THE MIDDLE HURON RIVER WATERSHED MANAGEMENT PLAN, SECTION 3.

WASHTENAW AND WAYNE COUNTIES, MICHIGAN

INCLUDING:
THE HURON RIVER FROM THE FLEMING CREEK OUTLET TO THE END OF BELLEVILLE LAKE

ALSO:

WILLOW RUN

FORD LAKE

BELLEVILLE LAKE

PREPARED BY
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Huron River Watershed Council

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EGLE
MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

EPA United States Environmental Protection Agency

This plan was approved by EGLE and the EPA in September 2024.

WATERSHED MANAGEMENT PLAN FOR THE MIDDLE HURON RIVER, SECTION 3.

TABLE OF CONTENTS

Chapter 4: Action Plan for the Middle Huron Watershed, Section 3 4-1

APPENDICES

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 (former name of EGLE)

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

WCWRC: Washtenaw County Water Resources Commissioner

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

μg/L: microgramsper liter (concentration of constituents in water), also equivalent to ppb: parts per billion

μS/cm: microsiemens per centimeter (conductivity)

Chapter 1: Introduction

1.1 The Middle Huron River Watershed Management Plan: Section 3

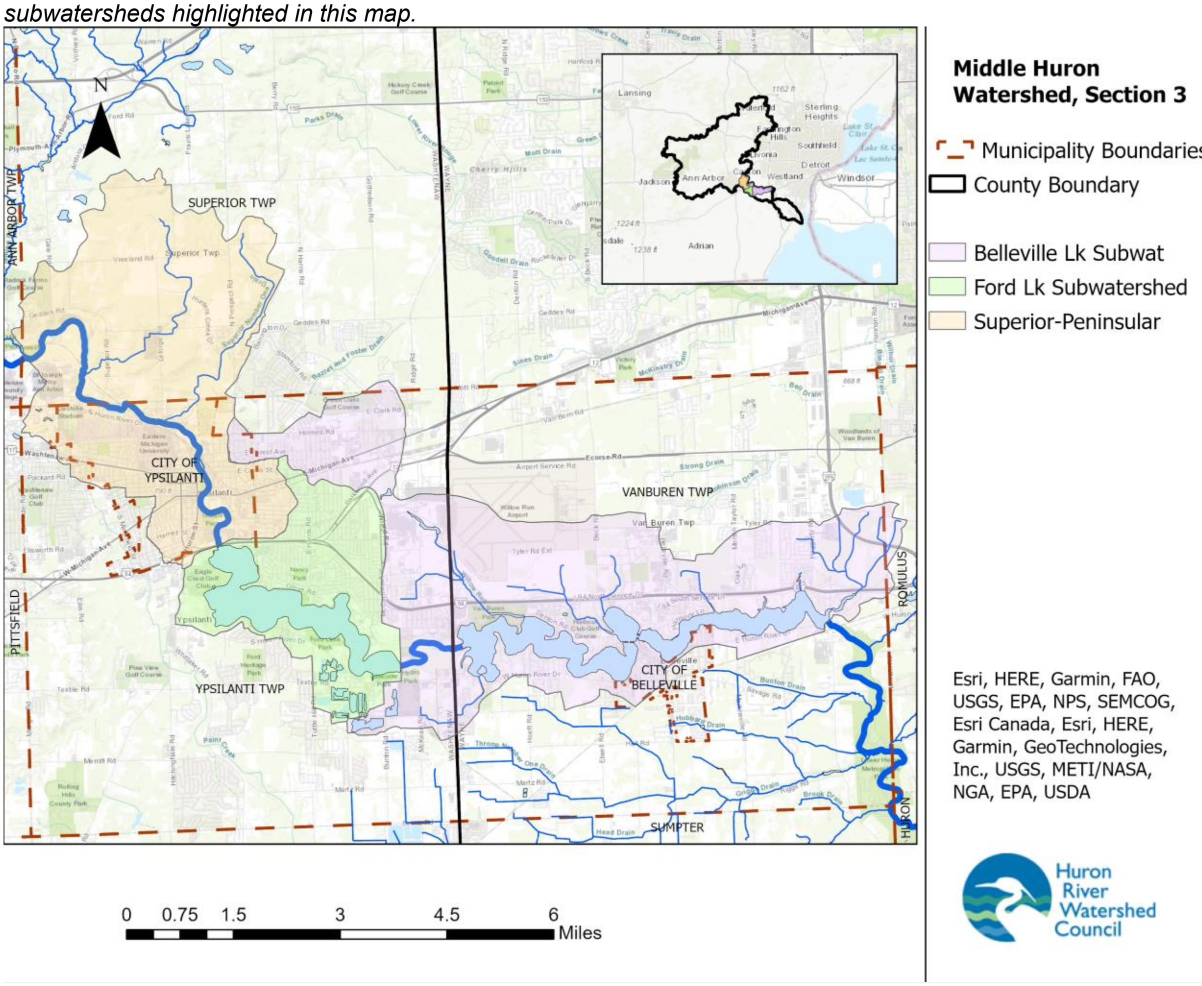
The Middle Huron River Watershed Management Plan (WMP): Section 3 is part of an effort led by communities in this area seeking to plan activities to address water quality issues highlighted in the State of Michigan's Clean Water Act §303(d) report on impaired waters. The original WMP was completed in 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 2023 version is the fourth update of that WMP, but it is narrower in scope as it only covers the lower geographic portion of that earlier WMP. Separate WMPs have been written for the upper (Section 1) and middle (Section 2) geographic portions.

For the purposes of this plan, Section 3 of the Middle Huron Watershed (Figure 1.1) will be referred to as the Watershed. It is composed of the Huron River starting just downstream of the confluence of Fleming Creek, and continuing through the Ford and Belleville Lakes, which are dammed impoundments in the Huron River. There are no major creeksheds in this section but there are several smaller tributaries often referred to as "direct drainage".

The Watershed is part of the larger 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 Watershed encompasses approximately 900 square miles (576,000 acres) of Ingham, Jackson, Livingston, Monroe, Oakland, Washtenaw, and Wayne counties. 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.

