ingham, Livingston, Monroe, Oakland and Washtenaw Counties, July-September 2002. Lansing, MI: MDEQ.
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[58] MDEQ, Water Bureau. February, 2005. A Biological Survey of the Huron River Watershed: Ingham, Livingston, Monroe, Oakland and Washtenaw Counties, July through September 1997. Lansing, MI: MDEQ.
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2.5 Impairments and Critical Areas

As shown throughout Chapter 2, there are various pollutants, also known as impairments, that reduce the water quality of the Watershed, and this presents challenges to meeting the designated and desired uses.

Analysis of existing data indicates that the Watershed has areas of medium-quality and low-quality waters that require mitigation of existing impairments. This section summarizes current impairments in the watershed and identifies the sources and causes of those impairments. There are both general impairments which occur across the Watershed and there are also specific impairments that are occurring in particular locations and tied directly to TMDLs.

2.5.1 General Impairments

The authors, with assistance from the Advisory Committee have compiled and updated the information necessary to identify and understand these impairments and their sources and causes. This list of impairments (Table 2.9) is based upon the results of analysis of the data presented in this chapter, Advisory Committee member observations, and citizen input.

Table 2.9. Impairments, Sources and Causes in the Watershed. Order of impairments within and between categories does not imply magnitude of impact.

Impairment 1: High Nutrient Loading	
Sources	**Causes**
1. NPDES permitted facilities	Nutrients in effluent
2. Fertilizers from residential, commercial, and golf courses	Lack of buffers Limited nutrient control ordinances Lack of nutrient management plans Overuse/improper application of fertilizers
3. Excessive runoff from developed areas	Lack of BMPs at existing development areas Impervious surfaces Poor storm drain maintenance
4. Legacy nutrients in lake / impoundment sediment	Sediment deposition Resuspension during storm events Dissolution during summer stratification
5. Illicit discharges	Aging sanitary sewer infrastructure Inadequate inspection/detection and repair due to cost Illegal septic application and trailer waste disposal
6. Pet and wildlife waste	Wildlife in storm drains Improper disposal of pet waste Ponds increase habitat for waterfowl, wildlife
7. Failing septic tanks	Old units are too small or don't meet codes Lack of a required maintenance program Poor maintenance/lack of education
8. Agricultural runoff from fertilizers/ livestock waste	Lack of nutrient management plans Lack of BMPs (upland and riparian buffers) Exposed soils

Impairment 2: Altered Hydrology	
Sources	**Causes**
1. Runoff from developed areas	Lack of BMPs at existing development areas Impervious surfaces Removal of woodland/forest, wetlands, and other pervious areas
2. Runoff from construction sites, new development	Removal of woodland/forest, wetlands, and other pervious areas Decentralized development increasing imperiousness Rerouting channel for development Lack of resources for enforcement/inspection Site exemptions Lack of education on alternatives
3. Engineered drains and streams	Loss of connection between stream and floodplain from channelization Loss of storage and infiltration capacity Removal of riparian buffer
4. Impoundment of streams	Dam construction Natural damming

Impairment 3: Sedimentation, Soil Erosion	
Sources	**Causes**
1. Eroding stream banks and channels	1. Flashy flows 2. Channelization 3. Drain maintenance 4. Eroding crossing embankments 5. Clear cutting/lack of riparian buffers
2. Construction sites	1. Clear cutting/lack of riparian buffers 2. Lack of resources for enforcement/inspection 3. Lack of soil erosion BMPs and BMP education 4. Insufficient penalties for noncompliance with ordinances 5. Exposed soils 6. Site exemptions
3. Developed areas	1. Lack of BMPs at existing development areas 2. Impervious surfaces 3. Clearcutting/lack of riparian buffers
4. Dirt, gravel roads	1. Poorly designed/maintained road stream crossings 2. Poor road maintenance
5. Sediments in impoundments	1. Legacy sedimentation, settling, then resuspension 2. Ineffective maintenance of dams
6. Agricultural field runoff	1. Lack of BMPs (upland and riparian buffers) 2. Exposed soils

Impairment 4: Pathogens	
Sources	**Causes**
1. Illicit Discharges	1. Aging development sanitary sewer infrastructure 2. Illegal septic application and trailer waste disposal 3. Incomplete inspection/detection and repair due to cost 4. Lack of education
2. Failing septic tanks	1. Old units are too small or don't meet codes 2. Lack of a required maintenance program 3. Inadequate enforcement by Health Departments 4. Poor maintenance/lack of homeowner education
3. Illegal/improper septage application	1. Lack of adequate septage disposal facilities
4. Pet and wildlife waste	1. Wildlife in storm drains 2. Improper disposal of pet waste (runoff from paved areas) 3. Ponds increase habitat for waterfowl, wildlife
5. Livestock waste from agricultural operations	1. Lack of BMPs

Impairment 5: Salts, Organic Compounds and Heavy Metals	
Sources	**Causes**
1. Legacy pollution	1. PCBs in Barton Pond, Ford and Belleville Lakes, and unnamed lake 2. PFAS from industrial facilities; fire-fighting foam 3. Excessive mercury in Second Sister and Unnamed Lakes 4. Illegal dumping
2. Developed areas	1. Lack of stormwater BMPs 2. PAH pollution from coal tar driveway sealants 3. Pharmaceuticals/Endocrine Disruptors in the water 4. Waste incineration (atmospheric deposition) 5. Illegal dumping 6. Illicit connections
3. Roads	1. Auto emissions 2. Lack of BMPs during road de-icing 3. Poor road maintenance
4. NPDES permitted facilities	1. Inadequate inspection 2. Lack of BMPs (upland and riparian buffers)
5. Turfgrass chemicals from residential, commercial lawns	1. Improper lawn care 2. Illegal disposal
6. Agricultural runoff	1. Lack of BMPS (upland, riparian buffers)

Impairment 6: High Water Temperature	
Sources	**Causes**
1. Directly connected impervious areas	1. Heated stormwater from urban areas 2. Lack of groundwater recharge
2. Eroded soil areas	1. Soil erosion from channel and upland
3. Solar heating	2. Lack of vegetated canopy in riparian zone

Impairment 7: Debris/Litter	
Sources	**Causes**
1. Roadways, parks, urban areas, residential areas	1. Illegal littering/dumping 2. Unsecured garbage containers and vehicles 3. Inadequate refuse containers

2.5.2 Specific Impairments: Critical Areas

In order to establish an effective plan for addressing the key threats and impairments in the watershed, it is helpful to determine which areas in the watershed are contributing the most to its impairment. These “Critical Areas” provide direction for further, more specific analysis.

The first step in identifying critical areas is to examine the TMDL coverage of impaired waters as mentioned in Table 1.1. These areas require specific analysis and treatment activities to address the listed impairments. Specific loading calculations for these areas are discussed in the following sections.

2.5.2.1 Phosphorus Total Maximum Daily Load for Ford/Belleville Lake

In December of 1993, a 12-month phosphorus loading analysis was initiated by EGLE to investigate the water quality of the Middle Huron. The analysis showed that Ford and Belleville lakes were impaired as they failed to meet water quality standards due to phosphorus enrichment, which contributed to nuisance algae blooms. Based on water quality sampling and accepted mathematical models, a phosphorus TMDL of 50 µg/L at Michigan Avenue and 30 µg/L in Belleville Lake was established for the months of April to September. This TMDL was originally approved by the U.S. EPA in 2000 and then updated in 2004 and 2010. It was completely revised and approved by EPA in 2019 (see Appendix G). This revised version ramped the phosphorus concentration target down to 30 µg/L in Ford Lake, while keeping the Belleville Lake target at 30 µg/L. It also extended the total load from six months to 12 months, covering the entire year.

According to EGLE, meeting the goals of the TMDL should result in the attainment of water quality standards for Ford and Belleville Lakes, in addition to meeting the requirements of Water Quality Standard R 323.1060(2) which states “nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi, or bacteria which are or may become injurious to the designated uses of the waters of the state.”

The TMDL estimates that the annual total phosphorus load to Ford Lake is 76,620 lbs/year. This estimate is based on point source reporting, and a land use model. The TMDL states that EGLE monitoring data shows a significant decline in phosphorus concentrations at river monitoring sites that is also consistent with a 20% decline in phosphorus concentrations observed by

HRWC and an 11-23% decline observed by Dr. John Lehman. An estimated 31% of the EGLE-estimated phosphorus load was derived from direct point sources, 12% was from stormwater (MS4) sources, mostly within this plan's watershed, and the remainder (57%) was from upstream nonpoint sources.

HRWC assessed monitoring data collected since 2003 to estimate loading from tributary drainages at multiple times since the original TMDL was developed. Most recently, HRWC worked with Dr. Tim Maguire to develop landscape-adjusted, April-September seasonal loading estimates for multiple drainages in the Middle Huron watershed using monitoring data from HRWC's Chemistry and Flow Monitoring Program. Across the most recent five years (2014-2018), total phosphorus loads ranged from 6,149 to 34,410 lbs per season with an average of 18,692 lbs/season. This 6-month mean translates to an estimate of 37,384 lbs for a complete year. This represents a 53% reduction in phosphorus loading from the estimate in the original TMDL.

Despite this decline in loading to Ford Lake, neither Ford nor Belleville Lake is showing any trend in lake phosphorus concentrations, based on periodic lake monitoring by EGLE. Because of this, the revised TMDL set new loading goals. EGLE used two lake models to estimate that each lake would need to reach a total phosphorus concentration of 30 µg/l to reach a healthy aquatic trophic status. Maintaining current trends of load reductions, and increasing reductions with activities recommended in Chapter 4 of this plan may eventually reduce phosphorus concentrations over the very long term.

The revised TMDL sets annual and daily load targets for Ford Lake as found in Table 2.10, and Belleville Lake. The Belleville Lake targets rely primarily on load reductions from Ford Lake upstream, internal lake management, and stormwater MS4 reductions.

Table 2.10 Ford Lake TMDL Loading and Target Load Goals

	EGLE Current Load Estimate (lbs/yr)	TMDL Goal (lbs/yr)	Reduction (%)	TMDL Goal (lbs/day)
Nonpoint Load Allocations				
Huron River Upstream	19,000	15,000	21%	41.1
Urban	3,000	800	73%	2.2
Agriculture	19,000	7,000	63%	19.2
Other	500	500	0%	1.4
Internal Load	2,000	480	76%	1.3
Precipitation, Deposition	130	130	0%	0.4
LA Total	**43,630**	**23,910**	**45%**	**65.5**
Point Waste Load Allocations				
WWTPs				
Ann Arbor	22,000	8,980	59%	24.6
Chelsea	600	560	7%	1.5
Dexter	270	180	33%	0.5
Loch Alpine	510	95	81%	0.3
Thornton Farms	200	45	78%	0.1
Other				
Chrysler-Chelsea Proving	40	40	0%	0.1
Sweepster	100	100	0%	0.3
Thetford/Norcold	40	40	0%	0.1
UM Power Plant	20	20	0%	0.1
Ann Arbor Drinking Water Plant	30	30	0%	0.1

Point WLA Total	23,810	10,090	58%	27
Aggregate Stormwater MS4s	9,180	2,500	73%	7
WLA Total	32,990	12,590	62%	34
Margin of Safety	NA	Implicit (0)		0
Total Load	76,620	36,500	52%	100

The TMDL target goal requires that the entire Middle Huron watershed reduce phosphorus loading by 52% from the EGLE loading estimate. This load from upstream sources has certainly been reduced, based on EGLE and HRWC monitoring. However, since lake concentrations have not changed significantly, it is necessary to continue to reduce loading from upstream sources. It is likely that it will require many years of low loading, in addition to active lake management, to reduce in-lake phosphorus concentrations.

Creekshed Breakdown

In an effort to determine critical areas for reducing phosphorus inputs, HRWC continues to monitor the watershed and estimate loading and changes in loading from tributary creeksheds and subsections of the Middle Huron watershed. Table 2.11 presents two sets of estimates of total phosphorus loading. The first estimates are based on four years of early monitoring program data and were produced using USGS P-load software. The second set were produced by a landscape-integrated GIS model that incorporated stream discharge and TP concentrations collected across the entire Huron River watershed for the most recent five years through 2018. Both are established in the table as mass-balance models. At certain river monitoring points, any unaccounted amount of surplus or deficit in the total load is balanced with a “other sources (sinks)” category.

Table 2.11. Estimates of Total Phosphorus Loading

Location	TP Mean Daily Load Est. (2003-2006)	TP Mean Daily Load Est. (2014-18)	Difference (%)
Huron @ N. Territorial (upstream)	38.34	59.15	35.2%
Mill Creek	25.26	40.72	38.0%
Boyden Creek		4.60	
Honey Creek	5.07	3.43	-47.8%
Allens Creek	3.41	3.42	0.23%
Subtotal to Wall St.	72.08	111.32	35.25%
Other sources/(sinks)	88.3	49.06	-80.0%
Huron @ Wall St.	160.38	160.38	0.00%
Traver Creek	0.83	2.70	69.24%
Millers Creek	0.28	4.49	93.77%

Malletts Creek	15.32	10.79	-41.99%
Swift Run	1.2	14.55	91.75%
Subtotal to Geddes Pond	178.01	192.91	7.72%
AA WWTP	49.62	60.23	17.62%
Fleming Creek	5.84	4.56	-28.03%
Superior Drain	0.7	29.29	97.61%
Subtotal to Ford Lake	234.17	286.99	18.40%
Other sources/(sinks)	-102.63	-184.85	44.48%
Huron @ Ford Lake (US-12)	131.54	102.14	-28.78%

Certain caveats for the 2014-2018 model should be considered. Due to the erratic nature of discharge from Allens Creek, loading estimates for that tributary are extremely variable and unreliable. To account for that, P-load was used to estimate Allens Creek loads. Since no additional monitoring data was collected at the Wall Street station and the mean flow was very similar to the 2003-06 period, the load estimates at that location were nearly identical. The estimate for the river at N. Territorial Road is also likely overestimated due to a lack of sufficient data upstream. Finally, the Superior Drain estimate used five years ending in 2013 since HRWC stopped sampling that site in 2013.

The bottom line suggests that phosphorus loading has decreased by 29% since sampling began in 2003. The results suggest that, Swift Run is the best target for loading reduction in the target watershed given the overall size of phosphorus load. Traver and Millers Creeks also show increasing loads, but their total contribution is much lower. Malletts Creek is also a good target, given the size of the load and the number of sources, but loading decreased by 42% from practices to date already, so allowing more time for recent practices to achieve their full potential may be the best approach in that creekshed. Mill Creek and Superior Drain (also good targets) are outside of the target Watershed.

2.5.2.2 *E. coli* TMDL for Geddes Pond

In August 2001, a TMDL for *E. coli* was established for the Huron River downstream of Argo Dam to Geddes Dam (Appendix H). To remove the reach from the impaired waters list, it will need to meet the water quality standard for pathogens. For the TMDL, the standard organism count of 130 per 100 milliliters (ml) as a 30-day geometric mean between May 1 to October 31 was used. Following the establishment of the TMDL, an implementation plan was compiled by affected stakeholders.

Data on counts for *E. coli* and fecal coliform bacteria vary widely throughout this river section and the contributing tributaries. Historical data indicate that Lower Geddes Pond has consistently exhibited the highest bacteria concentrations among all Huron River reaches in the Ann Arbor area. Additional sampling conducted in 2001 by EGLE corresponds with the findings of the historical data and indicates that the listed reach and its tributaries exceeded the WQS for *E. coli*.

The results of 2002 sampling for the implementation plan indicated that Geddes Pond exceeded the 30-day geometric mean for full body activities during the second half of July and all of August. There was one additional sampling event that exceeded the full body activity daily maximum standard (300 *E. coli* per 100 ml) in September. Each tributary sampled had elevated *E. coli*, and seemed to be influenced by wet weather events. Allens Creek typically had high *E. coli* concentrations and had visual evidence of illicit connections. Millers Creek, at the east and west branches at Plymouth Road, were typically higher than other locations. Sampling on Malletts Creek was started in July and showed high *E. coli* concentrations for the period sampled. Early season sampling on Swift Run Creek indicated elevated concentrations at various locations. However, the last four weeks of sampling were dry or stagnant. Traver Creek *E. coli* concentrations decreased later in the sampling season, but some of the highest concentrations overall were found at the creek mouth.

DNA sampling was also conducted during one sampling event on August 27, 2002, in the hopes of determining whether sources of *E. coli* were human or non-human. Unfortunately, the results were inconclusive.

Bacteria sources have been determined to consist of a range of wet and dry weather-driven sources. However, the primary loading of pathogens enters the Huron River directly through the tributaries and storm sewers within the listed reach. Potential pathogen sources for the listed waterbody include sources typically associated with urban and suburban runoff because the immediate watershed is primarily composed of these land types. Source evaluation indicates that bacteria loads from a large part of Ann Arbor enter Geddes Pond/Huron River via the storm water system. Bacteria loads are also delivered to Geddes Pond/Huron River by tributaries that drain a large portion of the Ann Arbor area. Other pathogen sources for Geddes Pond/Huron River likely include upstream inputs, illicit sewer connections, pet and wildlife feces, and a small number of malfunctioning septic systems. Agricultural land uses located in the upstream reaches of the Traver Creek watershed make livestock and horse feces other likely sources.

Since the bacteria standard is concentration-based, and bacteria are living organisms, rather than chemical pollutants, the TMDL is also concentration-based, rather than mass loading based like most other types of TMDLs. Further, since low concentrations were detected to be coming from river sources, the focus was placed on tributary sources.

Based on this reasoning, and considering other relevant factors, monthly average concentration maxima were established for each of the tributaries that match state WQ standards

Since a concentration standard is used, a total loading of bacteria from the creeks was not established for the TMDL. However, loading allocations were established for each creekshed based on these allowable concentrations and monthly stream flow averages. Based on this information, no fixed pathogen loading figures have been established, nor specific reduction targets. The Geddes E. coli Implementation Plan (Appendix H2) lays out a strategy to eliminate or reduce all major pathogen sources to meet the monthly average concentration goals.

HRWC has monitored each of the major tributaries (though not direct drainages) in the watershed for *E. coli* since 2006 (Table 2.13). HRWC volunteers collect single samples twice per month, rather than triplicate samples monthly, so the methods do not exactly replicate EGLE standard methods. HRWC results would be expected to be somewhat more variable, and therefore may overstate concentration levels. All of the tributaries have average bacteria counts (whether calculated as means or geomeans) that are above the TMDL targets (and state standard for full-body contact). Trends in the data suggest that conditions in the tributaries are becoming less conducive to bacteria growth over time, however. All show declining trends, and the trends in two of these tributaries are statistically significant. Geomeans for the most recent five years are getting closer to the standard for a single sample set (300 bacteria per 100 ml) for three of the five tributaries sampled, but occasional high counts still occur in all tributaries.

Table 2.13. Measured *E. coli* Concentrations for the Subwatersheds of the Huron River. Average *E. coli* Concentration (per 100 ml), (April-September)

Tributary	2010-19 mean	2015-19 mean	2015-19 geomean	10-year Trend	Statistically significant*
Allens Creek	3,669	2,742	754	Decline	Yes
Traver Creek	783	722	316	Decline	No
Millers Creek	764	545	343	Decline	Yes
Malletts Creek	1,012	1,521	312	Decline	No
Swift Run	2,488	2,136	431	Decline	No
Direct Drainage	NA	NA	NA	NA	NA

**Significance determined by ANOVA via regression analysis for year-to-year variation*

Since the TMDL sets a seasonal limit (May through October), HRWC also evaluated monthly geomeans to determine if there are any seasonal patterns (Table 2.14). Bacteria counts are at their lowest across all sites in April, before the TMDL takes effect, and all tributaries are either below the TMDL or within 30% of it then. Concentrations in May also are a bit lower than the rest of the season, but there do not appear to be substantive differences between the months of June through September. HRWC does not monitor in October. If anything, remedial activities should be focused on the June to September period to have the greatest impact.

Table 2.14. Monthly geomean *E. coli* concentrations (2015-2019)

Tributary	April	May	June	July	August	September
Allens Creek	272.94	279.39	467.14	576.39	2,429.19	3,976.15
Traver Creek	45.81	213.39	586.33	440.41	510.68	665.25
Millers Creek	78.03	240.06	731.96	596.17	516.31	462.80
Malletts Creek	152.49	168.31	555.03	414.45	388.60	388.75
Swift Run	129.04	209.95	729.80	672.83	802.14	671.31
Direct Drainage	NA	NA	NA	NA	NA	NA

The entire area, with the exception of Fleming Creek (outside of the TMDL drainage area), should be targeted for bacteria reduction activities. While progress can be seen in the data trends, more effort is necessary to meet water quality standards and return these creeks and the river to full recreational use. Particular targets for remedial activities are Allens, Malletts and Swift Run creeks, as these are the largest drainages that likely contribute the most bacteria to the river and ponded waters where most recreation occurs.