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.



The drainage area to the Watershed is 36 square miles (23,039 acres), representing approximately 4% of the total Huron River Watershed. All or portions of 9 municipalities (not counting Federal or State) are situated in the Watershed, as shown in Table 1.1.

The Watershed lies both in Washtenaw County (66% of the Watershed) and Wayne County (34%).

Communities with more than 10% of their municipality in the Watershed, and both Washtenaw and Wayne County, are called "Core Communities" throughout this document.

Table 1.1. Breakdown of Municipalities in the Watershed

Municipality	Size of Watershed in Municipality (sq mi)	% of Watershed in Municipality	% of Municipality in Watershed
Ann Arbor Township	0.03	<1%	<1%
City of Belleville	0.5	1.3%	43%
City of Ypsilanti	4.3	12%	91%
Romulus Township	0.2	<1%	<1%
Superior Township	8.4	23%	24%
Van Buren Township	11.6	32%	32%
Ypsilanti Township	12.0	33%	38%
Washtenaw County	24.7	66%	3%
Wayne County	12.3	34%	2%

The Huron River in the Watershed begins just downstream of Fleming Creek, where it very shortly gets impounded in Superior Pond, and then Peninsular Pond. The river then free flows through the City of Ypsilanti until it enters Ford Lake, and then Belleville Lake. The mainstem of the Huron River in the Watershed is 18 miles long, with 1.5 miles of that being free flowing water and 16.5 of that being impounded (if drawing a straight line through the impoundments). The elevation drops 82 feet over this distance for an average gradient of 4.6 ft/mi for the Huron River. For comparison, the entire Huron River has an average gradient of 3.3 ft/mi. Numerous small creeks enter the Huron River through this section, totaling 23.6 miles in length.

As of 2020 data, the watershed's land use is dominated by developed areas (37% of the Watershed).[1] Natural lands and farms are scattered about like a mosaic (Forest: 12%, Wetland: 7%, Open land/Old Field: 9%, Agriculture: 9%). There are 4 major dams on the Huron River through this stretch, and there are another 4 dams on the smaller tributaries. The dams create a massive amount of open water on the Huron River, including Ford and Belleville Lakes, adding up to about 12% of the total Watershed acreage.

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. Wayne County, if leaving out the City of Detroit which is not in the Watershed, has experienced slight growth. The region has increased from a population of about 100,000 in 1990 to a population of about 125,000 in 2020, a 22% growth rate[3]. The fastest area of growth in this time frame in the Watershed area is Superior Township (70% change) and Van Buren Township (45% change). On the other hand, the City of Ypsilanti has shrunk by 17% since 1990. These population numbers are not precise to the Watershed since they are based on census data and political boundaries, but they give a good rough estimate. [See Chapter 2.2 for complete details]

The SEMCOG forecast to 2040 predicts a 13% increase in population from 2020 levels, This indicates that the speed of growth in the Watershed could slow by half as compared to the rate of development that occurred in the recent past. This also presents a good opportunity for fixing as many of the problems caused by the rapid expansion as possible; sort of like cleaning your house after a major renovation.

Growth on the scale seen in the past decades hastened the degradation of the hydrology and water quality of surface waters. Through the processes of development, the Watershed has undergone wetland draining, deforestation, straightening and dredging streams (“drains”), removal of riparian vegetation, installation of impervious surfaces and storm sewers, inadequate control of soil erosion, and installation of poorly designed stream crossings. Such practices resulted in altered hydrology (“flashy” flows and flooding), soil erosion and sedimentation, elevated nutrients, nuisance algal blooms, dangerous levels of pathogens, degraded fisheries, and destruction of natural lands that provided wildlife habitat, recreation, air quality, filtering of polluted runoff, temperature regulation, flood control, groundwater storage, drinking water supply, carbon storage and sequestration, and a host of other ecosystem services.

The time is now to fix these issues wherever possible and prevent them from occurring again in the future.

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, Section 3. 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 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 the 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 also meet the "9 Minimum Elements:"

1. *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.*
2. *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.*
3. *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.*
4. *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.*
5. *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.*
6. *A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.*
7. *A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.*
8. *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.*
9. *A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.*

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.[4] The designated uses that apply to the Watershed are in boldface:

- **Agriculture**
- **Industrial water supply**
- Public water supply
- **Navigation**
- **Warmwater fishery**
- **Fish Consumption**
- **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.

That being said, there are many miles of streams in the Watershed that have not yet been assessed for the pollutants that may impair these designated uses.

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

1.2.3 Assessment Unit Identifiers

As of the 2022 EGLE Integrated Report[5] and the Statewide *E.Coli* Total Maximum Daily Load Addendum-2022[6] , three waterbodies as delineated by Assessment Unit Identifiers (AUID) in the Watershed are listed for water quality problems that can be addressed by this plan (Figure 1.2, Table 1.2).

Multiple waters throughout the Huron River watershed are listed as impaired for fish consumption due to PCB and mercury. The impairments are addressed by statewide TMDLs[7,8]. The AUIDs listed for these are included in Table 1.3, but because the problems associated with PCB and mercury pollution are linked to broadly diffuse air-deposition originating outside of the Huron River Watershed, actions designed to address this TMDL are not emphasized in this plan, which focuses on locally-sourced impairments.