2.5.2.3 Biota TMDL for Malletts Creek

The reach of Malletts Creek from its confluence with the Huron River at South Pond Park upstream to Packard Road has been listed as an impaired water due to poor fish and macroinvertebrate monitoring results. The impairment is based on data collected by EGLE in August 1997. A TMDL was established to address this impairment in August 2004 (Appendix B1).

Data collected by EGLE in 2002 and 2003 at two sites in the Malletts Creekshed indicated that fish and macroinvertebrate populations were acceptable. Habitat assessments conducted during the same time rated the sites as “good.” However, individual measures of flow and bank stability suggested unstable conditions. Also, HRWC data through 2005 for lower Malletts sites consistently rated the sites as “poor.” For these reasons, the TMDL was established.

The primary sources of concern for poor fish and macroinvertebrate conditions are hydrologic alteration and excessive sedimentation due to urban and suburban development. Reductions in storm sewer runoff rates and solids loads from both commercial and municipal storm water runoff sites, along with reduced stream bank erosion through more stable flow management are necessary to reduce impacts on the aquatic life.

Biota impairments do not lend themselves to direct loading calculations. Because of this fact, along with the concern about sediment dynamics in the system, the focus of loading calculations for the TMDL establishment was on total suspended solids (TSS). While the primary goal is to improve fish, macroinvertebrate, and habitat measures, TSS measurements will be used by EGLE to further assess improvements in Malletts Creek as a secondary goal. This secondary goal is represented by a mean annual, in-stream TSS concentration target of 80 mg/l to characterize wet weather runoff/washoff events. The mean annual target concentration of 80 mg/l TSS is based on a review of existing conditions and published literature on the effects of TSS by the EGLE. This secondary numeric target may be overridden by achievement of the biological and habitat numeric targets. However, if the TSS numeric target is achieved, but the biota or habitat numeric targets are not achieved, then the TSS target may have to be reevaluated.

This secondary goal has the added benefit of being consistent with goals to reduce phosphorus loading under the Ford and Belleville Lakes TMDL. According to the Malletts Creek Restoration Plan (Appendix B2), the plan targets a 50% reduction in total phosphorus, which is characterized as “…functionally equivalent to the mean TSS concentration of 80 mg/l.”

Table 2.15. Annual TSS loads based on NPDES permitted point sources and various land use categories in the Malletts Creek watershed. Estimated annual TSS loads and recommended TSS reductions (WLA and LA) are derived. (Source: Malletts Creek TMDL, EGLE)

Source Category	Acres	Estimated Current TSS (Pounds/Year)	TMDL Target Load TSS (Pounds/Year)
<u>WLA Components</u>:			
NPDES Individual/General Permitted Point Source TSS Load:		127,396	127,396
NPDES Permitted Storm Water TSS Load:			
Residential	2422	496,343	
Industrial	535	202,971	
Commercial and Service	686	405,831	
Transportation/Comm/Util.	232	68,643	
Subtotal:		1,173,788	985,853 (16% reduction)
WLA Total:	3875	1,301,184	1,113,249
<u>LA Components</u>:			
Agricultural Land			
Cropland	787	53,822	29,695 (45% reduction)
(Background Sources)			
Forested/Shrub/Open Land			
Deciduous Forest	437	10,512	10,512
Openland/Shrub/Rangeland	1559	37,500	37,500
Conifer Forest	8	192	192
Wetland			
Forested	9	191	191
Water Body			
Lake/Reservoir	21	445	445
LA Subtotal:	2821	102,662	78,535
Overall Totals:	6696	1,403,846	1,191,784 (Total 15% reduction)

At the time of the TMDL development, the estimated total annual TSS load from all NPDES permitted storm water discharges (there are no point sources identified), was approximately 651 tons (1.3 million pounds). Additional non-point source discharge (outside of stormwater areas) and background sources account for 51 tons, for an overall total load of 702 tons (1.4 million pounds). The TMDL target load of 596 tons of TSS will require a 15% overall reduction in loading (106 tons) – 16% reduction in storm water sources and 45% reduction in agricultural sources.

Since the original TMDL evaluation, conditions in Malletts Creek have improved significantly. HRWC monitors sites throughout the watershed for aquatic insect diversity and sensitive family counts. The downstream site in Malletts Creek at Chalmers Road has seen a steady and significant increase in insect diversity in both Spring and Fall sampling. The Fall 2018 count of 14 is the highest on record for the site, and would move the site from a poor to a fair rating. Sensitive families have not returned to the site, however. The Chalmers Road site also received a habitat rating of 68.5 in 2016, which is conducive to diverse biota populations.

HRWC also monitors the Chalmers Road site for TSS twice per month, April through September. TSS concentrations are generally low, with a mean concentration of 22 mg/l. However, TSS can exceed 80 mg/l target during larger storm events. In the most recent 5 years, the TSS concentration only exceeded the 80 mg/l target twice (both in 2018). Generally, it appears that Malletts Creek may be meeting the TMDL targets at the downstream sampling station. It should be re-evaluated to determine if the TMDL can be removed; DNR fish sampling and new EGLE macroinvertebrate sampling should be conducted at Chalmers Road to start this process.

2.5.2.4 Biota TMDL for Swift Run

The reach of Swift Run from its confluence with the Huron River at South Pond Park upstream to Ellsworth Road has been listed as an impaired water due to poor macroinvertebrate monitoring results. The listed impairment is based on data collected by EGLE in August 1997. A TMDL was established to address this impairment in November 2004 (Appendix F).

Data collected by EGLE in 1997 at Hogback Road rated the macroinvertebrate community as "poor." Further sampling by EGLE in 2003 at Shetland Drive also rated macroinvertebrate communities as poor. Habitat assessments conducted during the same times rated the Hogback site as "fair" or moderately impaired, and the Shetland site as "good." However, individual measures of flow and bank stability suggested unstable habitat conditions at both sites. For these reasons, the macroinvertebrate community was considered impaired and the TMDL was established.

As with the TMDL for biota in Malletts Creek to the west, the primary sources of concern for poor macroinvertebrate conditions in Swift Run are hydrologic alteration and excessive sedimentation due to urban/commercialized development. Reductions in storm sewer runoff rates and solids loads from both commercial and municipal storm water runoff sites, along with reduced stream bank erosion through more stable flow management are necessary to reduce impacts on the aquatic life.

Biota impairments also do not lend themselves to direct loading calculations. Because of this fact, along with the concern about sediment dynamics in the system, the focus of loading calculations for the TMDL establishment was on total suspended solids (TSS). While the primary goal is to improve fish, macroinvertebrate, and habitat measures, TSS measurements will be used by EGLE to further assess improvements in Swift Run as a secondary goal. This secondary goal is represented by a mean annual, in-stream TSS concentration target of 80 mg/l to characterize wet weather runoff/washoff events. The mean annual target concentration of 80 mg/l TSS is based on a review of existing conditions and published literature on the effects of TSS by EGLE. This secondary numeric target may be overridden by achievement of the biological and habitat numeric targets. However, if the TSS numeric target is achieved, but the biota or habitat numeric targets are not achieved, then the TSS target may have to be reevaluated.

This secondary goal has the added benefit of being consistent with goals to reduce phosphorus loading under the Ford and Belleville Lakes TMDL. According to the Malletts Creek Restoration Plan (Appendix B2), the plan targets a 50% reduction in total phosphorus, which is characterized as "…functionally equivalent to the mean TSS concentration of 80 mg/l."

Table 2.16. Land use categories and TSS loads in the Swift Run Creek watershed, Washtenaw County, Michigan (Source: Swift Run TMDL, EGLE; Scott Wade – LTI [2003a] using 2002 [Ann Arbor] and 1998 [Township] land use coverages)

Source Category	Acres	Estimated Current TSS (Pounds/Year)	TMDL Target Load TSS (Pounds/Year)
<u>WLA Components</u>:			
NPDES Individual/General Permitted Point Source TSS Load:		None	None
NPDES Permitted Storm Water TSS Load:			
Residential	678	138,943	138,943
Industrial	13	9,861	5,295 (46% reduction)
Commercial and Service	627	185,514	185,514
Transportation/Comm/Util.	600	177,526	177,526
Subtotal:		511,844	507,278 (<1% reduction)
WLA Total:	1,918	511,844	507,278
<u>LA Components</u>:			
Agricultural Land			
Cropland	349	23,868	13,168 (45% reduction)
(Background Sources) **Forested/Shrub/Open Land**			
Openland/Shrub/Rangeland	702	16,886	16,886
Water Body			
Lake/Reservoir	9	191	191
LA Subtotal:	1,060	40,945	30,245
Overall Totals:	2,978	552,789	537,523 (Total 3% reduction)

At the time of the TMDL development, the estimated total annual TSS load from NPDES permitted stormwater discharge (no point sources were identified), was approximately 256 tons (511,844 pounds). Additional non-point source discharge and background sources account for 20 tons, for an overall total load of 276 tons. The TMDL target load of 269 tons of TSS requires only a 3% overall reduction in loading (<1% reduction in stormwater sources and 45% reduction in agricultural sources), or a total load reduction of 7.6 tons per year. It was later determined that the City of Ann Arbor's landfill was misidentified as agricultural land, so most of the focus will need to be on practices to reduce peak flow rates and sedimentation from stormwater sources.

Since the original TMDL evaluation, conditions in Swift Run have not changed significantly. HRWC monitors sites throughout the watershed for aquatic insect diversity and sensitive family counts. The downstream site in Swift Run at Shetland Drive has seen a modest and statistically insignificant increase in insect diversity in Fall and no perceptible change in Spring sampling. All biota indicators suggest the site continues to have poor conditions for diverse populations.

HRWC also monitors the Shetland Drive site for TSS twice per month, April through September. TSS concentrations are generally low, with a mean concentration of 35 mg/l. However, TSS regularly exceeds the 80 mg/l target during storm events. In the most recent 5 years, the TSS concentration exceeded the 80 mg/l target seven times, though not in the most recent year (2019). Generally, it appears that Swift Run is not meeting the TMDL targets at the downstream sampling station. Activities to address altered hydrology, erosion and sedimentation should be implemented to improve conditions for stream biota.

2.5.2.4 Statewide Bacteria TMDL that Includes Fleming Creek

The latest TMDL for the watershed is Michigan's statewide TMDL for bacteria (Appendix M), which was approved by the U.S. EPA on July 29, 2019. No part of the watershed was listed in the original version of the TMDL. However, Fleming Creek was listed in the 2018 Addendum to the TMDL (also included in Appendix M).

To remove the reach from the impaired waters list, it will need to meet the water quality standard for pathogens. For the TMDL, the standard organism count of 130 per 100 milliliters (ml) as a 30-day geometric mean between May 1 to October 31 was used. Given the recent listing of Fleming Creek on the impaired waters list and within this TMDL, no implementation plan has yet been developed by affected stakeholders.

Data on counts for *E. coli* bacteria for the TMDL listing were limited. One set of 23 samples was collected in 2001 for a DEQ study. They were not collected to conform with the 30-day TBC standard. Of these samples, 15 (65%) met the single-sample TBC standard, 4 samples (17%) exceeded just the TBC standard of 300 *E. coli* per 100ml, and 4 samples (17%) also exceeded the PBC standard of 1,000 E. coli per 100 ml.

As discussed earlier in this chapter, HRWC sampling data at the downstream station in Fleming Creek are roughly consistent with the 2001 findings, though conditions appear to have gotten slightly better. Generally, bacteria concentrations are fairly low. The geomean of bimonthly sampling from April through September since 2010 is 124 counts per 100 ml. That is below the strictest 30-day standard of 130 counts per 100 ml. However, over those last 10 years (n=106 samples), 75% of individual samples met both standards, 13% exceeded the TBC standard only, and 12% exceeded the PBC standard. In the most recent year of sampling, the geomean was 152 E. coli per 100 ml, 75% of samples met both standards, 25% of samples exceeded the TBC and no samples exceeded the PBC standard. Overall, samples at the downstream site appear to be trending down, though the trend is not significant. So, in summary, Fleming Creek continues to exceed the state water quality standard, though not by much.

Since this is a new listing that was discovered at the end of the plan development process, HRWC has not had sufficient time to evaluate potential bacteria sources in the Fleming Creek watershed. However, in addition to the long-term, downstream monitoring station at Parker Mill, four investigative sites were monitored for a single season each (7-12 samples). Bacteria counts at these sites can be directly compared to results at the downstream site as they are taken on the same day. Two sites upstream on the main Fleming Creek channel showed little difference from the downstream site (-77% and +12% differences). Sampling at two sites on the westernmost tributary showed significantly higher bacteria counts (+1,062% and +166%). In between these sampling stations is a large farm with significant number of livestock of various types. This potential source should be further investigated.

Other potential pathogen sources for the listed waterbody may include sources typically associated with urban and suburban runoff because the immediate watershed is composed of these land types, but additional agricultural sources (such as livestock and manure application) are also possible.

Based on this information, Fleming Creek should be added to the target area for bacteria reduction activities. While progress can be seen in the data trends, more effort is necessary to meet water quality standards and return this creek to full recreational use.

Chapter 3:
Climate Change and Threats

3.1 Introduction

A dramatic increase in the concentration of greenhouse gases in Earth's atmosphere is causing warmer global temperatures.[1] The effects of these warmer temperatures manifest in different ways at a regional scale based on geography, topography, and other natural climate factors. In the Great Lakes region, and specifically in southeast Michigan, changes in precipitation and temperature have been observed in the historical data records, and models predict many changes will grow in frequency and magnitude. Because natural systems have evolved within a range of relatively stable climate conditions, it is critical to consider the implications of current and future deviations from historical climate conditions when managing natural resources.[2] The watershed management planning process is a critical time to capture and consider impacts of climate change on river systems. It is also an effective time to consider how the prioritization of strategies should adapt to dynamic conditions and how communities can prepare for extreme events. This chapter summarizes the best available climate information relevant for planners in the region and discusses the implications of changes in precipitation and temperature on critical watershed variables.

3.2 Climate Data Summary

The observed and projected changes in the climate data relevant to the Huron River watershed are consistent with the changes observed across southeast Michigan (described by NOAA as Michigan Climate Division 10: Southeast Lower Michigan)[3] and at a high-quality, long-term observational station at the University of Michigan (located in the Middle Huron watershed). More broadly, they are consistent with trends described for the Upper Midwest and Great Lakes region. Air, water, and land surface temperatures are rising. The form, seasonal timing, and volume of precipitation is changing. Heavy precipitation events are becoming more frequent and more severe. These changes are directly affecting watershed management, planning, and implemented best practices in the Huron River watershed.[4] [5] [6] [7] [8]

3.2.1 Ann Arbor and Regional Climate Summary

- The average air temperature across southeast Michigan increased by 2.4°F from 1950 through 2017.

- Average air temperatures in southeast Michigan are expected to rise by approximately 3.1°F to 5.2°F by 2050, relative to 1980-1999.
- Total annual precipitation measured in Ann Arbor increased by 44.6% from 1951 through 2019, relative to the 1951-1980 reference period.
- In the Midwest, the total volume of precipitation falling within the heaviest 1% of precipitation events increased by 42% since 1958.[9]
- Total annual precipitation will likely increase in the future, though types of precipitation will vary (i.e., more winter precipitation in the form of rain). [10]

Table 3.1 Historic climate normal and projected changes in key climate parameters for the Huron River watershed and southeast Michigan. Data provided in this table is based on observational data in the Global Historical Climate Network-Daily (GHCN) dataset, projections from Climate Model Intercomparison Project Phase 3 (CMIP3) and Phase 5 (CMIP5), RCP8.5, and a methodology for Dynamical Downscaling for the Midwest and Great Lakes Basin.[11 12 13]

Climate Parameter	Historic Ann Arbor (1981-2010)	Change by Mid-Century, 2040-2059 (RCP8.5)	Change by End of Century, 2070-2099 (RCP8.5)
Average Temperature	49.8°F	3.1 to 5.2°F	6.5 to 10.0°F
Winter	27.1°F	2.0 to 4.4°F	5.0 to 8.5°F
Spring	48.4°F	1.9 to 5.5°F	4.6 to 11°F
Summer	71°F	4.0 to 6.4°F	8.2 to 12.0°F
Fall	52.2°F	3.2 to 5.9°F	6.9 to 11.7°F
Average Low Temperature	40.4°F	3.3 to 5.4°F	6.7 to 10.5°F
Average High Temperature	59.1°F	3.1 to 5.3°F	6.4 to 9.8°F
Days/Year Greater than 90°F	8 Days	13 to 30 Days	31 to 64 Days
Days/Year Greater than 100°F	2 to 4 Days	3 to 17 Days	11 to 38 Days
Days/Year Less than 32°F	122 Days	27 to 23 Fewer Days	Not Available
Total Annual Precipitation	36.7 in.	0.3 to 3.8 in. (1.0 to 10.3%)	1.3 to 6.2 in. (3.5 to 16.9%)
Winter	7.9 in.	-0.5 to 2.5 in. (-6.3 to 31.2%)	-1.48 to 1.79 in. (-18.7 to 27.8%)
Spring	9.3 in.	-0.7 to 2.27 in. (-7.5 to 24.4%)	0.04 to 2.9 in (<-1% to 31.2%)
Summer	11 in.	-0.7 to 2.9 in. (-6.4 to 26.4%)	-1.0 to 0.8 in. (-9 to 7.3%)
Fall	9.4 in.	-0.4 to 0.6 in. (-4.3 to 6.4%)	0.53 to 1.89 in. (5.6 to 20.1%)
Heavy Precipitation Days/Year (>1.25")	3.7 Days	0.4 to 2.8 Days	2.4 to 2.8 Days/Year

3.2.2 Average and Extreme Temperatures

3.2.2.1 Average Temperature

The average air temperature in southeast Michigan has risen 2.4°F, which is consistent with much of the Great Lakes region. The more localized Ann Arbor area, however, has seen a more moderate increase of 1.0°F from 1951 to 2019, and the historical annual average temperature from 1980-2010 was 49.8°F. Average seasonal temperatures have also increased. Winter and spring temperatures have risen at a faster rate and warming has been distributed relatively evenly between daytime high temperatures and overnight lows.

Relative to the 1980-1999 historical reference period. Average temperatures in Ann Arbor are projected to increase by approximately 3.1 to 5.2°F by mid-century under a high emissions scenario that's consistent with the historic trajectory of increasing emissions (RCP 8.5, often described in the past as a "business as usual" scenario). The projected warming is distributed throughout the year, with the summer and fall season having somewhat higher projected ranges.[14]

3.2.2.2 Hot Days

The number of days per year with high temperatures exceeding 90°F have begun to increase slightly over time. Year-to-year variability is high, however. Days exceeding 100°F are statistically infrequent, and the average annual occurrence has remained relatively flat and within the range of annual variability. Most years on record have experienced 2 to 4 consecutive days over 90°F, with events of 5 to 7 consecutive days occurring less frequently. By mid-century (i.e., 2050), models suggest an increase of anywhere from 13 to 30 more days per year over 90˚F, and an increase of 31 to 64 more days per year over 90°F by end of century. Models are not able, however, to tell us if those days will be consecutive or not.

The number of days per year with high temperatures at or above 95˚F has shown little to no change since the middle of the 20th century. Events of consecutive days experiencing maximum temperatures over 100˚F are also quite rare and have not significantly increased or decreased in frequency. By mid-century (i.e., 2050), models project 3 to 17 more days per year over 100˚F, and an increase of 11 to 38 days per year over 100°F by end of century. However, such extremely hot days will not likely occur consecutively.

Heat waves can result from a combination of different drivers including high humidity, daily high temperatures, high nighttime temperatures, stagnant air movement, etc. In the future, models project an increase in the number of days experiencing high temperatures that could lead to additional heat waves, especially since air stagnation events are projected to increase. There is greater certainty that summer nighttime low temperatures will continue to increase, thereby making it more difficult to cool off at night during extended heat events. In addition, any periods of future drought may also contribute to extreme heat.[15] [16]

3.2.2.3 Cold Days

From 1981-2010, Ann Arbor experienced 122 days per year that fell below freezing (32°F), on average. Historical records show this number has decreased already. The city is projected to experience fewer nights below 32°F with decreases of 23 to 27 days by mid-century.

Significant for many natural ecosystems and built environments, models project modest decreases in the number of days falling below 20°F, with about 3 to 10 fewer days per year dropping below this threshold.