Figure 1.2: AUIDs reaches within the Section 3 Middle Huron River

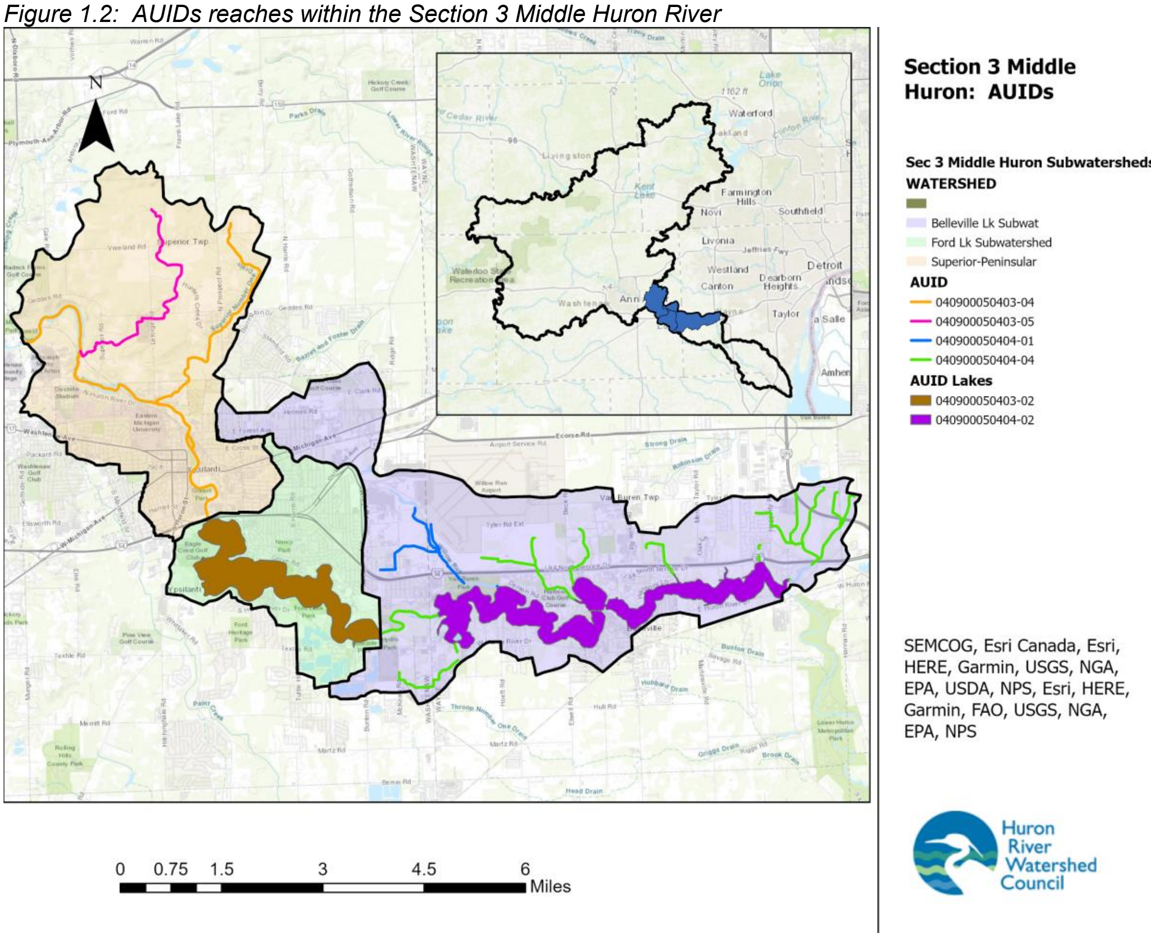


Table 1.2: Stream reaches within the Watershed, highlighting Impaired Designated Uses and established TMDLs (not including Fish Consumption: PCB and Mercury)

AUID	AUID Name	Designated Uses	Pollutant/Cause	Stream length (miles)
MI040900050404-01	Willow Run Drain	Not assessed for warm water fishery, total and partial body contact, other indigenous aquatic life and wildlife		3.1
AUID	**AUID Name**	**Designated Uses**	**Pollutant/Cause**	**Stream length (miles)**
MI040900050404-04	Tributaries to Belleville Lake	Not assessed for warm water fishery, total and partial body contact, other indigenous aquatic life and wildlife		12.1
		Not supporting Fish Consumption	PFOS	
AUID	**AUID Name**	**Designated Uses**	**Pollutant/Cause**	**Stream length (miles)**
MI040900050403-04	Huron River, Superior Number One Drain	Fully supporting warm water fishery and other indigenous life		10.3
		Partial Body Contact: Fully Supporting, Total Body Contact: Not Supporting	*E. Coli*	
		Not supporting Fish Consumption	PFOS	
AUID	**AUID Name**	**Designated Uses**	**Pollutant/Cause**	**Stream length (miles)**
MI040900050403-05	Snidecar Drain	Fully supporting warm water fishery and other indigenous life		4.0
		Not supporting Partial or Total Body Contact	*E. Coli*	
		Not supporting Fish Consumption	PFOS	
AUID	**AUID Name**	**Designated Uses**	**Pollutant/Cause**	**Lake Size**
040900050403-02	Ford Lake	Not assessed for warm water fishery and total and partial body contact		951 acres
		Not supporting:		
		Other indigenous aquatic life and wildlife	Total Phosphorus, Algae	
		Fish Consumption	PFOS	
AUID	**AUID Name**	**Designated Uses**	**Pollutant/Cause**	**Lake Size**
040900050404-02	Belleville Lake	Not assessed for warm water fishery and total and partial body contact		1248.2 acres

		Not supporting:		
		Other indigenous aquatic life and wildlife	Total Phosphorus, Algae	
		Fish Consumption	PFOS	

Table 1.3: Stream reaches with Fish Consumption impaired use due to PCB or Mercury (None listed for Mercury).

AUID	AUID Name	Designated Use Not Met	Pollutant/Cause	Stream length (miles)
MI040900050404-01	Willow Run Drain	Fish Consumption	PCB	3.1
MI040900050404-04	Tributaries to Belleville Lake	Fish Consumption	PCB	12.1
MI040900050403-04	Huron River, Superior Number One Drain	Fish Consumption	PCB	10.3
MI040900050403-05	Snidecar Drain	Fish Consumption	PCB	4.0
040900050403-02	Ford Lake	Fish Consumption	PCB	951 acres
040900050404-02	Belleville Lake	Fish Consumption	PCB	1248.2 acres

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 this 2023 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 2023 update, HRWC assembled a stakeholder committee which consisted of the Core Communities in the Watershed (all those with >10% of their municipality in the Watershed, Table 1-1.) Not all these invitees elected to join the stakeholder committee, but all were welcomed. Stakeholders were given an overview of HRWC's data collection and monitoring efforts over the past 10 years, and gave input as to what projects their municipalities had accomplished since 2008 and what projects they would like to see implemented. All stakeholders were given draft copies of the WMP for review and comment prior to final changes and approval by EGLE.

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 MDNR. 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 and the 2008 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 A) and was effective through 2009. The group still continues to meet and work in 2022, 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 were also given this plan for opportunity to review and comment prior to its finalization.

1.3.2 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. It is a revision from the previous plan approved in 2008.

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.

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[1] Southeast Michigan Council of Government. https://semcog.org/gis. Accessed 2021.

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

[3] U.S Dept of Commerce, Michigan: 2010. 2010 Census of Population and Housing. https://www.census.gov/prod/cen2010/cph-2-24.pdf. Accessed 2021.

[4] 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.

[5] EGLE, 2023. Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report. https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/SWAS/2022-Integrated-Report.pdf?rev=0a6b006c0cc44bcd936c75d5608659ed&hash=03A5B2B0F3379B07D369F289BA32C483. Accessed July 2023.

[6] EGLE. 2022. https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/SWAS/TMDL-Ecoli/statewide-ecoli-tmdl-2022-addendum.pdf

[7] EGLE 2020. Final 2020 Statewide PCB TMDL. https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-292645--,00.html. Accessed June 2021

[8] EGLE 2020. Final 2020 Statewide Mercury TMDL. https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-301290--,00.html. Accessed June 2021

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 various Geographic Information System's projects. It is difficult to explain the full breadth of what the GIS provides in text and static picture alone, so the projects and maps shown in this chapter are available from HRWC for any future project that could benefit from zooming in on specific locations.

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

In the upper section of this Watershed, the primary underlying glacial geology are moraines of fine or medium-textured till (Figure 2.1). End moraines are areas where glacial processes have 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 and can also create large areas of groundwater storage. The other upstream surficial geology in the Watershed are 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.

As the Huron travels downstream through Ypsilanti, it enters a new region of glacial impact—the ancestral lakebed of Lake Erie. From this point and downstream, the Huron River cuts through a glacial geology of lacustrine sand, gravel, clay, and silt. The slope of the land pushes most of the water in this area to drain in a west to east configuration toward Lake Erie and as a result the Huron River watershed grows very narrow. Stream substrates are more composed of fine textured particles and less apt to hold bigger particles like cobbles and boulders that provide hiding places for macroinvertebrates and fish. Fine particles are less permeable and thus much of the Watershed has a very low groundwater recharge rate (Fig. 2-2).

Figure 2.1. The Watershed's Glacial Geology.

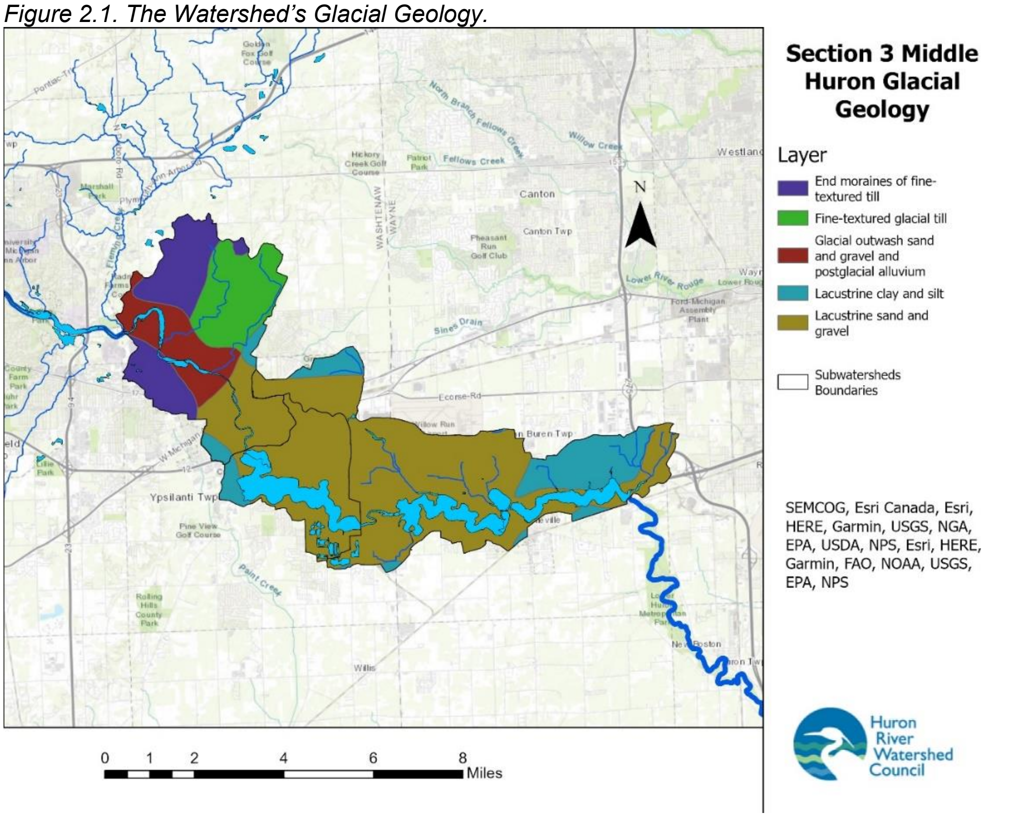
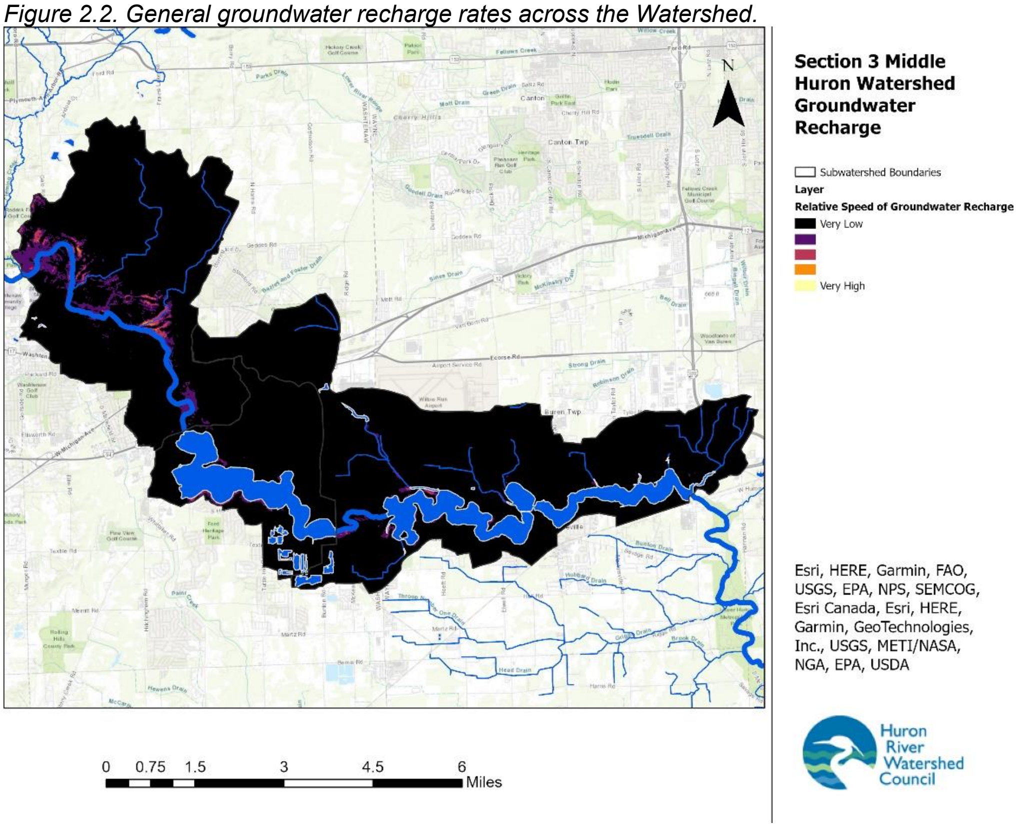