Days with temperatures at or below 10˚F are relatively common and have not experienced any clear trends over time. Consecutive days at or below 10˚F also common, and typically last for 2 to 7 days with less frequent occurrences lasting 8 to 15 days. In the future, there are projected to be substantially fewer 10°F cold days, so this type of event could become rare. Some models project few or no cold days dropping below this temperature by the mid or late century.[17]

3.2.2.4 Changing Seasonality

The Watershed experienced approximately 170 to 180 days per warm season (reference period of 1981-2010) in which the minimum temperature remains above 32°F. This is referred to as the growing season length or freeze-free season. With warmer temperatures, the growing season length is expected to last for a longer duration each year, with many studies projecting growing seasons 1 or 2 months longer by 2100. The parameter of climate is strongly influenced by hyperlocal factors, including local land use, so while the broad trajectory of a warmer, longer growing season is clear regionally, actual observations in specific locations will vary.

3.2.3 Precipitation and Flooding

3.2.3.1 Total Precipitation

The amount of total annual precipitation in Ann Arbor has increased by 44.6% (13.5") from 1951 through 2019. An increase in precipitation was observed in all four seasons, with the winter seeing the greatest percentage increase of 68.1% (3.9"). On average, most models project total annual precipitation in southeast Michigan to increase by 5 to 11 percent by mid-century compared to the period 1980-1999. The methodology presented in table 3.1 projects a broader range, though most models used in that analysis also project increases above 5%. Precipitation projections have a broad range of uncertainty, however, and seasonal variation and interannual variability are expected to increase in magnitude, potentially creating multi-year periods that either much wetter or much drier than the prevailing long-term trend.

3.2.3.2 Seasonal Precipitation Totals and Form

Across the Great Lakes region, projected changes in seasonal mean precipitation span a range of increases and decreases. This broad regional uncertainty is due in part to uncertainty in how the Great Lakes themselves will respond to warmer conditions. Generally, evaporation and decreasing soil moisture may play an increasingly important role on the region's hydrologic cycle at the end of the century, reducing available moisture for precipitation. On the other hand, there is also evidence that warm, humid air masses advected farther north from a changing Gulf Stream pattern may deliver more precipitation to the Great Lakes basin. In the winter and spring, the region is projected to experience wetter conditions as the global climate warms. By mid-century, some of this precipitation may manifest in the form of increasing snowfall, but projected warmer conditions by end of century suggests such precipitation events will most likely be in the form of rainfall.[18]

There has been a slight decreasing trend in historic heavy hourly snowfall (events with snowfall over 1") with varying year-to-year conditions, and little to no change in hourly snowfall exceeding 2". Generally, warmer temperatures in the future will cause some winter precipitation to fall in the form of rain rather than snow. As a result, annual snowfall is projected to decrease by 7" to 17" by mid-century, and decrease by 20" to 40" by end of century. Unlike areas in lake effect snowbelts, the Huron River watershed is not anticipated to see significant effects on precipitation due to potential changes in lake effect snow patterns. It is plausible that southeast Michigan may see some years without measurable snowfall by the end of the 21st century.

3.2.3.3 Rain Free Periods

Drought (defined here as periods of 3 weeks with less than 0.45” of rainfall) has been highly variable year-to-year, with slight decreasing trends in summer and fall events and a slight increasing trend in spring events. In the future, even though more annual precipitation is projected overall, more is anticipated to fall in shorter, extreme events. Thus, there will be longer periods of time that experience no rainfall, increasing the potential for drought. Most models project this effect to be most pronounced during the summer months.

3.2.3.4 Extreme Precipitation

The frequency and intensity of severe storms has increased. Ann Arbor has seen a 41.2% increase in the number of heavy precipitation events (36 storms from 1951-1981 compared to 51 storms from 1981-2010). Ann Arbor experienced an average of 3.7 days per year with precipitation totals that exceeded 1.25” from 1981-2010, and approximately 1 day per year with totals exceeding 2”. Daily precipitation events exceeding 3” are rare and generally occurred once every 5 to 10 years.

Future projections of extreme precipitation vary tremendously at sub-regional scales and between individual models. There is broad agreement, however, that heavy precipitation events will continue to become more frequent and increase in magnitude. Southeastern Michigan is projected to experience approximately an 0.4 to 2.8 (11 to 78%) increase in days of 1.25” precipitation events by mid-century. Heavy precipitation events of more than 2” in a day (i.e., 24-hour period) are projected to increase by no more than one day (0.25 to 1 days) by mid-century and increase by slightly more (0.75 to 1.25 days) by end of century. Changes in the frequency of precipitation events of more than 3” in a day are difficult to project at the regional and subregional scale due to their relative infrequency, though most models project increases in frequency at a rate faster than that of smaller magnitude storms.

A 2020 study found that human activity is causing the intensification of extreme events across North America. With relatively conservative warming of 1°C, storms that historically would have been expected to occur every 20, 50, or 100 years will likely become 4 to 5 times more likely. Storms that historically would have been expected to recur in 20, 50, and 100 periods were projected to occur every 1.5 to 2.5 years, on average, with +3°C of global warming. This would represent a 13- to 40-fold increase in the occurrence of catastrophic storms. Warming of 3°C or more is well within the range projected by global climate models in when humans fail to substantially reduce global carbon emissions by 2050.[19]

3.2.3.5 Flooding

Flooding results when rainfall volumes exceed the capacity of natural and built infrastructure to handle precipitation. Stormwater managers look at several different “design” storms (inches falling over a certain length of time) when designing and managing their systems. These “design” storms are effectively the probability of any given amount of precipitation falling in a set period of time, based on historical experience. Monitoring over time shows that the volumes falling during these “design” storms are increasing.

Table 3.2 below shows precipitation volumes in inches for both Bulletin 71 and Atlas 14, following the format: (Bulletin 71/Atlas 14). Bulletin 71 used data through 1986, and Atlas 14 added more recent data from 1987-2011.[20] [21] The percent change is reported in brackets. All percent change values are positive which means they are larger in Atlas 14. This data shows how the "design" storm thresholds have increased over time.

Note that Table 3.2 does not account for projected changes in these design storms. Broadly, future changes are expected to follow or exceed historical rates of change, with larger storms seeing a greater rate of change.[22] While total annual precipitation for the Midwest is projected to increase by 5-10% by mid-century, heavy storms likely to occur once in 25 years are projected to increase by 20 percent.[23]

Table 3.2 Observed Changes in Precipitation Frequencies for the City of Ann Arbor from NOAA Bulletin 71 and NOAA Atlas 14.

	1-Yr	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
1-hr	0.88/0.969 [10%]	1.06/1.14 [8%]	1.29/1.44 [12%]	1.47/1.70 [16%]	1.69/2.07 [22%]	1.87/2.38 [27%]	2.05/2.69 [31%]
12-hr	1.63/1.82 [12%]	1.97/2.06 [5%]	2.39/2.50 [5%]	2.72/2.90 [7%]	3.13/3.54 [13%]	3.46/4.09 [18%]	3.79/4.68 [23%]
24-hr	1.87/2.09 [12%]	2.26/2.35 [4%]	2.75/2.83 [3%]	3.13/3.26 [9%]	3.60/3.93 [9%]	3.98/4.50 [13%]	4.36/5.11 [17%]

3.3 Effects on River Systems and Natural Areas

River systems of the Upper Midwest face numerous effects due to climate change. Water quality, water quantity, the watershed's ecosystems services, and its functions as natural habitat will all face changes and may become impaired.

3.3.1 Effects on Forests

Changing temperatures may change the distribution of trees and plants as well as their growing season.[24] [25] [26]

Natural ecosystems in Michigan are being altered by warming temperatures, changes in precipitation, changes in land-use, and by an influx of invasive species. These factors commonly exacerbate the negative effects of each other.[27] Warmer temperatures are driving many tree species northward, and many native species well-suited to their historical climate have not been able to migrate as fast as their optimal climate range is shifting. Tree species currently near the northern extent of their suitable range may decline in number as they will not likely be able to migrate fast enough to outcompete species suited to encroaching climate conditions from the south. Species currently populating forests in more southern extents of their range will likely continue to shift northward in distribution. Maple, Beech, and Birch forest stands are vulnerable to climate change and associated stresses. Sugar maples, for example, may become less productive while red maples, several variety of oaks, and hickory may gain a competitive advantage.

The migration of native species northward is uncertain, however, as the fragmentation of midwestern forests and the flatness of the terrain raise the possibility that the ranges of particular tree species will not be able to shift to future suitable habitats within the Midwest.[28] To reach areas 1.8°F (1°C) cooler, for example, species in southern Michigan's relatively flat terrain must move up to 90 miles (150 km) north to reach cooler habitat, whereas species in mountainous terrain can shift higher in altitude over much shorter latitudinal (north–south) distances.[29]

3.3.1.1 Increased Stressors on Forests

Changes in climate will allow nonnative, invasive plants, insects, and pathogens to expand their ranges.[30] [31] [32] Pests and diseases will also become further established with warmer winter temperatures, and some pest insects have already been able to expand their ranges northward.[33]. Increased spring precipitation has been favorable to bur oak blight in Iowa and some parts of Illinois.[34] Forest pests and pathogens also disproportionately stressed ecosystems.[35] [36]

Non-native species and invasive species, on the other hand, particularly those limited by the northern extent of their temperature range, are often expected to spread rapidly and out-compete native species. It is also possible that nonnative plant species will take advantage of shifting forest communities and unoccupied niches if native forest species are limited. [37] [38] Nonnative invasive species such as honeysuckle, reed canary grass, and common buckthorn will likely be favored by future conditions brought on rapidly by climate change.[39] The reproduction and survival of emerald ash borers, the destructive invasive insect that attacks native ash trees, will increase due to warming winters in the region. Mortality of black ash trees, is even more likely in the future than current conditions as winter temperatures continue to rise.[27]

3.3.2 Effects on Wildlife

Rapid climate change through the 21st century will stress most species in southern Michigan and accelerate the rate of species declines and extinctions with potentially severe implications for loss of biodiversity. Interactions between climate change and other stressors, such as invasive species, habitat loss and fragmentation, and hydrologic modifications.

As with forests and other ecosystems, Michigan's relatively flat topography and high latitude position will force wildlife to shift their ranges (or retreat) particularly fast relative to species in other parts of the continental U.S. to keep up with the pace of even moderate rates of projected warming. Wildlife movements will often be limited by critically fragmented and diminished natural land cover, or lack of appropriate aquatic habitat. The presence of human-created barriers, such as large tracts of uninterrupted agricultural land or developed areas will exacerbate challenges for wildlife. The Great Lakes, and Michigan's abundant inland lake systems also create natural barriers to migration for terrestrial wildlife. The combined effect of these natural and human-created stresses puts wildlife in the Midwestern United States at particular risk.[40]

3.3.2.1 Changes in Bird Nesting and Migration Patterns

The wintering ranges of at least 305 North American bird species has shifted northward with warming temperatures by more than 40 miles since 1966. The trend is closely related to increasing winter temperatures and increasing overnight low temperatures, which have been rising in Michigan and in connected bird migration corridors.[41]

Overall, the migration routes and wintering areas of birds have also shifted away from ocean and Great Lakes coasts since the 1960s. A shift away from the large water bodies may relate to warming winter temperatures. Inland areas tend to experience more extreme cold than coastal areas, and those extremes are becoming less severe as the climate warms overall, making previously less hospitable zones more hospitable.[41]

The seasonal timing of bird migration has also changed. Many bird species are migrating northward earlier in the spring and/or later in the fall. In extreme cases, warmer temperatures and available food supplies have allowed some bird populations to remain resident in one location and have not migrated. For long-distance migrants, change in migration timing can desynchronize birds from the phenology of their food sources, as every species may adapt in different ways, with different capacity, and at different rates.[42]

Riverine habitat, wetlands, and other habitat types that bloom and emerge from winter earlier due to their proximity to water may provide increasingly critical oasis habitat and corridors through varying conditions for migrating birds. This may be particularly true in areas dominated by agriculture where nearby natural habitat is sparse, or in areas near migratory routes and adjacent to expansive agricultural areas like the Huron River watershed.[43] [44] [45]

3.3.2.2 Efffects on Fish and Aquatic Species

For freshwater and coastal species in southeastern Michigan, interactions between climate change, changes in land cover, and changes in hydrology will have significant effects. Land cover plays a very important role in determining the hydrologic and energy balance of a natural system. The removal or alteration of vegetation can and will shift these balances in ways could increase run-off, promote flooding, reduce precipitation and nutrient uptake, and deprive species of cool, shady relief, all of which would put stress on sensitive species and habitats.

Changes in air temperature and precipitation will affect water temperature and flow in streams and in groundwater inputs to spring ponds. Many lakes in Michigan and in the Huron River watershed stratify during the summer, with the coldest layer at the bottom.

As air and water temperatures warm and the seasonality of precipitation and runoff changes, the stability and duration of deep coldwater layers will be affected, reducing the suitability for coldwater fish. Dissolved oxygen will also be depleted to an extent stressful or harmful for many fish species during periods of prolonged stratification. The result may be the decline of coldwater fish populations.[46] [47]

The effects of climate change on freshwater mussels is still a developing area of research. There is broad concern among experts that rising temperatures may be negatively affecting freshwater mussel species, but there are relatively few studies applicable to any specific region of the country of the mussel species native to the Huron River watershed. Studies continue to indicate cause for concern and further caution.[48]

3.3.4 Effects on Wetlands

Michigan and other northern latitudes are not immune to drought levels that stress ecosystems. Some climate models project an increased risk in summer droughts for the Great Lakes region, but the long-term, broad effects of such droughts on wetland areas is still uncertain. There is greater concern for some specific effects, such as loss of spawning habitat for fish species like pike due to increased temperatures, concentration of precipitation into larger storms, and greater evaporation.[49]

Climate change may negatively impact vernal pools and other seasonally dependent wetlands. While climate models project increases in annual precipitation totals, the range of future projections in seasonal precipitation totals is large.[50] Future evaporation rates over land areas in the late-spring, summer, and early fall are also expected to increase with warmer temperatures, which may polarize wet and dry seasons, stressing or eliminating vernal pools as viable habitats.[51]

3.3.4 Effects on Erosion

Increased stream flow destroy habitat and scour the banks causing greater erosion. A greater frequency and magnitude of heavy precipitation events likely means the region will experience increased runoff, more rapid erosion, more pollutants being carried to the streams and river, and heavier sediment loads that can cause issues for fish life. The Middle Huron watershed straddles many particularly vulnerable landscapes that straddle both agriculture and areas of new, rapid urban and suburban development. These landscape types, without proper management practices, can erode rapidly as they are repurposed for residential and commercial development, or if the current management practices in agricultural areas are insufficient.

3.3.5 Effects on Water Quality

3.3.5.1 Sewage Overflows and Treatment Plant Discharges

Climate change will intensify other stresses on aging infrastructure in the Huron River watershed. In recent years, the increase in heavy downpours has contributed to the repeated discharge of untreated sewage to the river or its tributaries in several communities. While communities with combined sewage-overflow systems are more vulnerable to sewage discharges due to extreme precipitation events, communities with separate sanitary and storm sewers are also at increasing risk. Insufficient storage and treatment capacity at wastewater treatment plants is a major factor.

3.3.5.2 Related to agricultural landscapes

Many water quality effects derived from agricultural land management are related to soil water excess. Southeastern Michigan has seen an increase in annual precipitation with the largest percentage increases in the spring and fall. These shifting precipitation patterns coupled with more extreme precipitation events may harm water quality by increasing the transport of sediment, nitrate, and phosphorus to surface water bodies. There is evidence that annual variation in nitrate loads are related to annual precipitation amounts especially in the presence of extensive subsurface drainage where significant leaching may occur. Parts of the Huron River watershed are extensively subsurface drained area and these drains could carry nitrate from the during saturated soil conditions and heavy precipitation events, conditions expected to become more likely in the future.[52]

Stronger, more frequent storms particularly in both extended wet periods and following extended dry periods will likely increase surface runoff and erosion. The mechanism for erosion differs in these conditions. During particularly wet periods, transport over saturated soil can increase the distance which nutrients and sediment are carried. It can also destabilize roots systems and compromise the integrity of subsurface soil. Following dry periods, surface soils may be compromised, and rapid transport of surface sediment is possible. Potential increases in soil erosion with the increases in rainfall intensity show that runoff and sediment movement from agricultural landscapes will increase. [53]

3.3.5.3 Waterborne Disease and Heat

Changing climate conditions are altering the distribution and prevalence of waterborne illnesses around the globe and within the United States, making it possible for disease vectors to become established in areas previously in inhospitable climates.[54]

Warming temperatures may be increasing the risk of infectious waterborne diseases in Michigan. Of particular concern for much of Michigan is Legionella. Legionella is a naturally occurring bacteria usually found in warm water. Exposure through inhalation of mists or vapors from contaminated water can cause lung infections known as Legionnaires' disease or, in rare cases, Pontiac fever, collectively known as legionellosis. Legionella is the most frequently reported cause of water-related disease outbreaks in the U.S. and is usually associated with exposure to water in conditions of heat, stasis, and aerosolization that optimize transmission. Roughly 200 cases of Legionellosis are reported to the CDC from Michigan each year. Legionella species colonize outdoor water reservoirs including potable water systems and cooling towers, and the organisms grow rapidly at temperatures between 85°F to 110°F. Studies in the eastern U.S. and Europe suggest that Legionnaire's disease outbreaks may be associated with warm humid weather, possibly due to increased Legionella growth stimulated by warming of potable water in reservoirs and plumbing. Warm temperatures may also increase population contact with recreational waters, increasing the opportunity for exposure to pathogens in the water.[55]

3.3.5.5 Harmful Algal Blooms

Globally, climate change is driving increases is magnitude, duration, number of affected waterbodies, and health risks of harmful algal blooms. [56]Unless additional conservation actions are taken, the growing frequency and severity of intense spring rain storms in the Great Lakes region throughout this century will likely increase the number and extent of harmful algal blooms and "dead zones" in southeastern Michigan, though the effects on any specific river or lake system is uncertain. More total spring precipitation and stronger storms, combined with the greater availability of phosphorous due to current agricultural practices, means that greater amounts of the nutrient could be scoured from farmlands and into surface waters, fueling algae blooms and hypoxic zones. [57] [58]

The agricultural practices that contribute to increased availability of phosphorous from fertilizer include no-till farming, a method of planting crops without plowing. The technique reduces soil erosion but also leaves high concentrations of reactive phosphorous in the upper surface soil, where it can be more readily flushed out during substantial rainfall. The combination of these factors has caused the western Lake Erie basin to reverse some of the nutrient loading reductions experienced since the 1990s.[59]

While Huron River watershed drinking water sources are not particularly vulnerable to HABs (only Ann Arbor draws it's drinking water from river surface waters), the Huron River watershed contributes nutrient runoff to Lake Erie, a drinking water source that has suffered significant impacts to drinking water due to the presence of HABs.[60]

HABs do affect recreation on the Huron River. Most directly, swimming and fishing suffer, though repeated water quality issues may dissuade people from recreating near the river corridor even when there is little or no risk. Cyanobacteria in HABs is toxic and a skin irritant. Nutrient loading from agricultural and other sources in the above the Middle Huron have contributed to the outbreak of HABs in urban communities along Ford and Belleville Lake. Under future climate conditions (warmer summer temperatures and increased runoff) and without remediation of confounding factors, HABs will likely be more likely on sections of the Huron River in the future. [61]

3.3.6 Effects on Infrastructure

Effects of climate change on infrastructure in southeast Michigan are wide-ranging. Some effects, like the direct damage to stormwater infrastructure or built structures crossing waterways are virtually certain in the absence of intervention, due to the precipitation trends observed and projected. Some of these effects have already been recorded in the Huron River watershed. Heavy precipitation events have led to flashy flows which have overwhelmed stormwater drains, led to flooding, and damaged to infrastructure (bridges, roads, businesses, and residential homes). In some cases, high water tables and a changing groundwater-surface water interface has required deeper wells to protect drinking water.[62]

As the failures of the Sanford and Edenville Dams on the Tittabawassee River demonstrated in 2020, dams are inherently vulnerable to an increasingly severe heavy precipitation and flooding events. Dams have failed on the Huron River in the past as well, and such failures will become more likely across the country due to climate change and aging infrastructure.

Likewise, bridges, pipelines, and other infrastructure that cross waterways, especially rivers, will also become increasingly vulnerable to scouring and erosion.[63] The Middle Huron Watershed includes many urbanized areas with a significant number of intersections of with aging infrastructure. These intersections may be a substantial risk factor for the river over decades without attention or intervention.

Wastewater treatment facilities have been overwhelmed, resulting in damage and, more frequently, the release of untreated sewage. The Dexter wastewater treatment plant was one such facility, and as construction was being completed to increase the plant’s capacity, it failed again, highlighting rapidly changing conditions.

3.4 Implications for Action Planning

3.4.1 Implications for Infrastructure Design and Planning

As described above, the changes in the recurrence of design storms between NOAA Bulletin 71 and NOAA Atlas 14 demonstrate that size and frequency of storms communities need to prepare for has already shifted. Recent studies indicate that the observed trend will continue or accelerate in the future. From Bulletin 71 to NOAA Atlas 14, the sizes of all design storms increased. The 100-year, 24-hour design storm, for example, increased in magnitude by 17% due to both an increase in the frequency and severity of precipitation events. By 2100, 25-, 50-, and 100-year design storms over the Great Lakes region and northeastern United States may occur every 1.5 to 2.5 years, a 10 to 40-fold increase in anticipated frequency relative to the recent past. This implies that much of the infrastructure in the watershed may be insufficiently designed to safely manage and attenuate the current distribution of storms and will be less able to manage future design storms.

The likely increase in the severity and frequency of severe storms carries implication for many elements of built infrastructure. Infrastructure in the intended path of stormwater management will be most affected. This includes drainage networks, culverts, and retention areas in place to present harmful or damaging runoff. Changing storm sizes also likely mean more areas will be vulnerable to flooding, yet floodplains as defined by FEMA do not include projections of future conditions or even guidance for planning future infrastructure in areas potentially vulnerable in the future.

3.4.1.1 Implications for Dams

Notably, given the recent dam failures along the Tittabawassee River, current regulations use past flow conditions for assessing the condition and capacity of dams. High-hazard dams, like many of those that exist in the Middle Huron River, are generally built and maintained to safely manage 200-year floods. The recurrence interval of those floods is affected by the recurrence intervals of extreme precipitation events and underlying total seasonal precipitation. The relation of storm size to in-stream flows is usually not quantified in most watersheds. The coupling of hydrological and climatological models is often an expensive and practical barrier to such assessments, but even if such information was readily accessible, regulations don’t require account of future potential changes in flow. Multiple trends in climatological and hydrological data from across the U.S. indicate this is a major vulnerability for dams and other in-stream infrastructure. The precipitation event that factored in the 2020 collapse of the Edenville and Sanford Dams was a 500-year weather event over much of Michigan, dropping an excess of 7.5 inches in 48 hours, yet an event of similar magnitude happened just 34 years prior over the same area of Michigan, and other low probability precipitation events have occurred more frequently than historical data suggests they should. It is probable that dams, bridges, and other in-stream, built infrastructure will face storms and flow conditions within their anticipated lifetime that are beyond their design specifications and for which their condition rating does not address.

3.4.1.2 Proactive Planning for Dynamic Flood Risk

Proactive planning for continually increasing risk to infrastructure is warranted. The anticipated costs of climate change effects is expected to accelerate in coming decades, and required changes to infrastructure will become more costly and more challenging over time due to aging infrastructure and even greater weather variability. The ability of communities to adapt or avoid local-scale effects of climate change in the future relies heavily on actions taken before the adaptation are critical and necessary. The risk of catastrophic natural disasters is also likely to increase, and rebuilt infrastructure will better prepare communities for addressing potentially unavoidable failures during unprecedented weather events.

Preparing for future storms is challenging for communities without mandates in state or federal regulation, without critical data, and without available funding for large infrastructure projects. Some communities in the Middle Huron watershed currently use available historical data for design storms and, in the absence of quantitative assessment, apply an additional conservative factor to account for future infrastructure needs. This estimated factor assumes a 10-50% increase in the size of the applicable design storm, depending on the community, specific application, cost, and other factors. A more robust and sustainable approach is needed to quantify needs in specific watersheds and reliably fund large infrastructure projects.

3.4.1.3 Green Infrastructure

In many cases, building infrastructure to manage future storms and floods will be impossible or impractical, either due to costs or the rate of change in design storms. In such cases, the use of green infrastructure and natural areas conservation should be incentivized wherever possible to mitigate the pace and magnitude of future changes. Relying on natural ecosystems to attenuate stormwater, runoff, and flooding is inherently dynamic, whereas built infrastructure will always be at least partially static and likely to become obsolete in the future.

The EPA, USGS, the Trust for Public Land and numerous other state, federal, and private firms have found that Green Infrastructure either direct cost savings or value through indirect environmental services such as improvements to public health, though estimates range widely on the amount saved and hyperlocal factors play a major role in cost-benefit analysis.[64]

3.4.2 Citizen Science, Education and Individual Action

Rapid changes in climate and the associated risks of flooding, erosion, and water quality are still not widely understood by many residents and community leaders. The HRWC, municipalities, and community partners will need to continue programs that inform residents and entities about the risks and potential solutions to the challenges we face. Continued and expanded citizen science programs that engage and educate watershed residents is one effective strategy that both serves to inform people and monitor changes over time. HRWC and partners intend bring members of the public into such citizen science efforts and provide an open forum to address any changes observed.

Individual household and property owner actions can amount to significant solutions. Landscaping decisions that reduce runoff, nutrient loading, and municipal stormwater treatment can significantly relieve burdens on built infrastructure while reducing overall community costs, for example. Rain gardens, rain barrels, using less fertilizer for aesthetic purposes, and planting appropriate vegetation are all strategies that can have significant and positive local impact.[65]

3.4.3 Dam Operator Communication and Dam Management

Changing climate conditions and development patterns that lead to less predictable and more extreme flows will require re-evaluating the way Huron River dams are controlled in response to large, sudden storms, how the lifespan of the dams may shorten, how equipped dams are to manage the range of projected storm sizes, and how maintenance costs may change in response to these factors. The designation of larger floodplain areas will likely be necessary in the event of a dam failure, which would require more greater insurance costs for dam owners and a greater number of nearby property owners required to hold flood insurance.

The installation of additional stream gages along the Huron River and its tributaries would be informative to dam operators in forecasting currently unpredictable flows. Over time, a network sufficiently dense stream gages would provide an effective understanding of how storm size and duration over various locations in the watershed translate to flows elsewhere downstream.

Stream gages and additional communication among dam operators will be essential to ensure that downstream dam operators can effectively respond to management actions taken by dam operators upstream. Toward this goal, HRWC currently facilitates a network of Huron River dam operators and is working with researchers at the University of Michigan to install stream gages throughout the watershed and monitor flows following precipitation events.[66]

3.4.4 Development Planning and Land Protection

The Great Lakes region and the Upper Midwest is one region of the United States where many experts expect to see gains in population driven by people migrating from other areas.[67] The summer climate of Michigan will likely hit and subsequently pass what most people feel are optimal summer temperatures.[68] In combination with abundant recreational waters, the Great Lakes region is predicted to remain attractive for tourism, residence, and business are other parts of the country, like the Southern United States, face climate conditions unsustainable for agriculture. Population dynamics are driven by many unrelated factors, but many of these factors indicate our region will see an increase in population, and an increase for housing, through the middle of the 20th century.

Added development pressure could stress watershed health as pervious surfaces and wetlands are developed and more impervious surface constructed. Communities are advised to take a proactive approach to planning, zoning, and land protection in anticipation of accelerated population growth.[69] Protecting existing undeveloped land should be a priority for communities with limited fiscal capacity due to the high rate of economic benefit. The Trust for Public Land has found that land protection creates a $4 to 10 return on investment for every $1 spent on land protection.[70]

In particular, the use of pervious pavements to reduce concentrated runoff during heavy precipitation events, as has been demonstrated throughout the watershed, are recommended. Even better is planning that reduced the amount of artificial pervious or impervious surface needed entirely. Actions that accomplish this at the community scale may be include putting in place proactive ordinances to reduce parking requirements, zoning for higher density in urbanized areas, and prioritizing sustainable transportation means like buses, trains, and bicycle routes. Maintaining existing natural infrastructure or utilizing green infrastructure options when possible is recommended.

3.5 Emerging Research

The scientific understanding of the cascading effects physical, ecological, built, and social systems of the planet continues to evolve rapidly. This advance of scientific knowledge is even more pronounced at regional, subregional, and watershed scales. As new information emerges, best practices will also need to readily adapt.

The causes of global climate change, as well as the projected trajectories of many fundamental climate characteristics of southeast Michigan, are clear, however. It is extremely unlikely that the trajectory of observed and contemporary changes in climate will deviate to such a degree to fundamentally alter watershed management priorities or planning objectives over the coming decades

Several iterative datasets and comprehensive reports serve the Huron River watershed particularly well due to their tailored focus to our regional climate and other local factors. These resources are peer-reviewed and vetted at multiple levels and at every phase of collection and production. Some of these key resources, used to guide this and other Huron River watershed management plans are described below:

Data and climate summaries are periodically compiled by the Great Lakes Integrated Sciences and Assessments (GLISA) team at the University of Michigan and Michigan State University, most recently in 2019. The summary data and narratives rely on multiple datasets from numerous sources. More information can be found at https://glisa.umich.edu.

The Fourth National Climate Assessment, the most recent iteration of a report mandated by The Global Change Research Act of 1990, was written to help inform decision-makers, utility and natural resource managers, public health officials, emergency planners, and other stakeholders by providing a thorough examination of the effects of climate change on the United States. It provides chapters detailing effects by region and by type of impact. The supporting technical materials for this and previous iterations of the report also provide a sound, vetted summary of many complicated fields of study, many of which have implications for watershed management. More information can be found at https://nca2018.globalchange.gov/chapter/front-matter-about/.

The Midwest Technical Input Team to the Third National Climate Assessment, the previous iteration of the process outlined above, was the first such team to be led by experts from Michigan State University and the University of Michigan. While the scope of the Fourth National Climate Assessment followed a similar approach as the Third iteration and updated much of the relevant information, many of the references and key findings of the Midwest Technical Input Team provide relevant guidance for Michigan watersheds. More information can be found at: http://glisa.umich.edu/resources/nca

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Chapter 4: Action Plan for the Middle Huron Watershed, Section 2

Watershed management planning provides the opportunity for communities and other stakeholders to assess the current condition of their watershed, and also to peer into the future to see what the watershed will look like if they simply maintain the status quo. The quality of life that a community desires for its future residents often does not coincide with the realities of the direction in which the community is headed.

This chapter details a set of goals and objectives to ensure that the designated and desired uses in the watershed will be met. Because surface water quality is ultimately a function of what water carries off of the land, much of the discussion will focus on how human activities impact the land and actions that can be taken to improve human land use from a water quality/quantity perspective.

4.1 Goals and Objectives for the Watershed

The designated and desired uses for the Watershed (Chapter 1) provide a basis from which to build long-term goals and objectives. Long-term goals describe the future condition of the Watershed toward which the communities will work. No single community or agency is responsible for achieving all of the goals or any one of the goals on its own. The goals represent the desired end product of many individual actions, which will collectively protect and improve the water quality, water quantity and biology of the watershed. The communities of the Watershed will strive together to meet these goals to the maximum extent practicable by implementing a variety of BMPs over time, as applicable to the individual communities and agencies, relative to their specific priorities, individual jurisdictions, authority, and resources.

Due to the complex ecological nature of the response of watersheds to management practices, it is difficult to predict when these goals will be met. Ultimately, long-term goals can never be said to be fully achieved, because there is always more that can be done. The stakeholder communities will continuously strive to meet these goals by implementing best management practices (BMPs) that are recommended for addressing the goals. The stakeholder communities will understand what progress is being made to achieve these goals by using an iterative process of implementing BMPs and evaluating the effects of these BMPs by regularly monitoring the river for change and degree of improvement. Much progress has been made since this WMP was originally drafted in 1996 and then updated in 2000, 2008, and now 2020.

The long-term goals and objectives as agreed upon by the Advisory Committee are presented in Table 4.1. Short-term objectives are presented for each goal, which are achievable and measurable. Progress has already been made toward the achievement of many of these objectives at this point.

The goals and objectives are listed in priority order. These priorities were determined in discussion with the Advisory Committee after reviewing the previous version of this plan, progress made to date, and the current list of priority impairments, sources and causes, all of which is based on analysis of relevant data as presented in previous sections of this plan. The Committee determined that the combined actions implied by these goals and objectives would be the most effective way to address high-priority watershed impairments.

Table 4.1. Prioritized Goals and Objectives for the Watershed, and the Designated and Desired Uses They Address

Long-Term Goal	Short-Term Objective	Uses Addressed
1. Reduce flow variability	a. Adopt County and local stormwater management requirements that minimize flow fluctuations in receiving waterways, and associated bank erosion, channel widening and habitat destruction.	Designated Uses: Warmwater fishery, Aquatic life and wildlife Desired Uses: Coordinated development; Hydrologic functions
	b. Encourage local ordinances, strategies and programs that: 1. Prevent unnecessary modification of the Huron River, its tributaries and adjacent riparian areas.	
	2. Maintain and restore hydraulic function of floodplains and floodways by discouraging their alteration and encouraging restoration.	
	c. Promote local site planning review standards that favor utilization of stormwater as an on-site resource.	
	d. Monitor flow dynamics of the river and tributaries through established monitoring program.	
	Long-Term Objectives	
	e. Preserve natural infiltration and the recharge of groundwater, by protecting and restoring open spaces and natural recharge areas, installing infiltration BMPs, and reducing the amount of impervious area.	
	f. Meet TMDL goals for biota in Mallets Creek and Swift Run.	
2. Reduce nonpoint source loading and reduce soil	**Short-Term Objective**	Designated Uses: Warmwater fishery; aquatic life and wildlife; partial and
	a. Adopt County and local stormwater management requirements that minimize pollutant loading to receiving waterways by capturing and	

erosion and sedimentation	treating or infiltrating the smaller, more frequent storm event.	total body contact recreation; industrial water supply; public water supply Desired Uses: Coordinated development; hydrologic functions
	b. Encourage local ordinances, strategies and programs that: 1. Minimize the adverse effects of stormwater runoff from new highways and streets.	
	2. Encourage the use of native landscapes and reduced dependence on chemical applications.	
	c. Promote local site planning review standards that foster a hierarchy to guide the selection of stormwater management approaches and favors source reduction.	
	d. Maintain stable oxygen levels in the hypolimnion of Ford and Belleville Lakes	
	e. Improve application and enforcement of soil erosion and sediment controls both during and after construction activity.	
	f. Identify and repair the most eroded and susceptible stream channels and banks.	
	g. Maintain water quality monitoring programs to measure progress toward TMDL goals.	
	h. Maintain baseline monitoring of sedimentation in the River and tributaries.	
	i. Increase education on BMPs among property owners and developers.	
	Long-Term Objectives	
	k. Meet TMDL goals for phosphorus concentration in Ford and Belleville Lakes	
	l. Meet TMDL goals for pathogens in Geddes Pond and Allens Creek	
	m. Reduce erosion and sedimentation to meet habitat goals in Malletts Creek and Swift Run TMDLs	
3. Protect and mitigate loss of natural features for stormwater treatment and wildlife habitat	**Short-Term Objectives**	Designated Uses: Warmwater fishery; aquatic life and wildlife; industrial water supply; public water supply Desired Uses: All
	a. Encourage local ordinances, strategies and programs that: 1. Preserve natural infiltration and the recharge of groundwater, by protecting and restoring open spaces and natural recharge areas, and reducing the amount of impervious area.	
	2. Promote buffering of waterways from the direct impacts of stormwater-related pollution.	
	b. Monitor water quality and biota to measure progress.	
	c. Educate local decision makers and the public about the benefits of critical habitat protection.	
	Long-Term Objectives	
	d. Meet TMDL goals for biota in Malletts Creek and Swift Run.	
4. Increase public awareness and involvement in protecting	**Short-Term Objectives**	Designated Uses: all Desired Uses: all
	a. Conduct on-going programs to raise the public and practitioners' awareness of watershed management and nonpoint pollution issues and solutions.	

water resources	b. Increase opportunities for public involvement in the protection of watershed resources. **Long-Term Objective** c. Reduce pollution and hydrologic impacts to the watershed by increasing public awareness and behavior change.	
5. Gain broad implementation of watershed management plan and associated plans	**Short-Term Objective** a. Promote intergovernmental coordination and cooperation in land use planning, natural resource protection, nonpoint source pollution control and stormwater management. b. Establish financial and institutional arrangements for WMP fulfillment c. Ensure the long-term viability of the Middle Huron Partnership Initiative. d. Increase public awareness of progress in WMP implementation.	Designated Uses: all Desired Uses: all
6. Continue monitoring and data collection for water quality, water quantity and biological indicators	**Short-Term Objectives** a. Maintain an adaptive monitoring strategy that yields data to measure progress toward achievement of WMP goals and objectives. b. Develop a comprehensive database, using the best available and most appropriate technology, to serve the stormwater management, flood control and water quality planning and monitoring information needs of the watershed. c. Track and report on short- and long-term maintenance of public and private stormwater conveyance and storage facilities.	Designated Uses: all Desired Uses: all

4.2 Recommended Actions to Achieve Watershed Goals and Objectives.

To prepare the recommended actions to achieve the goals for the watershed, the original Advisory Committee created an extensive, but not exhaustive, list of possible best management practices (BMPs). The Advisory Committee considered which BMPs would (1) best address the priority impairments for the watershed, (2) be among the more environmentally effective at addressing priority sources and causes, and (3) be more likely to be implemented. This list of BMPs was shared among the stakeholder communities in order to coordinate ideas and resources, as well as to solicit suggestions from participants, identify gaps and ensure that watershed goals were being addressed adequately. Furthermore, this list of actions also provides a good structure to report on activities that have been accomplished through the WMP since its first writing. The list of management options and accomplishment is given in Appendix I.

From this list of general ideas, more specific plans were drawn and detailed as given in 4.2.1: Recommended Action to be Taken (2020-2030).

4.2.1 Recommended Action to be Taken (2020-2030).

The table on the next several pages is a series of actions that are recommended for implementation for 2020-2030. They are organized by priority. Priority 1 actions are those that can and should be undertaken immediately and fully implemented within the first five years. Priority 2 actions are those that may require time to develop. If all priority 1 and 2 actions are implemented, it is anticipated that, over time, all TMDLs will be reached and watershed functions will be restored. Priority 3 actions are those that will help to improve the watershed conditions, but may be more difficult to implement, require additional support or have potential outcomes that are less certain. Each of the priority 1 and 2 actions are described more specifically below the action table.