Figure 2.2. General groundwater recharge rates across the Watershed.



2.1.3 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, farm-field tile drains, and construction sites all play a role in producing flashy, sediment-laden flows.

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% grade). The Huron River flowing through our Watershed region is steeper than average at 4.6 feet per mile (0.08% grade), but less steep as the previous section of the river as it flows through Ann Arbor (7.6 feet per mile (0.14% grade)). The river channel gradient has a controlling influence on river habitat such as flow rates, depth, width, channel meandering, and sediment transport. There are particular areas in the Watershed with localized steeper slopes and these are the areas most likely to be dammed; which is clearly the case, with the Huron River extensively dammed throughout this Watershed (and upstream through the Ann Arbor area).

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)[1]. While not in this Watershed section of interest, this is the closest USGS gage.

In 2022, the mean annual flow at the Wall Street station was 691 cubic feet per second (cfs), representing a drainage area of 729 square miles, or 0.94 cfs per square mile. Across the whole historical data record, an average year would flow at 475 cfs. Examining the average years over time, the data record show that flow has increased in the Huron River since 1914 (Figure 2.3).

When HRWC made a similar graph in 2018 for the Middle Huron Section 2, the average flow at Wall Street for the time period was 470 cfs. Flow continues to increase—the slope of the red line is approximately +2 cfs/year.

While monthly streamflow naturally varies from year to year, despite the year, conditions in the watershed vary most in the spring and early winter and remain relatively constant over the summer months (Figure 2.4). Seasonally high flows generally occur in early spring during winter snowmelt and spring rains, with baseflow conditions most apparent between July and October.

Figure 2.3. Average Annual Discharge of the Huron River at Wall Street, from water year 1915-2022. The red line indicates an increasing linear trend over time.