Table 4-2. Summary of 10-Year Watershed Improvement Strategy, 2020-30

Activity	Impairment / Source Reduced	Implementation Timeframe	Cost Estimate 2020-2030	Lead Agency*	Success Measures
Priority Activities					
1A. Develop and implement a Green Stormwater Infrastructure strategy and program	All/ Runoff	2020-22 plan 2022-30 implement	$200k - $20M	HRWC, Municipalities, UM, AAPS, Washtenaw County	Increased baseflow and reduced flow variability; reduced nutrient and bacteria concentrations and loading; monitoring
1B. Targeted stream channel restoration	Biota/ sediment	2020-30	$500k - $5M	HRWC, municipalities, WRC	Increased DO levels; improved channel morphology; biota monitoring
1C. Enforce restrictions of new discharge permits in TMDL	Phosphorus / new sources	2020-30	Unknown	HRWC, partners	No newly permitted dischargers of phosphorus effluent
1D. Implement stormwater management plans	All/ stormwater	2020-30	$50k	Municipalities, county agencies, UM, AAPS	Numerous. See individual stormwater plans.
1E. Enforce rules, standards and ordinances for stormwater management	All/ new stormwater	2020-30	$1M - $5M	WCWRC	Reduced runoff and nutrient/bacteria concentrations; monitoring
1F. Implement the Information and Education Strategy	All/ Multiple	2020-25	$215,000	HRWC, all partners and residents	Impairment knowledge from survey; participation rates, monitoring
1G. Inspect, maintain and clean stormwater system	All/ stormwater	2020-30	$1M - $5M	Municipalities, UM, AAPS, WCWRC, WCRC	Problems corrected; sediment removed; wildlife flushed

Activity	Impairment / Source Reduced	Implementation Timeframe	Cost Estimate 2020-2030	Lead Agency*	Success Measures
1H. Conduct bacterial source identification and remediation	Bacteria/ multiple	2020-2022 ID 2022-25 remediate	$90k	HRWC, municipalities	# human sources IDed and remediated; reduced bacteria concentrations
1I. Pet waste ordinance education and enforcement	Pathogens/ Pet waste	2021-26	$25,000	City of Ann Arbor	Resident knowledge from survey; call volume; violation #
1J. Create and implement a Green Streets policy	Phosphorus, sediment/ stormwater	2020-30	$15,000	HRWC, municipalities (Ann Arbor active), WCRC, UM	Volume infiltrated; pollutants removed
1K. Develop a best practice strategy for deicing	Conductivity (salts)/ stormwater	2020-2023	$15,000	HRWC, municipalities, WCRC, UM	Modeled conductivity change; potential volume (or weight) of salts applications reduced
1L. Develop detention pond evaluation and maintenance/ retrofit strategy	Multiple/ stormwater	2020-25	$28k - $3M	HRWC, municipalities, WCRC, UM	# of asset inventories; potential TP, TSS, salts removed; potential volume retained
1M. Continue to implement Malletts Creek Strategy	Phosphorus, sediments/ various	2020-30	$16M	City of Ann Arbor, WRC	Many. TSS load reduction.
1N. Continue to implement actions from Millers Creek strategy and sediment accumulation study	Phosphorus, sediments/ various	2020-30	$6M - $10M	City of Ann Arbor, WRC, UM	TSS load reduction. Linear feet stabilized.
1O. Natural Areas Protection	All	2020-2030	$100k-$1M	HRWC, municipalities	# of new priority natural acreage receiving development protection

Activity	Impairment / Source Reduced	Implementation Timeframe	Cost Estimate 2020-2030	Lead Agency*	Success Measures
Secondary Activities					
2A. Canine source detection	Bacteria/ Human	2024-27	$9,500	HRWC, WCWRC	Linear feet inspected; sources identified
2B. Place doggie bag stations at target locations	Pathogens/ Pet waste	2025-27	$20,000	HRWC, County, municipalities	Stations established; use rate; pounds removed; monitoring
2C. Targeted enforcement of phosphorus fertilizer law	Nutrients/ runoff	2024-2025	$5,000+	EGLE, municipalities	Violations eliminated; lbs TP removed; TP monitoring
2D. Buffer Enhancement Program	All/ Runoff	2024-27	$40k - $200k	HRWC, Washtenaw County, municipalities	Linear feet established; % streams properly buffered; monitoring
2E. Implement recommendations from flood control strategy	Phosphorus, sediments/ alt. hydro.	2021-30	$115M - $155M	City of Ann Arbor	Runoff stored or infiltrated; increased baseflow; pollutants removed
2F. Septic Inspection, Education and Remediation Program	Pathogens/ Human	2025-28	$27,000	WC Environmental Health	Inspection call rate; annual septic remediations
Primary & Secondary Activities	**Total**	**2020-30**	**$25.3M - $65.6M without 2E $140.3M - $220.6M with 2E**		

Activity	Impairment / Source Reduced	Implementation Timeframe	Cost Estimate 2020-2030	Lead Agency*	Success Measures
Tertiary Activities					
3A. Investigate sources of high conductivity	General/ point sources	TBD	$8,000	HRWC, municipalities, WCWRC	Identification of source constituents and potential point sources
3B. Wetlands Restoration and Protection Program	All/ Stormwater	TBD	$2,200/ac + $15,000	Municipalities	Reduced runoff and bacteria concentrations; monitoring
3C. Protect Priority Conservation Areas	All/multiple	TBD	TBD	All partners, land conservancy	Protect terrestrial and aquatic habitat; improved filtration
3D. Goose Control Program	Pathogens/ Wildlife	TBD	TBD	Municipalities, WC Parks	Goose population estimates; bacteria monitoring
3E. Native Landscaping Ordinance Development	Nutrients, pathogens/ stormwater	TBD	$5,000	Municipalities	Ordinance developed; natives planted; monitoring
Important Activities External to the Watershed					
A. Continue active management of Ford Lake *(Lower section plan)*	Phosphorus / internal lake	2020-30	$119k - $125k	Ypsilanti Township	Reduced algae bloom count; low DO management events

4.2.2. Primary Implementation Activities

1A. Green Stormwater Infrastructure Program
HRWC developed a process to incorporate available geographic, aerial and other remotely collected information to identify opportunities for Green Infrastructure projects for stormwater treatment (GSI).[1] Figure 4.1 shows a map of GSI opportunities in a portion of the watershed. Opportunities are identified for streets, large lots and roofs. Projects and programs already exist in the watershed, such as Washtenaw County's residential Rain Garden Program,[2] the City of Ann Arbor's Green Streets policy (see activity 1J), and numerous public and private GSI projects that are inventoried across the county.[3] Hundreds of projects have been identified of many types including residential rain gardens, community rain gardens, native restoration, green roofs, water quality units, and infiltration practices.

A program to incorporate key GSI retrofit designs along key roads or other publicly-owned properties based on targets identified in the GSI Opportunities Map should be developed, as well as large business properties. Public and private property owners or managers would need to participate as willing partners. New and redevelopment projects in the watershed should also be encouraged to use GSI approaches. This program would promote the use of designs that slow and settle runoff waters from impervious surfaces like roads, drives and sidewalks and infiltrate as much of the runoff as possible. Slowing run-off waters will reduce stream flashiness, addressing the top long-term goal of reducing flow variability in the Watershed. This also allows a greater portion of runoff to be filtered through groundwater, removing pollutants, and where bacteria will not reproduce, thus reducing stormwater runoff sources of contamination. Research on bacteria reduction indicates that few structural BMPs work to significantly reduce bacteria levels in stormwater runoff. However, properly designed detention or retention basins have been shown to reduce bacteria in outflow. Existing detention ponds and stormwater systems in critical areas of the watershed should be evaluated for retrofit opportunities to capture, settle and treat stormwater runoff, as well (see Activity 1L).

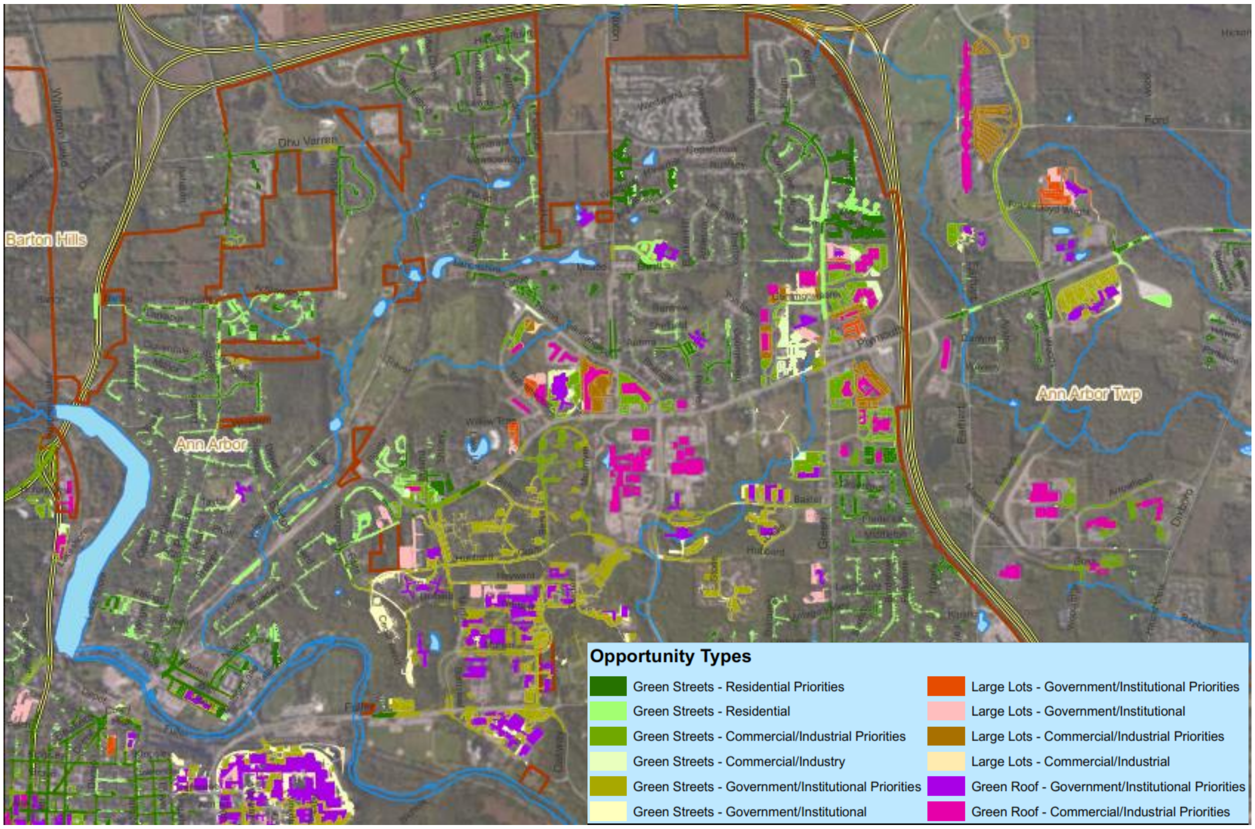
Ideally, all impervious surface within the watershed would be captured and treated at some level, whether it be detention ponds, underground storage or GSI. Based on an analysis of the watershed, there are about 9,600 acres (20%) of impervious surface. At a conservative 7:1 ratio of impervious surface to treatment area, **an appropriate goal would be to develop 1,400 acres or 60 million square feet of GSI or other treatment in the watershed.** Based on standard designs, this implies the need for 90 million cubic feet of total storage capacity.

Timeframe: 2020-2030
Milestones:
- 2020: Estimate current treatment area (or storage capacity) and set a 10-year goal for new development
- 2020-21: Identify primary GSI project targets and develop a strategy
- 2020-2021: Develop a marketing strategy for primary and secondary targets
- 2021-22, develop a self-funding program to identify, fund, design, install, and maintain GSI projects
- 2022-2030.implement program and install projects

Cost: Highly variable, depending on project, but usually lower than conventional cost of construction or reconstruction and maintenance. $10k to form and launch program.
Potential funding sources: Section 319, local government match, local agency or private investment

Success Measures: Reduced runoff volume, pollutant concentrations, and bacteria concentration measured from projects compared to conventional development*,* monitoring

Figure 4.1. Green Stormwater Infrastructure opportunities in a portion of the watershed. (Colors represent different types of GSI.



1B. Targeted stream channel restoration

The second step towards remediation and climate resilience is stream channel restoration. A restored channel, with a more moderated delivery of stormwater to the river provided by GSI efforts, will accentuate the river's resiliency to ability handle climate-related impacts. GSI planning and implementation is proposed for the more developed areas in the watershed. This will help to reduce nutrient inputs and slow flows from runoff events to reduce erosion and bed scouring. The added infiltration from GSI practices will increase groundwater flow and even out flows during the longer dry periods that are expected under the changing climate regime.

Stream channel restoration is proposed for the highest priority stream reaches that were identified in the BANCS inventory (Appendix E). Eight priority restoration projects were identified through this process (Table 4.3). Restoration projects should proceed after upstream flow can be shown to be stable. Almost all of the target reaches would benefit from GSI or other flow control in their contributing areas, but those areas are also almost entirely built-out and their hydrology has stabilized at its current pattern.

Table 4.3. Priority Stream Restoration Reaches

Reach ID	Stream Name	Reach Length (linear ft)	Erosion Rate (tons/yr/ft)	Total Erosion (tons/yr)	Notes
55	Unnamed (Barton Hills)	1,595	0.299	476.1	Very steep slopes. Should be evaluated for slope failure remediation and installation of natural grade control.
697	Millers Creek	2,756	0.186	511.7	Worst erosion reach identified in sediment accumulation study. See study[4] for detailed recommendations. Other sites identified in study as well.
669	Traver Creek	987	0.133	131.3	Heavily urbanized with little floodplain remaining. Bank stabilization is likely only possibility unless property can be purchased.
173	Malletts Creek	1,859	0.124	230.7	Heavily urbanized area. May be undersized culvert. Shorter sections of reach identified for potential restoration or stabilization techniques. Lack of floodplain to connect with.
674	Traver Creek	1,130	0.113	127.9	Between two confluences, intermittent eroding banks. Ample floodplain connection opportunity. Soils should be evaluated.
29	Unnamed Direct Drainage	1,795	0.110	197.1	Small drainage through Kubler-Langford Park. Poor soils in area with intermittent high slopes. Natural grade control? Good floodplain connection possible.
720	Malletts Creek	2,640	0.101	266.2	Heavily urbanized area, but with decent floodplain for possible storage. May be undersized culvert(s). Channelization correction may be possible.
725	Swift Run	7,181	0.085	613.6	Very long reach with smaller sections of significant erosion. Best opportunities downstream of Clark Road, though US-23 clover leaf may be problem area.

Restoring streams to more natural channel configuration provides the template for restored ecosystem function that will support the return of a healthy biological community once flashy flows are mitigated. The existing floodplain should be connected where possible to allow for flooding from smaller as well as larger storms to better establish floodplain communities and provide better riparian habitat. Restoration projects identified for the Malletts Creek and Swift Run watersheds are particularly important as those tributaries have impaired biological communities.

Specific restoration projects will need to be identified and restoration designs developed that are based on site-specific survey data that was beyond the scope of the rapid assessment survey. This more detailed survey data can be used to develop a more precise erosion estimate, which can further be used to derive sediment and phosphorus loading reduction estimates from the restoration projects.

Possible stream restoration practices that can improve stream function may include, but not be limited to the following:

- *Grade controls* including the creation of step pools using natural materials such as logs or stone from the surrounding watershed
- *Form-based restoration* that could include the use of anchored deflectors or log jams to deflect energy from eroding banks, slow stream velocity and introduce complexity to stream form. In some cases, native rock and wood can be used to create larger deflection as with “J-hooks.”
- *Connectivity restoration* may be possible in some places by flattening bank slopes and allowing the stream channel to reconnect with available floodplain. Additional flood storage can also be constructed within this floodplain in wetland or oxbow features.
- *Channel complexity* can be added where there is insufficient room to connect to floodplain features or allow a channel to meander. Two-stage channels with periodic or continuous benches along one or both sides of a channel that has over-widened can allow natural features to recover and create needed flow diversity. Natural log benches can be used to stabilize banks and allow low-flow accumulation of sediments.
- *Riparian restoration* can be added to almost any channel corridor by adding a matrix of native grasses, forbs and live stakes to help stabilize banks and provide needed cover.

Additional restoration opportunities can be identified using the complete BANCS survey results which is summarized in Appendix E2.

Timeframe: 2020-2030
Milestones:

- 2020-21: Identify capital improvement and grant opportunities and schedule projects:
- 2020-2030: recommend restoration improvements to development projects:
- 2021-2030: Implement public projects

Cost: Highly variable, depending on project. A small (~1,000 lf), low construction project is estimated at $50,000, but could range to $100,000 with permitting or construction difficulties. Larger projects with more earth movement required can cost multiple millions of dollars. An estimate for 8 projects is $500,000 to $5,000,000
Potential funding sources: Stream restoration grants, local government match; local agency or private investment; mitigation funding.
Success Measures: Increased DO levels; improved channel morphology dimensional measures and substrate characterization; biota monitoring (see chapter 5)

1C. Enforce restrictions of new discharge permits in TMDL

The TMDL for Ford Lake and Belleville Lake concludes that there is excess phosphorus entering the lakes from current sources. The policy establishes phosphorus loading limit goals for all identified sources as well, and in some cases states how EGLE staff believe that the sources can be reduced to the stated goals. These targets are then used as guidelines to set limits within NPDES discharge permits. Given that the lakes exceed the TMDL, the addition of new phosphorus sources within the TMDL watershed would be counterproductive. It is imperative to the success of all the phosphorus reduction activities going forward that no new sources be added to counteract these nutrient reduction efforts. To prevent new sources from being added, HRWC and partner agencies commit to participate fully in public response to new permit applications. In this public response, the partners will request that EGLE give full consideration of the effort made within the watershed to control existing phosphorus sources and uphold the goals of the TMDL by rejecting any new source permits.

Timeframe: 2020-2030
Milestones: Review and comment on all discharge permit applications.
Cost: HRWC and partner staff time. Unknown value.
Potential funding sources: Staffing budgets.
Success Measures: Zero new phosphorus discharge permits; monitoring (see chapter 5).

1D. Implement Stormwater Management Plans
All MS4s in the watershed submitted complete Stormwater Management Plans (SWMPs) along with permit applications in 2013. EGLE has only approved one plan and issued a permit to the county Water Resources Commissioner. SWMPs all include plans to address six different areas of stormwater management including priority activities in this WMP: 1E, 1F and 1G. The SWMPs included specific activities conducted by individual MS4s to control and manage the quality and quantity of stormwater flowing through and out of their systems. Readers should refer to SWMPs from individual municipal and county agencies to find activities beyond those specified within this WMP. SWMPs are available for the following municipal organizations: City of Ann Arbor, Pittsfield Township, Washtenaw County Water Resources Commissioner, Washtenaw County Road Commission.

Timeframe: 2020-2030
Milestones:

- Completed in 2013; Submit applications for plan approval to EGLE.
- 2021, 2026: Revise plans and resubmit for permits.

Cost: Development of SWMPs and permit applications: $25k. $50k total.
Potential funding sources: Municipal general funds, county budgets, stormwater utility fund
Success Measures: Monitoring results (see chapter 5); numerous success measures included in each plan

1E. Enforce rules, standards and ordinances for stormwater management
This program helps reduce the pollutant concentrations and bacteria in surface water by preventing flooding, modulating flow, treating storm water, and discouraging geese by using native landscape buffers near waterways and ponds. Washtenaw County's program provides likely the greatest protection from stormwater impacts from new and re-construction projects across the state. The current standards and rules require infiltration of storms up to the bankfull event, in most cases, and controls flow to pre-development rates. Most municipalities in the county have adopted stormwater ordinances which refer to the Water Resources Commission stormwater standards. The city of Ann Arbor, and Ann Arbor Township have their own standards and review process, both of which are more protective overall. WRC or municipal staff review development proposals to ensure they meet WRC or municipal standards. Projects that do not meet standards must be redesigned or adjusted in order to receive municipal building permits.

Timeframe: ongoing
Milestones: 2023, 2030: Report on standards outcomes
Cost: Not tracked specifically. Estimates are $400 - $4,000 per project, depending on complexity. Annual estimate: $100k - $500k. 10 years: $1M - $5M
Potential funding sources: Funded directly by WRC.
Success Measures: Reduced runoff compared to previous standards, monitoring (see chapter 5)

1F. Implement the Information and Education Strategy (Public Education Plan)
Municipal and agency partners developed a Public Education Plan (PEP), as part of compliance with stormwater regulations and to address public sources of impairments. The PEP includes 22 activities and strategies to address nine stormwater topics identified by EGLE. Further, the PEP includes activities to address all impairments listed in this WMP. It also includes a strategy to

evaluate the success and progress of education measures. Therefore, the PEP will serve as the information and education strategy for the WMP. The PEP can be found in Appendix K.

Timeframe: 2020-2030
Milestones: Found in PEP
Cost: $104,000 for five years. $215,000 total
Potential funding sources: All funding currently is provided by municipal and agency partners
Success Measures: Increased public knowledge about watershed and runoff topics; public commitments to engage in behavior changes, monitoring (see chapter 5)

1G. Inspect, maintain and clean stormwater system
The municipalities and county agencies with stormwater systems in the watershed all have completed asset inventories and management plans. This is an important first step to gaining a full understanding of system needs and the resources that will be necessary to repair or replace failing parts, replace or upgrade aging parts, and maintain the function of stable parts of the stormwater conveyance system.

Timeframe: 2020-2030
Milestones:

- 2020-23: Systems inventoried and cataloged: complete; repair or replace failing parts or elements
- 2021-30: Upgrade aging parts:
- Ongoing: Maintain system components

Cost: Difficult to estimate. $10k - $100k annually, on average though years with major repairs or upgrades will exceed the average considerably. $1M - $10M total.
Potential funding sources: Primarily paid for with general funds, stormwater utility funds (City of Ann Arbor), and agency budgets. Larger system upgrades should take advantage state and federal grant and low-interest loan programs like the state revolving fund. Municipalities without a stormwater utility should consider the cost of developing one against the cost of upgrading the system to maintain a satisfactory level of service.
Success Measures: % of systems meeting satisfactory or equivalent ratings, # problems corrected, lbs of sediment cleared, wildlife accesses blocked (bacteria source)

1H. Conduct bacterial source identification and remediation
The project aims to determine the presence, absence, and sources of bacteria in the watershed through a suite of potential monitoring techniques. By utilizing genetic analyses, canine source detection, and ambient water sampling, the project will evaluate fecal indicator bacteria sourcing. For any positive human detections, HRWC and WCWRC and the Washtenaw County Department of Environmental Health will contact any suspected homeowner to remediate any failing septic systems or illicit connections. HRWC and local partners will also execute outreach and education strategies to property owners in the impaired creekshed on pathogen problems as well as home and pet owner remediation actions. The goals of these strategies are to improve awareness, knowledge and action concerning proper pet waste disposal and septic system maintenance. Local officials and HRWC will also install pet waste stations at local parks and frequently recreated public areas to reduce any bacteria contamination of stormwater.

Timeframe: 2023-2026
Milestones:

- 2023-2024: Identification of bacteria impairments

- 2024-2026: Outreach to homeowners in the affected watershed, including distribution of educational materials to constituents on pet waste and septic systems
- 2025-2026: Installation of pet waste stations

Cost: Fecal indicator bacteria monitoring, analysis, source identification, and follow-up: $90,000; Outreach and education campaign: $100,000; Pet waste station installation: $10,000
Potential funding sources: Section 319
Success Measures: Number of human sources identified and remediated; bacteria monitoring (see chapter 5)

1I. Pet waste ordinance education and enforcement
This program builds off the work of 1H. in educating the general public on the impacts of pet waste on surface water quality and the existing local regulations concerning pet waste. Efforts will work to increase public awareness of local pet waste ordinances, including those in the City of Ann Arbor, and drive behaviors to reduce pet waste entering storm drains. In addition, HRWC will work with other watershed municipalities on the development, adoption and implementation of ordinances requiring the removal and proper disposal of pet waste with fines for infractions, through the sharing of educational materials as well as the installation of informational signage and pet waste disposal stations in public areas.

Timeframe: 2021-2023, 2026, 2029
Milestones:

- 2021-23. Draft ordinance developed, revised and passed in Pittsfield and Ann Arbor Townships.
- 2023. Education Materials distribution.
- 2024. Ordinances enacted.
- 2026 and 2029. Follow-up education and surveys.

Cost: Technical assistance with ordinance development: $8,000; Elected official time in review and enactment: $10,000. Total: $18,000. Education costs are included in item 1F.
Potential funding sources: Section 319, local government match
Success Measures: Ordinance enactment, volume of calls about ordinance, ordinance enforcement rate, monitoring (see section 5).

1J. Create and implement a Green Streets policy
The City of Ann Arbor created and implements an internal Green Streets policy that requires city transportation engineers to give full consideration and make every attempt to include infiltration projects when a city street is up for reconstruction. This policy has resulted in numerous alternative drainage projects that include rain gardens and bioinfiltration cells, underground storage and infiltration, water quality filtration, and the use of porous materials. Other municipalities with roads and the county Road Commission should develop similar internal policies to encourage projects that infiltrate runoff from one of the largest sources of impervious surface in the watershed – roads. (Table 4.4)

Timeframe: 2020-2025
Milestones:

- 2020-21: Discuss internally and plan policy. draft and roll-out policies.
- 2022-2025: implement and track project implementation.

Cost: Difficult to track as it is all internal staff time. Estimate $5k per policy of direct expenditures. $15k total.
Potential funding sources: Internal budgets
Success Measures: # of new road infiltration projects, volume infiltrated, peak flow reduced, pollutants removed, monitoring

Table 4.4 Recommended Greens Streets BMPs from the Ann Arbor Stormwater Model Report

Site	Watershed	Recommendation	Cost Estimate
1. Lower Allen Creek – Main Branch	Allen	BMP-Combination	$80m - $120m*
2. Edgewood/Snyder	Allen	Conveyance-Storage	$4.1m
3. Park Place Apartments	Allen	Conveyance	$1.0m
4. Churchill Downs/Lansdowne	Malletts	Conveyance-Storage	$16m
5. S. University/E. University	Allen	BMP-Storage	$3.6m
6. Mulholland Drive	Allen	Storage	$1.9m
7. Scio Church/S. Seventh	Malletts	BMP-Storage	$2.4m
8. Glendale/Charlton	Allen	Storage	$1.2m
9. Glen Leven	Allen	Further Study	--
10. Church St./Cambridge	Malletts	None	--
11. Village Oaks/Chaucer Ct.	Malletts	Storage	$1.2m
12. Parkwood/Pittsfield Village	Malletts	Storage	$0.5m
13. Signature Drive	Malletts	Conveyance	$0.2m
14. S. Industrial/Packard Rd.	Malletts	None	--
15. Traver/Barton	Traver	Conveyance	$0.2m
16. Glendale Circle / Virginia Park	Allen	BMP-Storage	$5.1m*

**Cost estimates for these sites are based on Green Streets policy implementation only. Other portions of the recommended stormwater management improvements would take place on private property and would not be funded by the City.*

1K. Develop a best practice strategy for deicing
As indicated in chapter 2, the river and tributaries in the watershed have consistently high conductivity levels. Further, conductivity variation has been shown to be highly correlated with chloride (Cl-) levels, and, to a lesser extent, sodium (Na+) levels. None of these pollutants appear on the State of Michigan’s Impaired Waters list, but a number of salt ions are on the

water quality standards list. The state should consider evaluating all urban waters in the state for salt impairments, and it may do so in the near future.

Nonetheless, water resources in this watershed are likely impaired by high salt levels. High ion concentrations have been shown to be correlated with lower biota diversity. Since monitoring is currently conducted April through September, and salts are applied to roads, sidewalks and parking areas during the winter months, it is likely that dissolved salt ions are making their way through groundwater and entering surface waters at all times of the year. Some road agencies within the watershed, in the greater Huron River watershed, and across the nation have experimented with a variety of management practices to reduce salt applications. The partner organizations in the watershed should review the available information on these practices and their evaluation and develop guidelines and recommendations for use by agencies and departments that manage streets, roads and large parking areas. Recommendations can also be incorporated into elements of the Public Education Plan for use on residential drives, sidewalks and walkways.

Timeframe: 2020-2025
Milestones:

- 2020; Discuss with Middle Huron Partners
- 2020-21: Literature review summary
- 2021-22: Develop guidelines and recommendations document
- 2022-25: Implement, measure outcomes and revise

Cost: Literature review and meetings: $9,000; Produce guidelines document: $4,000; revise document: $2000. $15k total.
Potential funding sources: 319 grant, GLRI grants. Local funds for match.
Success Measures: ion and conductivity levels, monitoring (see chapter 5), reduction in salt application levels

1L. Develop detention pond evaluation and maintenance/retrofit strategy
Since modern stormwater management guidelines began to be implemented, dozens of stormwater facilities have been constructed within the watershed, mostly associated with new development projects or major redevelopments. The most common type of facility installed is the detention pond. Construction and post-construction standards require that property owners maintain detention ponds to ensure proper and continued function, but anecdotal evidence and a few detention pond surveys suggest that very few facilities are getting the maintenance they need. Unmaintained detention ponds can get clogged or filled in with sediment and they lose their ability to reduce flood flows and improve water quality.

Some public facilities were evaluated as part of asset inventories, and they are now included in maintenance and upgrade plans. The rest are privately owned. Most are accessible through agreements with the county WRC. Detention ponds in the watershed should be first identified by aerial observation (GIS), and a plan for inspection and evaluation developed. Once a sufficient number have been evaluated, a strategy can be developed to determine the appropriate maintenance or retrofit strategy to employ to improve their overall function. Ponds in Malletts Creek and Swift Run should be especially targeted due to hydrologic and sediment impairments identified in those creeks.

Timeframe: 2021-2028

Milestones:

- 2021-22: GIS inventory and classification of ponds
- 2022-24: Survey a subset of ponds by classification for first round of evaluation
- 2024: Assess evaluation results and identify maintenance and retrofit needs
- 2024-28: Evaluate additional ponds to fill gaps and create schedule to evaluate all ponds
- 2023-28: Develop targeted maintenance and retrofit strategies and projects

Cost: Inventory and evaluation: $8,000; Maintenance and retrofit projects: $20k - $3M, difficult to estimate.
Potential funding sources: 319, GLRI grants; SRF loans; local fund match; HRWC volunteers
Success Measures: inventory completeness, % functionality, volume and pollutant improvements from maintenance/retrofit projects; monitoring (see chapter 5)

1M. Update and continue to implement Malletts Creek Strategy
Malletts Creek has been a focus of implementation projects for many years. Efforts have shown marked improvements as documented in chapter 2. Two strategies were developed for Malletts Creek. A specific implementation strategy was developed to address the biota impairment and TMDL in 2011. Additionally, the Malletts Creek Coordination Committee, comprised of citizens, HRWC and local government agency representatives maintains and periodically revises an implementation strategy. Many activities overlap in these two strategies. Further, the City of Ann Arbor and Washtenaw County WRC periodically update a project list for the State Revolving Fund (SRF) Loan Program. Together, activities from these strategies were projected to reduce over 1,000 tons of sediment per year. All 3 of these plans are included in Appendix B.

Timeframe: 2020-30
Milestones:

- 2021, 2026, 2030: Review strategies and update
- 2020-30: Implement projects

Cost: > $16M, according to the five-year TMDL Implementation Strategy
Potential funding sources: 319, GLRI grants; SRF loans; stormwater utility funds
Success Measures: Monitoring (see chapter 5); TSS load reduction; biota diversity improvement; bacteria reduction

1N. Continue to implement actions from Millers Creek strategy and sediment accumulation study
In 2003, an action plan was developed to address the severe sediment erosion and accumulation that was occurring in Millers Creek. It contained 45 activities, many of which overlap with activities recommended in this plan. Some activities in this plan have been completed, such as streambank and bed stabilizations and Huron Parkway bioswales. Other activities are no longer relevant. More recently, in 2013, a sediment accumulation study was conducted to evaluate the sources of sediment loss and accumulation and recommend remediation activities. Table 4A in the study includes a set of recommended activities. These should be conducted first before considering activities in the older plan. Both plans are included in Appendix A.

Timeframe: 2020-2030
Milestones: see individual plans

Cost: The Millers Creek Watershed Improvement Plan estimated activity costs at $19,348,000 over ten years, some of which have been completed. Capital costs from the sediment study: $5.3 million. Annual maintenance costs: $27,000. Total 10-year estimate: $6 - $10M.
Potential funding sources: see individual plans for funding source recommendations
Success Measures: TSS load reduction, pollutant reductions, reduced peak flows and extended base flows, monitoring (see chapter 5)

1O. Natural Lands Protection

Figure 2.6 shows the subwatershed's remaining natural areas (discussed in section 2.1.3), land already protected as public parks or land conservancy properties, and privately-owned natural areas HRWC has determined have a high potential to be of utmost importance to protect for their ecosystem services.

It is recommended that partners pursue field assessments on these areas and consideration for permanent protection through acquisition or conservation easements.

Land protection programs include the City of Ann Arbor's Greenbelt program, Scio, Ann Arbor, and Webster township land preservation programs, and Washtenaw County's Natural Areas Protection Program. All of these programs are funded through a land protection millage levied on property taxes.

Other protection funding includes Clean Water Act Section 319, State Revolving Loan Programs, Carbon off sets purchased by companies and municipalities with carbon neutrality goals, NRCS funding through their Regional Conservation Partnership Program, and others.

Conservation easements purchase can run from $5000 an acre to $15,000 an acre, depending on the location of the property and assessed value of the property. It is clear, therefore, that the preservation of important natural areas through purchase of easements or outright purchase would be an insurmountable task, budget-wise. Fortunately, local governments have regulatory tools at hand to allow development while protection important natural areas. Tools include: Wetland, riparian buffer, and other natural feature protection ordinances; and, regional planning to direct development away from natural areas.

Timeframe: 2020-2030
Milestones:

- 2020-2025: Conduct natural area surveys in the Watershed
- 2025: Develop a set of recommendations for the WMP stakeholders that map and list the priority natural areas in the watershed.
- 2030: At least 100 new acres of priority natural areas in the Watershed receives some sort of protection from future development, be it conservation easements or ordinance protection.

Cost: $100k over ten years for BioReserve assessments and HRWC staff time in promoting natural area protection to partners; $5000- $15,000 an acre for easements.
Potential funding sources: see text above
Success Measures: # of acres protected

4.2.3. Secondary and Tertiary Implementation Activities

Secondary Activities

2A. Canine source detection

The professional sewage detection canine teams will be contracted to confirm human sewage sources. Canine detection has been shown to have a high detection rate with low false positive rate. Canine detection is also specific to human sewage and can be used to filter out non-human animal sources. The service has been shown to be helpful in identifying illicit connections as well as septic system failures. Positive detections from surface water connections identified in 1H will be followed upstream until sources are identified. Positive detections from outfalls will be followed up to storm system access points for further evaluation until a direct source is identified. Positive detection information will be provided to relevant agencies for follow-up.

Timeframe: 1 season. 2024-2027
Cost: $9,500 for inspection of 20,000 linear foot of stream
Success Measures: Linear feet inspected, # of sources identified and remediated

2B. Place doggie bag stations at target locations

This program provides bags for pet waste clean-up through the installation of waste stations in public areas, such as parks and trails. This should reduce pet waste in high traffic areas, subsequently reducing the amount of E. coli entering the watershed via pet waste. HRWC will work with local municipalities and homeowner associations to install pet waste stations, including free bags and trash receptacles, and ensure proper maintenance. Based off use of stations and feedback from station managers, HRWC will modify the placement of the stations or expand the network. This activity can be done in conjunction with activity 1I.

Timeframe: 2025-2027
Cost: 100 dog waste stations @ $100 ea.: $10,000; technical assistance, installation, maintenance labor: $10,000. Total: $20,000
Success Measures: Number of stations installed, bag volume utilized, pounds of feces removed, monitoring (see chapter 5).

2C. Targeted enforcement of phosphorus fertilizer law

Fertilizer is a contributing source of dissolved phosphorus in the watershed. While the State of Michigan banned the use of phosphorus-based fertilizers, these fertilizers are still widely available, and enforcement of the law is based on neighbor complaints. In this project, HRWC will work with area municipalities to educate constituents about the water quality impacts of phosphorus-based fertilizers and coordinate with local retailers to minimize or eliminate sale of the product. HRWC will also work with local municipal law enforcement agencies to observe violations and enforce the law within target neighborhoods in an effort to encourage greater compliance. Preceding this enforcement effort, a series of public meetings should be held in residential neighborhoods to inform and educate about the importance of the law.

Timeframe: 2024-25
Cost: Difficult to determine. $5,000 for police force training. $2,000 for public meetings.

Success Measures: frequency of violations pre- and post-education and enforcement actions, monitoring (see chapter 5)

2D. Develop a buffer enhancement program

Vegetated stream buffers are valuable permanent measures for water quality and habitat enhancement. Buffer zones are strips of undisturbed native vegetation, either original or reestablished, bordering a stream, river, or wetland. These buffer zones also are known as riparian buffer zones, referring to the zone along a waterway or waterbody where the water meets the shore. The trees, shrubs and plants, and grasses in the buffer provide a natural and gradual transition from terrestrial to aquatic environments. To reap all the benefits of buffers, they should be at least 100 feet wide on either side of a stream – both intermittent and perennial. Though not optimal even buffers 10 feet wide could provide many benefits, and this could be a possible solution in highly urbanized or agricultural regions.

These areas are critical for wildlife habitat, storing water during periods of high water flow, and protecting lakes and rivers from physical, chemical, and biological pollutants. Establishing buffers that protect riparian corridors, especially floodplains, wetlands, and steep slopes, offers a way to filter material with active microbes before they enter the stream. Restoring natural vegetation in bacteria hot spots also discourage Canadian geese populations from congregating. Planting and maintaining native grasses and sedges at common geese or animal access areas to replace some of the turfgrass will help reduce E. coli counts.

Adding wide riparian buffers will be difficult to add in the critical areas where they are most needed, like in Malletts Creek and Swift Run watersheds. There is simply little room left in which to create buffers. However, in upper reaches of Traver Creek, much of Fleming Creek and in many direct drainages, it is possible to preserve and enhance riparian buffers. As part of outreach efforts discussed in activity 1F, property owners will be encouraged to seek Wildlife Habitat Incentive Program (WHIP) contracts through the Natural Resource Conservation Service (NRCS). The Conservation Reserve Enhancement Program (CREP) offers additional incentives to encourage landowners to implement practices that will help reduce sediment and nutrients and will improve wildlife habitat, while also removing bacteria and microbes. The USDA Farm Service Agency (FSA) provides an annual land rental payment, including a CREP special incentive payment, plus cost-share of up to 50 percent of the eligible costs to plant grasses or trees on highly erodible cropland, establish vegetated buffers along streams, restore wetlands, provide shallow water areas for wildlife, and restore habitat for rare and declining species. Additionally, Fleming Creek is in the target area for the Whole Farms for Clean Water program, which provides incentive payments for phosphorus loss reductions.

In addition to agricultural lands, the Buffer Enhancement Program would also encourage residential landowners to establish native vegetation and properly manage stream buffers. Interested landowners would be given planting designs and instruction, management guidelines and native plant seedlings and seed at no or reduced cost. Technical assistance would also be provided. In turn, the landowner would sign a commitment to manage the land as a natural buffer for 15 years.

Timeframe: 2025-30
Cost: Plants and seed @ $500/ac for 80 ac: $40,000; mailing, site visits, planning, technical assistance, reporting: $25,000. Total: $65,000.
Success Measures: # landowners participating, # and % of riparian acres buffered, monitoring (chapter 5)

2E. Implement recommendations from Ann Arbor flood control strategy
The City of Ann Arbor spent several years and many resources to develop a stormwater model to use to identify storm system weaknesses and predict flooding extent in city drainage areas. After developing the model, the team released a study that identified a series of practices needed to reduce flood frequency and extent. Included within these recommendations were a set of storage and treatment practices that would also have water quality benefits. The study includes recommendations for 16 different locations throughout the city and watershed where potential flooding needs to be addressed. At most of the locations, multiple treatment options were evaluated, including distributed green stormwater infrastructure. The target locations, project type and cost estimates are included in Table 4.4. Adding storage for flood control will have the added benefit of reducing peak flows in smaller storms as well as the larger flood events they are designed to capture, but not all recommendations are the most cost-effective for addressing altered hydrology, erosion, sedimentation and nutrient reduction. The full report is included in Appendix L.

Timeframe: 2020-2030 (and beyond)
Cost: $115 million - $155 million
Success Measures: runoff storage added, peak flow reduced, base flow time increased, nutrient and sediment reduction monitoring (see chapter 5)

2F. Septic Inspection, Education and Remediation Program
Septic System Inspection Programs are meant to identify and correct failing septic systems that discharge human waste into groundwater or on the surface, and directly or indirectly into surface water.

Washtenaw County's "Time of Sale" Ordinance requires that prior to any residential property transfer: 1) the septic system must be inspected by certified inspectors, 2) a report must be submitted to the Environmental Health Regulation Department and 3) the seller must receive an authorization letter from the Department. Over 4,300 systems have been evaluated annually, countywide, with over 540 septic system corrections documented to date.

The majority of homeowners in the watershed are connected to Ann Arbor's sewer system. However, many homes outside city boundaries and some pockets within the city are still on individual septic treatment. The current Time of Sale program can serve as the basis for an expanded effort to reach residents on septic systems to increase inspections and remediate those that are failing. After IDEP inspections and following canine source detection, areas confirmed as human source areas but without direct illicit connections will be identified as likely areas of septic failure. Neighboring residents will be contacted directly about participating in the program.

This new program should remove barriers such as cost and expertise by providing inspections free of charge to residents in target areas and a list of qualified contractors to remediate failing systems. An additional element to the program should be added to help finance failing systems for residents who lack the means to pay for expensive fixes. The availability of assistance may help to address barriers on the part of homeowners to participate in the inspection program. The program could host workshops on septic system care and maintenance that would be promoted by direct mail and offer a free "Water Efficiency" kit for those who attend.

The new inspection and remediation program could include messaging and material targeted to program participants to increase awareness about septic systems and their effect on water quality and educate watershed residents on best practices for maintaining, and identifying and correcting failed septic systems (from the Information and Education Strategy referenced in 1F).

Timeframe: 2020-2030
Cost: Follow-up inspection and remediation of unknown number of connections estimated at $10,000 per year = $100,000 total.
Success Measures: Differential in number of inspection requests (pre-post information distribution), number of septic remediations in target areas, monitoring (see chapter 5).