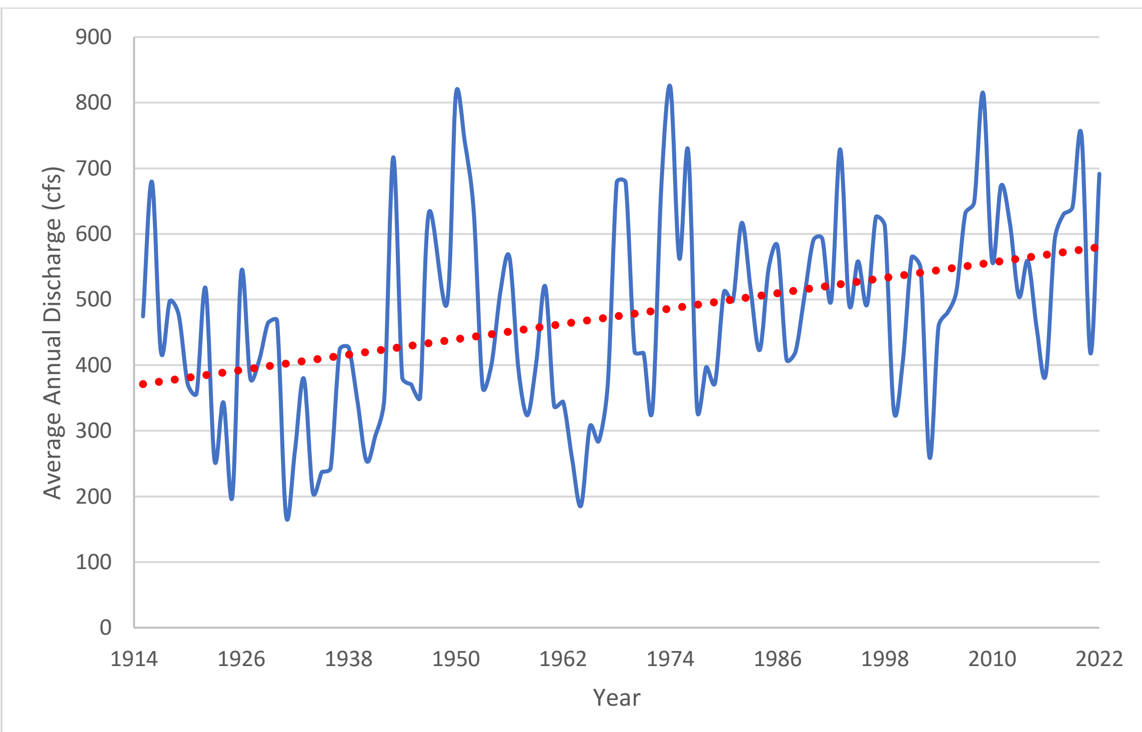
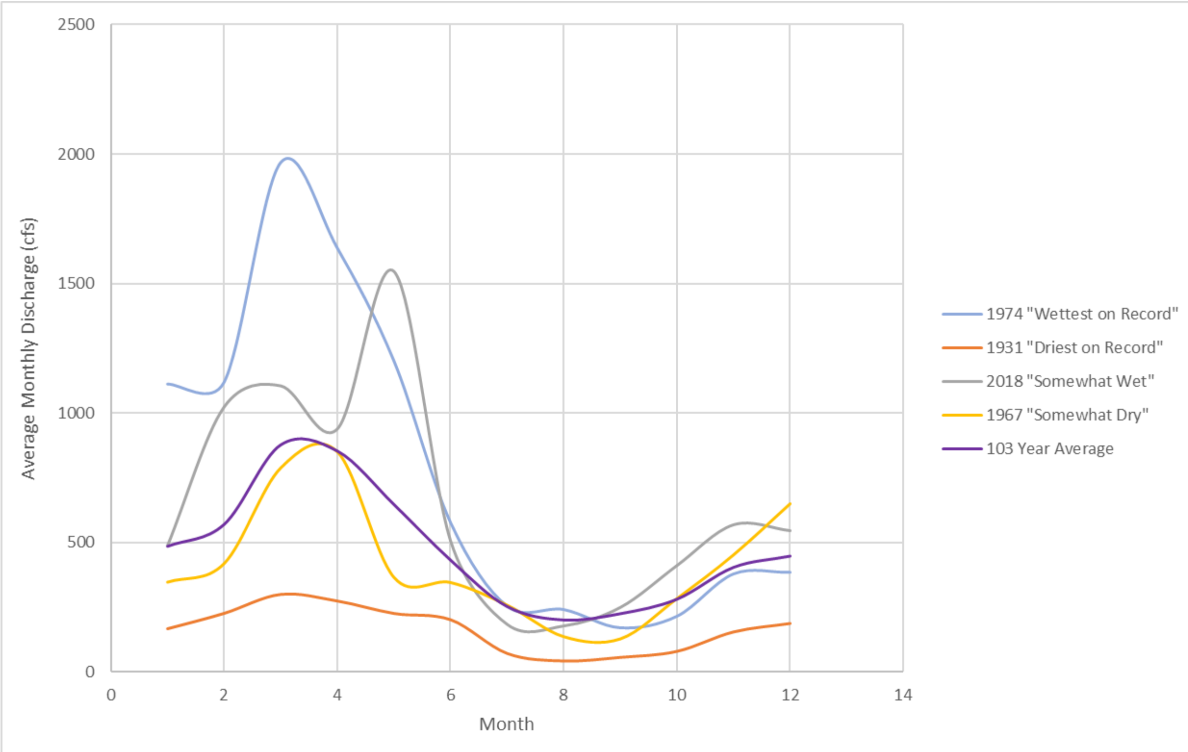


Figure 2.4. Variety of monthly flow conditions over the flow data on record for the Huron River, Wall Street. (USGS station #041744500).



HRWC also installed a water level and flow sensor at the Forest Avenue river crossing within the Watershed, which drains an area of 800 square miles. That sensor has only provided reliable data since February 2022. With just over a year of data, the mean flow was 619 cfs, which compares to 419 cfs for the Wall Street USGS gage for the same time. For that year period, the extra 71 square miles of drainage generated 2.81 cfs/sq mi, which is much larger than the 0.57 cfs/sq mi for the USGS station. This suggests that runoff is flowing to the river surface water in the study Watershed at a much faster rate than upstream. However, the flashiness index at the Forest Avenue site is only 0.16, which puts it among the least flashy quarter of all sites studied across Michigan, at least for this one year of data. The maximum discharge during the record period was 3,340 cfs and the minimum was 95 cfs, as 2022 was wetter than average at the USGS station.

Development and resulting changes to hydrology and hydraulics are 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.

2.1.3.1 Dams and Impoundments

Another component contributing to the hydrology of the Middle Huron Watershed is the presence of dams and impoundments. According to the National Inventory of Dams, eight dams are located in the Watershed (Figure 2.5 and Table 2.2).[2]

Dams may be constructed for uses such as hydropower, recreation, or stormwater and flood control. Most of the dams in the Watershed were developed for hydropower—100 years ago, this area was full of industry. However, dams that were previously useful can outlive their intended purposes and become hazards and ecological detriments to the river. In the full Huron River Watershed, there are only 4 dams still used to produce hydroelectric power; 3 of them are found in this section 3 Middle Huron—Superior Dam, Ford Lake Dam, and French Landing Dam.

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, eliminating fish spawning habitat, increasing nuisance plant growth in impoundments, altering water temperatures, and injuring or killing fish.

Several of the dams in the Watershed have specific issues worth discussing here.

Peninsular Paper Dam: Peninsular Paper Dam (Pen Dam) in Ypsilanti is of particular concern and HRWC is actively supporting the City of Ypsilanti to remove the dam. Pen Dam is a high-hazard dam since loss of life is probable following catastrophic failure. In 2022, EGLE downgraded the condition of the dam from "fair" to "low," underscoring the urgency to remove the dam. Planning and assessment efforts to remove the dam are well underway with an anticipated removal of the dam in 2025. Impoundment restoration activities will run concurrently to dewatering of the impoundment and demolition of the dam and will continue for several years after the removal of the spillway.