Tertiary Activities
3A. Investigate sources of high conductivity
While there is some evidence to suggest that road salts are suspected to be the primary source of high conductivity levels in most of the watershed, it is possible that other direct sources could be identified. Investigations were conducted to track down sources in Millers Creek and Swift Run previously. No single source was identified for Millers Creek, though it was concluded that previous high salt applications in business park parking lots in the upper part of the shed were a probable source. In Swift Run, the source was narrowed to a drain pipe from a Washtenaw County facility that was later addressed. HRWC can follow-up on additional high conductivity stream segments by tracing conductivity readings upstream until readings peak and then searching for a connecting source (i.e. outfall pipe or connecting stream). At that point, HRWC can collect water samples to test for a range of other constituents to narrow in on the type of pollutant driving the high conductivity readings. Findings can then be delivered to the local municipality or other landowner for remediation or other follow-up.

Timeframe: 2025-27
Cost: Sampling labor: $4,000; sample analysis: $1,500; follow-up communication and assistance with remediation: $2,000
Success Measures: # of sources identified; types of constituent pollutants identified; # of sources remediated; conductivity reduction monitoring (see chapter 5)

3B. Wetlands Restoration and Protection Program
This program, consisting of local regulations and incentives, is meant to: 1. protect existing wetlands of one-fifth of an acre in size or larger, and 2. restore significant wetlands that were previously lost. Damaged and destroyed small wetlands cannot provide the services of filtering and cleaning pollutants in storm water, while restored wetlands can add to this benefit. The program could protect numerous wetlands in the Traver and Fleming Creek watersheds, as well as a few in Malletts Creek and Swift Run. Local wetland protection ordinances already exist in the City of Ann Arbor, Ann Arbor Township and Pittsfield Township. HRWC can use these as models to promote wetland ordinances in other municipalities. Restoration opportunities will be evaluated based on their functional value as evaluated by wetland inventories.

Timeframe: 2025-2030
Cost: $15,000 for an ordinance and $2,000/ac for conservation
Success Measures: Reduced runoff volume, reduced or avoided nutrient export, reduced bacteria concentration from site or avoided additional bacteria input, monitoring (see chapter 5).

3D. Establish a goose control program
Efforts have been made to decrease Giant Canada goose populations, eliminate year-round goose habitation, and in turn, reduce the amount of goose droppings containing *E. coli* that have potential to contaminate waterways in the Huron River watershed. Best management practices such as pond buffer plantings, replacing turf with shrubs and trees, and interfering with feeding

and nesting will potentially reduce areas of contamination. Plant materials could be obtained from the Washtenaw County Conservation District. Research on goose control BMPs (including programs within the Huron River watershed) shows availability of numerous successful and cost-effective methods. Those with expertise in goose control BMPs should be made available through a workshop for those managing detention ponds and other open water sources in high bacteria areas of the watershed.

Timeframe: 2025-30
Cost: Variable
Success Measures: Reduced goose populations near waterways, monitoring (see chapter 5).

3E. Develop or improve native landscaping ordinances
This program diminishes green grass cover, which provides very shallow root zones, little uptake of nutrients, often minimal infiltration, and on which geese enjoy foraging with an unobstructed view. Often native plantings are used within stormwater conveyance swales, depressions and wet ponds. However, native landscaping as an alternative to traditional lawns is becoming more common. Native plants, especially those adapted to prairie environments, require little to no irrigation, fertilizer or pesticides and allow stormwater to percolate more efficiently down into the soil. Local weed ordinances, however, indirectly prohibit the use of native landscaping without a variance. Communities should adopt ordinances that allow and encourage native landscaping as an alternative to lawns while not negating the intent of common weed ordinances. The purpose of this activity is to promote deep-rooted native vegetation with native landscaping ordinances. Several of the municipalities in the watershed have existing ordinances that can be used as models for other townships.

Timeframe: 2025-30
Cost: $8,000
Success Measures: Ordinances or standards adopted, native area planted, goose populations reduced, monitoring (see chapter 5).

Activities External to this WMP
A. Continue active management of Ford Lake dam flow
The end-point for phosphorus reduction efforts in the watershed is ultimately Ford and Belleville Lakes, since they are the water bodies for which the phosphorus Total Maximum Daily Load policy is established. Those lakes are downstream of this watershed, but it is important to recognize a key activity that is engaged to control a large source of phosphorus loading within the Middle Huron River system. Ypsilanti Township operates the dam that forms the Ford Lake impoundment of the Huron River. The dam is constructed to allow the Township to normally draw water through electric turbines and release flow over the top of the dam under normal circumstances. However, when the dissolved oxygen levels in Ford Lake bottom water drop to zero, the Township can open gates at the bottom of the dam (reducing turbine flow) which causes lake water to mix and increase oxygen. This replacement of oxygen keeps phosphorus in bottom sediment from releasing into the water column. This practice prevents phosphorus levels from exploding and prevents algae blooms in the lake. It essentially locks up an important source of phosphorus.

Timeframe: 2020-2030
Cost: $9,900 - $10,500 per year in lost electricity revenue, $2k per year in monitoring and operation. Total 10-year cost: $119,000 to $125,000
Success Measures: Reduced algae bloom count, DO levels, lake phosphorus monitoring (see chapter 5)

4.3. Impairment Loading Implications

Ford Lake and Belleville Lake Phosphorus Impairment

The TMDL for Ford Lake sets a maximum load goal for total phosphorus at 36,020 lbs/year entering the lake, not counting the internal lake load, or 36,500 lbs/yr with the internal load. The most recent loading analysis using river flow and monitoring data estimates, which account for source reduction activities up to the current date, estimates the current loading rate into Ford Lake is 37,384 lbs/yr. If all primary actions are fully implemented, HRWC estimates that an additional 3,241 lbs will be prevented annually from entering the lake, bringing the total phosphorus load to 34,143 lbs/yr. This load reduction would be more than sufficient to meet the TMDL load target. In addition, further activities will be taken within the rest of the TMDL watershed, so there is sufficient margin of safety, and the plan is thus quite conservative for addressing the phosphorus nutrient impairment. As stated in chapter 2, it may still require many years at these low loading levels for the internal load within the lakes to decrease significantly, and therefore reduce mean TP concentrations to water quality targets.

Table 4.5 is a summary of a selection of phosphorus reduction activities along with their loading reduction estimates, schedule and cost estimates. Loading reduction estimates are based on published estimates when available or analysis using available load estimate models.

Table 4.5 Summary of Major Phosphorus Reduction Activities

Activity Category	P Load Reduction Estimate (lbs/yr)	Implementation Timeframe	Cost Estimate over Ten Years
Green Stormwater Infrastructure activities including Green Streets	undetermined	Several ongoing programs currently. Plan and launch coordinated effort by 2021.	$5 M
Stream restoration projects	undetermined	New projects 2020-2030	$5 M
Construction Site Runoff Control	328	Ongoing program. Regular inspection, O&M.	$626,000
Illicit Discharge Elimination	266	Investigations ongoing. Eliminations 2020-2030.	$278,000
Post-construction runoff controls for reconstruction	undetermined	Ongoing program. Regular inspection, O&M.	$2 M
Public education leading to behavior change	331	Current. Annual campaigns ongoing.	$143,333
Stormwater and detention pond repairs and upgrades	undetermined	System inventory complete. Repairs and upgrades 2020-2030.	$4 M
Malletts Creek Strategy activities	1,000	2020-2030	$16 M
Millers Creek sediment control recommendations	383	2020-2030	$8 M
Phosphorus Fertilizer Reduction Law	693	Enacted in 2012. Ongoing O&M.	$64,000
Septic Inspection and Repair	240	Ongoing program	$10.7 M
Totals	**3,241**		**$70.77 M**

Any activities conducted by the Ann Arbor Waste Water Treatment Plant, along with those included in the table above will account for more than the needed load reduction in order to meet the reduction target for the middle Huron River watershed.

Argo Dam to Geddes Pond and Fleming Creek Bacteria Impairment
As indicated in chapter 2, no specific loading targets were set for the *E. coli* TMDL since it is concentration based. It is quite difficult to estimate loading reductions for pathogen impairments. It also is not entirely appropriate to focus on load reductions since the impairment itself is based on point counts or concentrations. The focus is better placed on activities to reduce *E. coli* sources.

The E. coli TMDL Implementation Plan was developed to establish an effective strategy to reduce potential sources through a set of implementation activities. Please refer to that strategy found in Appendix H for more details on activities, impacts, schedules and cost estimates.

Malletts Creek Biota Impairment
A completed plan for addressing the biota impairments in Malletts Creek can be found in the in the TMDL Implementation Plan in Appendix B3. The overall phosphorus reduction under this plan translates to well over the 106 tons per year of TSS reduction required by the TMDL. These reductions come at a cost of $19.1 million. This plan indicates that activities designed to address the phosphorus TMDL for Ford and Belleville Lakes will have the secondary benefit of more than addressing the sediment loading reduction targets set for the biota TMDLs.

Swift Run Biota Impairment
A TMDL Implementation Plan for Swift Run was developed in 2011 and can be found in Appendix F. Below is a summary of earlier proposed actions. Refer to Appendix F for more updated information.

Table 4.6 lists a number of actions that can be undertaken to address the hydrologic degradation and sediment transport that is targeted as the source of biota impairment. Some of the broad-based programs will have the effect of mitigating peak flows and reducing sediment transport in Swift Run. In addition to these programs, a desktop analysis of the creekshed, looking at land use patterns, hydrology, and critical areas for sediment transport was conducted to inventory potential areas for projects specifically designed to reduce hydrologic and sedimentation impacts on aquatic habitat in Swift Run. A set of 34 “Improvement Opportunities” were identified within the creekshed that could control erosion, reduce sediment transport, detain or slow runoff, reduce channel erosion or increase storage capacity. These opportunities will be further evaluated to determine the feasibility of each potential project and prioritize each project for implementation. It is anticipated that a selection of these projects will be implemented over the next ten years to address the problem sources in the creekshed and improve the aquatic habitat to allow for improvement of benthic biota measures.

The improvement opportunities were classified into the following eight categories:

- Channel Improvement – including streambank and streambed stabilization;
- New Detention – including construction of detention ponds, wetlands, bioswales or infiltration basins;
- Residential BMPs – including rain barrels, rain gardens, downspout disconnections, tree planting, and targeted education;

- Basin Retrofits – including reconstruction of existing flood control structures to provide sediment trapping and longer retention times;
- Enhanced Floodplain – including floodplain connections, native planting and seeding, and access reduction;
- Vegetative BMPs – including buffer planting, natural area restoration, and reforestation; and
- Wetland Improvement – including hydrologic restoration, invasives removal, and establishment of native species.

Relevant broad-scale project activities and the above improvement activities are listed in Table 4.6 for use in estimating anticipated load reductions toward TMDL targets. In this case, TSS load reductions are estimated based on model results and ten-year cost estimates are also indicated based on figures from sections 4.2.2 and 4.2.3, previous WMPs or best estimates from practitioners.

Table 4.6 Inventory of management practices to address biota TMDL (TSS based) for Swift Run

Management Practice	Responsibility	Level of effort	Estimated TSS Load Reduction (tons/year)	Estimated 10-year Costs
Public Education	WCDC, Ann Arbor, Ann Arbor Twp, Pittsfield Twp	Across creekshed	UNKNOWN	
Street Sweeping	Ann Arbor, WC Road Commission	Twice per year	7.4	$14,525
Construction Site Erosion Control	WCDC, Ann Arbor, Ann Arbor Twp, Pittsfield Twp	New construction in creekshed	36.4	$122,000
Channel Improvement	WCDC, Ann Arbor	4,500 linear feet	2.4	$1,500,000
New Detention	WCDC, Ann Arbor, Ann Arbor Twp, Pittsfield Twp	3 potential projects	1.0	$90,000
Residential BMPs	WCDC, Ann Arbor, Ann Arbor Twp, Pittsfield Twp	Targeted residential areas . ~ 200 acres	3.8	$74,074[1]
Basin Retrofits	WCDC, Ann Arbor, Ann Arbor Twp, Pittsfield Twp	4 potential projects	4.9	$200,000
Enhanced Floodplain	WCDC, Ann Arbor	8 acres	2.0	$500,000[2]
Vegetative BMPs	WCDC, Ann Arbor, Ann Arbor Twp, Pittsfield Twp	0.75 stream miles	0.25	$30,300

Wetland Improvement	WCDC, Ann Arbor, Ann Arbor Twp, Pittsfield Twp	100 acres	2.2	$75,600
Totals			60.35	$2.61 M

(1) Estimate from Millers Creek 319 project extrapolation
(2) Estimate from Millers Creek Improvement Plan

The activities under this plan exceed the load reduction target by a factor of almost ten. Specific projects need to be identified and prioritized. Opportunistic implementation can then follow by working toward the most promising projects first. Note that some project types, like channel improvement rely on prerequisite implementation of other projects in order for them to be effective. This sequencing will also need to be taken into account.

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[1] Huron River Watershed Council. 2014. Green Infrastructure Opportunities. https://www.hrwc.org/our-watershed/protection/surrounding-land/green-infrastructure/green-infrastructure-opps/
[2] Washtenaw County Water Resources Commissioner. Undated. Rain Gardens. https://www.washtenaw.org/647/Rain-Gardens.
[3] Washtenaw County Water Resources Commissioner. Undated. Green Infrastructure. https://gisappsecure.ewashtenaw.org/public/greeninfrastructure/.
[4] https://www.a2gov.org/departments/systems-planning/planning-areas/water-resources/Documents/MillersCreekSediment_FinalDraft_12%2031%2013.pdf

Chapter 5:
Evaluation and Conclusions

5.1 Evaluation Methods for Measuring Success

Objective markers or milestones will be used to track the progress and effectiveness of the Action Plan management practices in reducing pollutants to the maximum extent possible (see Table 4.2). Evaluating the management practices that are implemented helps establish a baseline against which future progress at reducing pollutants can be measured. The U.S. EPA identifies the following general categories for measuring progress:

1. **Tracking implementation over time.** Where a BMP is continually implemented over the permit term, a measurable goal can be developed to track how often, or where, this BMP is implemented.
2. **Measuring progress in implementing the BMP.** Some BMPs are developed over time, and a measurable goal can be used to track this progress until BMP implementation is completed.
3. **Tracking total numbers of BMPs implemented.** Measurable goals also can be used to track BMP implementation numerically, e.g., the number of wet detention basins in place or the number of people changing their behavior due to the receipt of educational materials.
4. **Tracking program/BMP effectiveness.** The goal of BMP effectiveness monitoring is to demonstrate if a specific BMP was successful in improving water quality in a specific location. For example, measurable goals can be developed to evaluate BMP effectiveness, for example, by evaluating a structural BMP's effectiveness at reducing pollutant loadings, or evaluating a public education campaign's effectiveness at reaching and informing the target audience to determine whether it reduces pollutants to the MEP. A measurable goal can also be a BMP design objective or a performance standard.
5. **Tracking environmental improvement.** The ultimate goal of the NPDES storm water program is environmental improvement, which can be a measurable goal. Achievement of environmental improvement can be assessed and documented by ascertaining whether state water quality standards are being met for the receiving water body or by tracking trends or improvements in water quality (chemical, physical, and biological) and other indicators, such as the hydrologic or habitat condition of the water body or watershed.

Although achievement of water quality standards is the goal of plan implementation, the Steering Committee members need to use other means to ascertain what effects individual and collective BMPs have on water quality and associated indicators. In-stream monitoring, such as physical, chemical, and biological monitoring, is ideal because it allows direct measurement of environmental improvements resulting from management efforts. Targeted monitoring to evaluate

BMP-specific effectiveness is another option, whereas ambient monitoring can be used to determine overall program effectiveness. Alternatives to monitoring include using programmatic, social, physical, and hydrological indicators. Finally, environmental indicators can be used to quantify the effectiveness of BMPs.

Environmental indicators are relatively easy-to-measure surrogates that can be used to demonstrate the actual health of the environment based on the implementation of various programs or individual program elements. Some indicators are more useful than others in providing assessments of individual program areas or insight into overall program success. Useful indicators are often indirect or surrogate measurements where the presence of the indicator points to likelihood that the activity was successful. Indicators can be a cost-effective method of assessing the effectiveness of a program because direct measurements sometimes can be too costly or time-consuming to be practical. A well-known example is the use of fecal coliform bacteria as an indicator of the presence of human pathogens in drinking water. While *E. coli* is now the preferred indicator of bacterial contamination, fecal coliform has been successfully used for more than a century and is still in widespread use for the protection of public health from waterborne, disease-causing organisms.

Table 5.1 presents environmental indicators that have been developed specifically for assessing stormwater programs.[1] Water quality indicators 1 through 16—physical, hydrological, and biological indicators—can be integrated into an overall assessment of the program and used as a basis for the long-term evaluation of program success. Indicators 17 through 26 correspond more closely to the administrative and programmatic indicators and practice-specific indicators.

Table 5.1. Environmental Indicators for Assessing Project Success

Category	#	Indicator Name
Chemical Indicators This group of indicators measures specific water quality or chemistry parameters.	1	Water quality pollutant constituent monitoring
	2	Toxicity testing
	3	Loadings
	4	Exceedance frequencies of water quality standards
	5	Sediment contamination
	6	Human health criteria
Physical and Hydrological Indicators This group of indicators measures changes to or impacts on the physical environment.	7	Stream widening/downcutting
	8	Physical habitat monitoring
	9	Impacted dry weather flows
	10	Increased flooding frequency
	11	Stream temperature monitoring
Biological Indicators	12	Fish assemblage
	13	Macroinvertebrate assemblage

This group of indicators uses biological communities to measure changes to or impacts on biological parameters.	14	Single species indicator
	15	Composite indicator
	16	Other biological indicators
Social Indicators This group of indicators uses responses to surveys, questionnaires, and the like to assess various parameters.	17	Public attitude surveys
	18	Industrial/commercial pollution prevention
	19	Public involvement and monitoring
	20	User perception
Programmatic Indicators This group of indicators quantifies various non-aquatic parameters for measuring program activities.	21	Number of illicit connections identified/corrected
	22	Number of BMPs installed, inspected and maintained
	23	Permitting and compliance
	24	Growth and development
Site Indicators This group of indicators assesses specific conditions at the site level.	25	BMP performance monitoring
	26	Industrial site compliance monitoring

Measurement and evaluation are important parts of planning because they can indicate whether or not efforts are successful, and they also provide a feedback loop for improving project implementation as new information is gathered. If the watershed partners are able to show results, then the plan likely will gain more support from the partnering communities and agencies, as well as local decision makers, and increase the likelihood of project sustainability and success. Monitoring and measuring progress in the watershed necessarily will be conducted at the local level by individual agencies and communities, as well as at the watershed level, in order to assess the ecological effects of the collective entity actions on the health of the Huron River and its tributaries in the Middle Huron Watershed.

Monitoring and measuring progress in the watershed will be two-tiered. First, individual agencies and communities will monitor certain projects and programs on the agency and community levels to establish effectiveness. For example, a community-based lawn fertilizer education workshop will be assessed and evaluated by that community. Also, with the implementation of a community project such as the retrofitting of detention ponds, the individual community responsible for the implementation of that task may monitor water quality/quantity parameters before and after the retrofit in order to measure the improvements.

Secondly, there will be a need to monitor progress and effectiveness on a regional – subwatershed or watershed – level in order to assess the ecological effects of the collective community and agency actions on the health of the river and its tributaries.

The watershed partners recognize the importance of a long-term water quality, quantity and biological monitoring programs to determine where to focus resources as they progress toward meeting collective goals. These physical parameters will reflect improvements on a regional scale.

The monitoring program should be established on a watershed scale since this approach is the most cost effective and consistent if sampling is done by one entity for an entire region.

5.2 Qualitative Evaluation Techniques

As seen in the Action Plan presented in Chapter 4, and the subwatershed plans in the appendices, there are and will be a range of programs and projects implemented—ranging from stream bank stabilization projects to public education—to improve water quality, water quantity and habitat in the Middle Huron Watershed, Section 2. Finding creative ways to measure the effectiveness of each of these individual programs is a challenge. Many of the evaluation techniques utilized for individual projects are listed in the Appendices (Millers Creek: A, Mallets Creek: B, Allens Creek: C, Swift Run: F)

A set of qualitative evaluation criteria can be used to determine whether pollutant loading reductions are being achieved over time and whether substantial progress is being made toward attaining water quality standards in the watershed. Conversely, the criteria can be used for determining whether the Plan needs to be revised at a future time in order to meet standards. A summary of the methods provides an indication of how these programs might be measured and monitored to evaluate success in both the short and the long term (Table 5.2).

Some of these evaluations may be implemented on a watershed basis, such as a public awareness survey to evaluate public education efforts, but most of these activities will be measured at the local level. By evaluating the effectiveness of these programs, communities and agencies will be better informed about public response and success of the programs, how to improve the programs, and which programs to continue. Although many of these methods of measuring progress are not direct measures of environmental impact, it is fair to assume that successful implementation of these actions and programs, collectively and over time, will have a positive impact on in-stream conditions.