French Landing Dam: As of 2023, the operators of French Landing Dam are working with Van Buren Township officials to relicense the dam for hydropower generation through the Federal Energy Regulatory Commission (FERC). The relicensing procedure is comprehensive and has revealed several opportunities to improve safety for recreation and flow management near French Landing Dam. In particular, the portage around this dam is considered the most dangerous along the entire Huron River Water Trail. The entire portage trail is subject to routine vandalism, and the downstream portage launch is a narrow set of wooden steps anchored to a concrete retaining wall. Given the position and dimension of the portage, along with flow management of the dam, it's common for the wooden steps to be suspended several feet from sure footing for launching small watercraft. All options should be considered for improving, fortifying, or relocating the portage access points, as climate change will likely make flows even less predictable and more dangerous to people accessing the portage.

Of interesting historical note- not water quality.

Susterka Lake Dam: This dam and impoundment are an odd piece of local history as the site of a 1920's-1950's era "dance hall frequented by nearby college students, and a loosely regulated summer swimming hole for families and school children." The impoundment and dam seem to exist solely for recreational purposes even today, though just for the local property owners.

The What Shall We Weird blog tells this odd story:

https://whatshallweweird.com/3387/below-susterka-lake/.

Tyler Dam and Beyer Dams: Tyler and Beyer Dams, on Willow Run Creek and within the Belleville Lake watershed, were constructed in the 1940's to support operations at the

Willow Run Bomber Plant. In the late 1970s, General Motors gave ownership of Beyer Dam to the Washtenaw County Drain Commissioner (now Water Resources Commissioner, WCWRC).

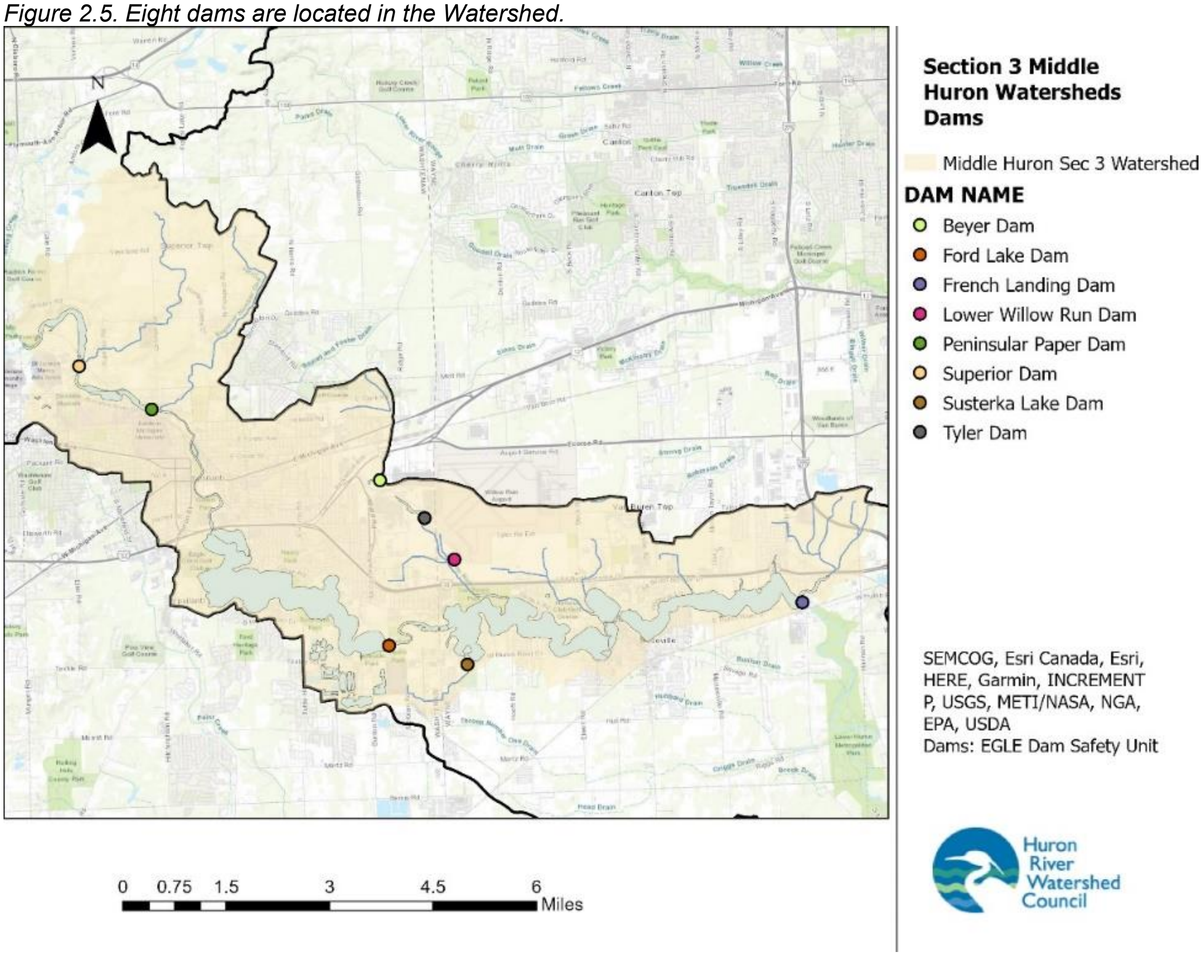
Due to deteriorating conditions, in 2017, Ypsilanti Township with engineering firm Stantec permanently drew down the impoundment at Tyler Dam and decommissioned the structure, though the structure itself was left in place[3]. Shortly after, the Township was able to transfer the dam ownership to WCWRC. In 2022, the WCWRC made the decision to remove the Tyler Dam structure and the upstream Beyer Dam, turn it into a County Drain, and restore the creek to a wetland and stream ecosystem. As of the time of this writing, the WCWRC is seeking funds for the $10 million price tag and proceeding forward with the studies and engineering plans needed to facilitate both removals and ecosystem restoration.