Table 5.2. Summary of qualitative evaluation techniques for the Middle Huron Watershed

Evaluation Method	Program/Project	What is Measured	Pros and Cons	Implementation
Public Surveys	Public education or involvement program/project	Awareness; Knowledge; Behaviors; Attitudes; Concerns	Pro: Moderate cost. Con: Low response rate.	Pre- and post- surveys recommended. By mail, telephone or group setting. Repetition on regular basis can show trends. Appropriate for local or watershed basis.
Written Evaluations	Public meeting or group education or involvement project	Awareness; Knowledge	Pro: Good response rate. Low cost.	Post-event participants complete brief evaluations that ask what was learned, what was missing, what could be done better. Evaluations completed on-site.
Stream Surveys	Identify riparian and aquatic improvements.	Habitat; Flow; Erosion; Recreation potential; Impacts	Pro: Current and first-hand information. Con: Time-consuming. Some cost involved.	Identify parameters to evaluate. Use form, such as Stream Crossing Inventory, to record observations. Summarize findings to identify sites needing observation.
Visual Documentation	Structural and vegetative BMP installations, retrofits	Aesthetics. Pre- and post- conditions.	Pro: Easy to implement. Low cost. Con: Can be subjective.	Provides visual evidence. Photographs can be used in public communication materials.
Phone call/ Complaint records	Education efforts, advertising of contact number for complaints/ concerns	Number and types of concerns of public. Location of problem areas.	Con: Subjective information from limited number of people.	Answer phone, letter, emails and track nature of calls and concerns.
Participation Tracking	Public involvement and education projects	Number of people participating. Geographic distribution of participants. Amount of waste collected, e.g. hazardous waste collection	Pro: Low cost. Easy to track and understand.	Track participation by counting people, materials collected and having sign-in/evaluation sheets.
Focus Groups	Information and education programs	Awareness; Knowledge; Perceptions; Behaviors	Pro: Instant identification of motivators and barriers to behavior change. Con: Medium to high cost to do well.	Select random sample of population as participants. 6-8 people per group. Plan questions, facilitate. Record and transcribe discussion.

Adapted from: Lower One SWAG, 2001

5.3 Quantitative Evaluation Techniques

In addition to measuring the effectiveness of certain specific programs and projects within communities or agencies, it is beneficial to monitor the long-term progress and effectiveness of the cumulative watershed efforts in terms of water quality, water quantity and biological health. Watershed-wide long-term monitoring will address many objectives established for the Middle Huron Watershed, Section 2, and monitoring also can show localized, small scale success which are important for proving incremental improvement and morale boosts of partnerships. A monitoring program at the watershed level will require a regional perspective and county or state support. Wet and dry weather water quality, stream flow, biological and other monitoring will afford communities and agencies better decision-making abilities as implementation of this plan continues.

Parameters and Establishing Targets for River Monitoring
Beyond the data collected for the original Watershed Management Plan and its updates, it was recognized that there is a need to augment the type of parameters monitored, the number of locations in the watershed, and the frequency of wet weather monitoring. A holistic monitoring program has been established to help communities and agencies to identify more accurately water quality and water quantity impairments and their sources, as well as how these impairments are impacting the biological communities that serve as indicators of improvements.

HRWC Monitoring
The long-term monitoring program has been established so that progress can be measured over time. The program includes the following components:

- Stream flow monitoring to determine baseflows and track preservation and restoration activities upstream. Additionally, physical and hydrological indicators such as stream widening/downcutting, physical habitat, stream temperature, and a variety of geomorphology measures are collected at HRWC Adopt-a-Stream sites throughout the Watershed. Adopt-A-Stream began in 1992 and the Chemistry and Flow Program began in 2002.

- Wet and dry weather water quality data are being collected in the watershed to identify specific pollution source areas within the watershed, and measure impacts of preservation and restoration activities upstream. Included as water quality indicators are: water quality pollutant monitoring; and loadings. However, due to limited funding, only limited collection of this data has been performed. More regular collection of these parameters along with exceedence frequencies of water quality standards, sediment contamination, and human health criteria need to be added to complete the program.

- Biological monitoring of macroinvertebrates (as a part of the Adopt-a-Stream program) is conducted regularly at sites throughout the watershed. Additional monitoring of fish and mussels would improve the scope of biological knowledge. These indicators are used as measures of the potential quality and health of the stream ecosystem. Include as biological indicators: fish assemblage; macroinvertebrate assemblage; single species indicators; composite indicators; and other biological indicators.

- Identification of major riparian corridors and other natural areas is being conducted via HRWC's Bioreserve Program in order to plan for recreational opportunities, restoration and linkages. The BioReserve program began in 2000.

- The monitoring within the watershed maximizes the use of volunteers to encourage involvement and stewardship.

The HRWC monitoring program currently includes measurement of Dissolved Oxygen (DO), Bacteria (*E. coli*), Phosphorus (P), total suspended solids (TSS), Nitrate-Nitrite, stream flow, conductivity, aquatic macroinvertebrates, temperature, physical habitat, and channel structure.

Establishing Targets
Measuring parameters to evaluate progress toward a goal requires the establishment of targets against which observed measurements are compared. These targets are not necessarily goals themselves, because some of them may not be obtainable realistically. However, the targets do define either Water Quality Standards, as set forth by the State of Michigan, or scientifically-supported numbers that suggest measurements for achieving water quality, water quantity and biological parameters to support state designated uses such as partial or total body contact, and fisheries and wildlife. Using these scientifically-based numbers as targets for success will assist the advisory bodies in deciding how to improve programs to reach both restoration and preservation goals and know when these goals have been achieved. These targets are described below.

Dissolved Oxygen: The Michigan Department of Environment, Great Lakes and Energy (EGLE) has established state standards for Dissolved Oxygen (DO). The requirement is no less than 5.0 mg/l as a daily average for all warm water fisheries. The Administrative Rules state:

> . . . for waters of the state designated for use for warmwater fish and other aquatic life, except for inland lakes as prescribed in R 323.1065, the dissolved oxygen shall not be lowered below a minimum of 4 milligrams per liter, or below 5 milligrams per liter as a daily average, at the design flow during the warm weather season in accordance with R 323.1090(3) and (4). At the design flows during other seasonal periods as provided in R 323.1090(4), a minimum of 5 milligrams per liter shall be maintained. At flows greater than the design flows, dissolved oxygen shall be higher than the respective minimum values specified in this subdivision.
>
> (Michigan State Legislature. 1999)

Bacteria: State standards are established for Bacteria (*E. coli*) by EGLE. For the designated use of total body contact (swimming), the state requires measurements of no more than 130 *E. coli* per 100 milliliters as a 30-day geometric mean during 5 or more sampling events representatively spread over a 30-day period. For partial body contact (wading, fishing, and canoeing) the state requires measurements of no more than 1000 *E. coli* per 100 milliliters based on the geometric mean of 3 or more samples, taken during the same sampling event. These uses and standards will be appropriate for and applied to the creek and those tributaries with a base flow of at least 2 cubic feet per second.

Phosphorus: State water quality standards for phosphorus require that "phosphorus which is or may readily become available as a plant nutrient shall be controlled from point source discharges to achieve 1 mg/l of total phosphorus as a maximum monthly average effluent concentration unless other limits, either higher or lower, are deemed necessary and appropriate." In the case of the Middle Huron Watershed, the Ford and Belleville Lakes TMDL defines effluent standards for point sources and establishes an environmental standard of 30 µg/L at Ford Lake and Belleville Lake (Appendix G). The State also requires that "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state." Monitoring frequency and number of sites for phosphorus and nitrogen needs to be increased to capture seasonal variation and dry and wet weather conditions, and effectively estimate changes in loading of these nutrients.

Total Suspended Solids/Sediment: No numerical standard has been set by the state for Total Suspended Solids (TSS) for surface waters. However, the state requires that "the addition of any dissolved solids shall not exceed concentrations which are or may become injurious to any designated use." To protect the designated uses of fisheries and wildlife habitat, as well as the desired recreational and aesthetic uses of the surface waters in the watershed, there are recommended targets established on a scientific basis. From an aesthetics standpoint, it is recommended that TSS less than 25 mg/l is "good", TSS 25-80 mg/l is "fair" and TSS greater than 80 mg/l is "poor."[2] The TSS target, therefore, will be to maintain TSS below 80 mg/l in dry weather conditions. Another measurement that can be used to determine the impacts of sediment loading is to determine the extent of embeddedness of the substrate (how much of the stream bottom is covered with fine silts) and the bottom deposition (what percentage of the bottom is covered with soft muck, indicating deposition of fine silts). These are measurements taken by the Surface Water Assessment Section (SWAS) protocol habitat assessment conducted by EGLE every five years, and by the Adopt-A-Stream program more frequently. Rating categories are from "poor" to "excellent." The target should be to maintain SWAS "excellent" and "good" designations at sites where they currently exist, and to improve "fair" and "poor" sites to "good." Further standards for TSS are established by TMDLs for Malletts Creek and Swift Run (Appendix B and F)

Stream Discharge: Stream flow, or discharge, for surface waters do not have a numerical standard set by the state. Using the health of the fish and macroinvertebrate communities as the ultimate indicators of stream and river health is most useful in assessing appropriate flow. Recommended flow targets for the river and its tributaries will be established once the necessary research has been conducted that will determine the natural, pre-development hydrology and current hydrology. Peak flow data is needed to compare more accurately observed flow to the target flow. As describe in chapter two, USGS stream gages are located on the Huron River between Argo and Geddes Dams and on Malletts Creek near its mouth. These provide continuous measurement of discharge.

Conductivity: Conductivity measures the amount of dissolved ions in the water column and is considered an indicator for the relative amount of some types of suspended material in the stream. The scientifically-established standard for conductivity in a healthy Michigan stream is 800 microSiemens (µS), which should be the goal for the Huron River and its tributaries.[3] Levels higher than the standard may indicate the presence of suspended materials from stormwater runoff, failing septics, illicit connections, ground water seeps or other sources.

Fisheries: Numerical or fish community standards have not been set by the state. However, EGLE has developed a system to estimate the health of the predicted fish communities through the SWAS 51 sampling protocol. This method collects fish at various sites and is based on whether or not certain expected fish species are present, as well as other habitat parameters; fish communities are assessed as poor, fair, good, or excellent. The state conducts this protocol every five years in the Huron River Watershed. The target should be to maintain SWAS 51 scores of "excellent" and "good" at sites where they currently exist, and to improve "fair" and "poor" sites to "good." The SWAS 51 protocol also identifies whether or not there are sensitive species present in the Huron River and its tributaries, which would indicate a healthy ecosystem. Certain species are especially useful for demonstrating improving conditions. These species tend to be sensitive to turbidity, prefer cleaner, cooler water, and their distribution in the Huron Watershed is currently limited. The target is to continue to find species currently found in self-sustaining population numbers, at a minimum. Improvements in habitat and water quality should also result in the expansion or recruitment of additional species.

Benthic Macroinvertebrates: Similar to the assessment of fish communities, the state employs the SWAS protocol for assessing macroinvertebrate communities on a five-year cycle for the Huron River Watershed. The HRWC Adopt-A-Stream program monitors macroinvertebrate health and physical habitat at sites in the Watershed using a volunteer friendly adaptation of the SWAS procedure. The sites are monitored for macroinvertebrates two or three times each year and periodically for physical habitat health. The monitoring target for macroinvertebrate communities will be to increase EGLE and Adopt-A-Stream monitoring sites to improve the existing database and attain scores of at least "fair" at sites that currently are "poor," and improve "fair" sites to "good," while maintaining the "good" and "excellent" conditions at the remaining sites.

Temperature: The state lists temperature standards only for point source discharges and mixing zones – not ambient water temperatures in surface water. However, recommendations for water temperature can be generated by assessing fish species' tolerance to temperature change and these guidelines are found within the statute. Although some temperature data have been collected in the Middle Huron system by the HRWC Adopt-A-Stream program and as part of the monitoring for the Middle Huron Partnership Initiative, additional studies are needed to establish average monthly temperatures and whether increased temperatures are limiting biota habitat.

Wetlands: An annual review should be done of EGLE wetland permit information and local records in order to track wetland fills, mitigations, restoration and protection to establish net loss or gain in wetlands in the watershed. The target for this parameter is to track the net acres of wetland in the watershed to determine action for further protection or restoration activities. In addition, the Bioreserve Project evaluates small, non-regulated wetlands. Once identified, these should also be tracked as above.

Details regarding responsible parties, monitoring standards, sampling sites, and frequency of monitoring for qualitative and quantitative evaluation techniques need to be periodically reviewed by the Middle Huron Partners and subwatershed groups. Results from monitoring and progress evaluation are reported through a variety of mechanisms. The Middle Huron Partnership Initiative reports on progress toward the Ford and Belleville Lakes TMDL every two years, on average. Many of the communities and other responsible agencies in the Middle Huron submit annual reports as part of Phase II stormwater compliance. HRWC produces a summary of results on the Adopt-a-Stream program once per year.

5.4 Evaluation Monitoring for the Middle Huron Watershed

Based on an evaluation of the above information, the goals and objectives of this plan, and the causes and sources of water quality impairments in critical areas, the monitoring plan detailed in Table 5.3 has been established. This plan is contingent upon funding and participation of community partners and monitoring agencies.

The monitoring plan is based around four programs administered by three organizations. First, HRWC's Adopt-a-Stream Program collects data on benthic macroinvertebrates three times a year, including a special collection of winter stoneflies. Adopt also does a complete stream habitat assessment of each site every 4-5 years, which includes a number of geomorphic characteristics along with general habitat characteristics as with the EGLE protocol. Adopt collectors also sample for water conductivity at each macroinvertebrate event. Summer temperatures are also documented every 5 years. The Adopt program uses volunteers to collect the vast majority of the data. Results from this program are included in section 2.4

The second program is EGLE's rotational watershed assessments. EGLE returns to the watershed every five years to collect benthic macroinvertebrates, habitat assessment data and, in some cases, a suite of water chemistry parameters. Site selection varies each year.

HRWC also administers the Middle Huron Tributary Monitoring Program on behalf of the Middle Huron Partnership. HRWC uses volunteers and staff to collect water samples and deliver to the Ann Arbor Water Treatment Plant for analysis. Analytes include total phosphorus, nitrates, nitrites, total suspended solids and E. coli. Volunteers also collect stream discharge data from all ten sites to allow for the calculation of pollutant loads. Currently, data is collected once or twice per month (depending on site) with additional storm event and high flow samples collected opportunistically during the April to September growing season.

Finally, EGLE conducted a water quality monitoring of six lake sites in Ford and Belleville Lakes and two sites on the Huron River. Nutrients and other parameters were collected once per month from April to September. This program was in effect through 2006 when it was halted due to funding cuts. It was restarted again, and EGLE currently returns biennially to sample lake sites only in even years.

Table 5.3 Middle Huron River (Section 2) Watershed Monitoring and Evaluation

See Figure 2.20 for locations

Monitoring Site[1]	Parameter Target	Type of Analysis	Protocol	Frequency	Test Agent
Huron River		Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC, EGLE
Adopt (61)		Total Suspended Solids	SM20 2540 D[5]	1x/Mo Apr-Sept	AA WTP[4]
WWTP Bridge sites (2)	S,N,DO,T,I,	Total Phosphorus, Nitrates, Nitrites	SM20 4500	1x/Mo Apr-Sept	AA WTP; EGLE
EGLE[3]	B, Bio[2]	Temp, DO, pH, Conductivity	Multi-Meter	1x/Mo Apr-Sept	AA WTP
		E. coli	SM20 9213 D	1x/Mo Apr-Sept	AA WTP
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC, EGLE
Allens Creek		Total Suspended Solids	SM20 2540 D	2x/Mo + Rain event	HRWC to AA WTP
Middle Huron (MH04)		Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo + Rain event	HRWC to AA WTP; EGLE
	S, N, DO, T, I, B	Temp, DO, pH, Conductivity	YSI Multi-Meter	2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	2x/Mo + Rain event	HRWC to AA WTP
Traver Creek		Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC, EGLE
Adopt (42,43, 101)		Total Suspended Solids	SM20 2540 D	2x/Mo + Rain event	HRWC to AA WTP
Middle Huron (MH05B)	S, N, DO, T,	Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo + Rain event	HRWC to AA WTP; EGLE
	I, B, Bio	Temp, DO, pH, Conductivity	YSI Multi-Meter	2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	2x/Mo + Rain event	HRWC to AA WTP
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC, EGLE
Millers Creek		Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC, EGLE
Adopt (35,72,76)		Total Suspended Solids	SM20 2540 D	2x/Mo + Rain event	HRWC to AA WTP
Middle Huron (MH08)	S, N, DO, T,	Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo + Rain event	HRWC to AA WTP; EGLE
	I, B, Bio	Temp, DO, pH, Conductivity	YSI Multi-Meter	2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	2x/Mo + Rain event	HRWC to AA WTP
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC, EGLE
Malletts Creek		Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC, EGLE

Adopt (27, 29, 56)		Total Suspended Solids	SM20 2540 D	2x/Mo + Rain event	HRWC to AA WTP
Middle Huron (MH07)	S, N, DO, T,	Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo + Rain event	HRWC to AA WTP; EGLE
	I, B, Bio	Temp, DO, pH, Conductivity	YSI Multi-Meter	2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	2x/Mo + Rain event	HRWC to AA WTP
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC, EGLE
Swift Run		Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC, EGLE
Adopt (41)		Total Suspended Solids	SM20 2540 D	2x/Mo + Rain event	HRWC to AA WTP
Middle Huron (MH09)	S, N, DO, T,	Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo + Rain event	HRWC to AA WTP; EGLE
	I, B, Bio	Temp, DO, pH, Conductivity	YSI Multi-Meter	2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	2x/Mo + Rain event	HRWC to AA WTP
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC, EGLE
Fleming Creek		Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC, EGLE
Adopt (9,11,13,84)		Total Suspended Solids	SM20 2540 D	2x/Mo + Rain event	HRWC to AA WTP
Middle Huron (MH06)	S, N, DO, T,	Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo + Rain event	HRWC to AA WTP; EGLE
	I, B, Bio	Temp, DO, pH, Conductivity	YSI Multi-Meter	2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	2x/Mo + Rain event	HRWC to AA WTP
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC, EGLE

[1] Adopt = HRWC Adopt-a-Stream; Middle Huron = Middle Huron Partners tributary nutrient monitoring; EGLE = EGLE lake monitoring

[2] S= Sediment; N= Nutrients; DO= Dissolved Oxygen; T= Temperature; I= Ions; B= Bacteria; Bio= Biota

[3] Specific sites will be included as part of EGLE Water Resources Division rotational water quality monitoring program; these locations vary every 5 years across all of these creeksheds. No long term trend sites are located in this Watershed.

[4] HRWC staff and volunteers to collect samples and deliver to Ann Arbor Water Treatment Plant for analysis under their direction.

[5] Analytical protocols follow “Standard Methods for the Examination of Water and Wastewater”, 20th edition, by the American Waterworks Association

5.5 PARTING WORDS

The Middle Huron River Watershed Management Plan: Section 2 was created to provide a strong foundation and framework for improving water quality in the Middle Huron Watershed and protecting its valuable natural resources for future generations. The authors hope that choosing a consensus-based approach to developing the Plan will pay off in the form of a strong sense of ownership and unanimous support for the Plan in the years to come.

The task ahead—continued implementation of this watershed management plan—demands patience, persistence, determination, and cooperation of many partners and stakeholders at all levels. No matter how much effort and dedication was put into the Plan, it is of little value if the Plan itself remains the primary end-point. Fortunately, the partners who contributed to the Plan over the past nearly three decades have been implementing many of its remedial activities, started many ongoing programs, and plan to do much more. The partners have put in a great effort to date and progress is obvious. Many of the accomplishments have been listed in Appendix I.

Each community in the watershed has a choice. It can regard the Plan as merely another plan required for state funding or regulation and move on to the next requirement, or it can use the Plan as it is intended: to guide each community not only in fulfilling its own requirements, but also in partnering with other stakeholders throughout the watershed to protect the land and water that connects us all.

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[1] Claytor, R. in Schueler, T. R. and H. K. Holland. 2000. The Practice of Watershed Protection. Ellicott City, MD: The Center for Watershed Protection.

[2] Riggs, E. H.W. 2003. Mill Creek Subwatershed Management Plan. Ann Arbor, MI: Huron River Watershed Council for the Michigan Department of Environmental Quality.

[3] Dakin, T. and Martin, J. 2003a. Monitoring Gazette, Winter-Spring 2003. Ann Arbor, MI: Huron River Watershed Council.