Table 2.3. Inventoried Dams in the Watershed

Dam Name	**Waterway**	**Ownership**	**Downstream Hazard Potential**[t]	**Purpose**	**Date Built**	**Dam Height** (Feet)	**Impound-ment Area** (acres)
Beyer Dam	Willow Run Creek	Racer Properties	Low	Retired Hydro	1941	20	8.5
Ford Lake Dam	Huron River	Ypsilanti Township	High	Hydroelectric; Recreation	1932	45	1050
French Landing Dam	Huron River	Van Buren Township	High	Hydroelectric; Recreation	1925	38	1270
Lower Willow Run Dam	Willow Run Creek	Wayne County Road Commission	Low	Unknown (Related to Willow Run Airport)	Un-known	9	5
Peninsular Paper Dam	Huron River	City of Ypsilanti	Significant	Retired Hydro; currently Recreation	1914	16	177
Superior Dam	Huron River	City of Ann Arbor	High	Hydroelectric; Recreation	1920	28	93
Susterka Lake Dam	Tributary to Belleville Lake	Private landowner	Low	Recreation	Un-known	Un-known	1
Tyler Dam	Willow Run Creek	Ypsilanti Township	Formerly Significant. Altered to low after drawdown	Former Fire Suppression	1942	22	Prior to drawdown: 23

[t]Dam Hazard Potential:
Three hazard potential categories:
High- expected loss of life, severe impacts
Significant- possible loss of life, significant impacts
Low- no loss of life, minor impacts

Figure 2.5. Eight dams are located in the Watershed.



2.1.4 Significant Natural Features and Biota

2.1.4.1 Threatened, Endangered, and Special Concern Biota

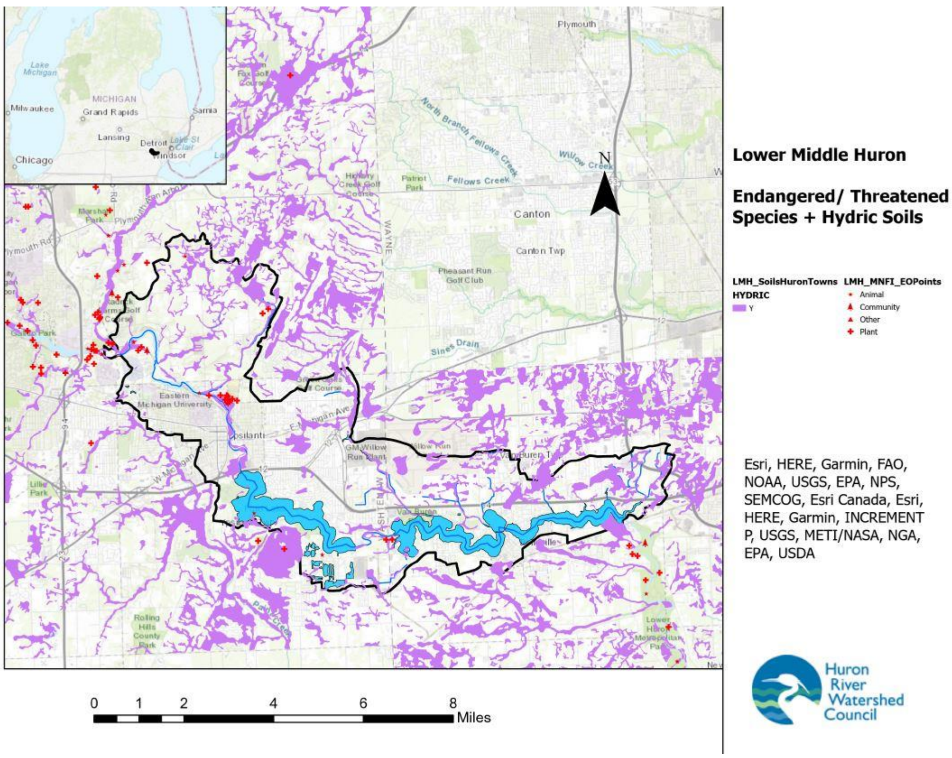
With the fast growth of Washtenaw and Wayne County, significant building pressure has caused the Watershed to become altered and degraded. Still, pockets of high-quality habitat and diverse species persist due to conscientious planning and policy-making efforts that seek to preserve wildlife habitat. 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 protection. Among those conservation targets are the threatened and endangered species that have been observed in the Watershed (Appendix B)[4]. Many of the plant and animal occurrences in the table are partially or entirely dependent on aquatic ecosystems for survival. In total, there are 263 plant and animal species in Washtenaw and Wayne Counties that are federally or state listed as Endangered, Threatened, or Species of Concern.

2.1.4.2 Critical Habitat and Ecosystem Services

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 2.6 shows the location of Endangered and Threatened species from the Michigan Natural Features Inventory overlaid on hydric soils (Soils regularly saturated with water and indicating wetland and riparian conditions).

Figure 2.6. Location of Endangered/threatened species or communities and regions of hydric soils.



Natural areas close to and draining directly to tributaries and lakes are highly important to water quality, creeks rely on those areas to filter pollution and hold floodwaters after our ever-increasingly intense storms. Areas that encompass headwater streams provide a host of services to the river system – their close connection to groundwater, wetlands and subsurface water flows provides base flow to streams, controls flooding downstream, and spawning areas for fish.

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 ecosystem 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.
- Drinking water: Residents of Ann Arbor rely on the Huron River for drinking water, while residents of the rest of the Huron River Watershed rely on private or municipally controlled drinking water wells that pull groundwater from aquifers replenished through natural areas.
- 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 undeveloped 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.
- Carbon storage and sequestration. Plants take up carbon as a major nutrient and store it as they grow; when they die, the soil stores the degraded plants as carbon.
- Property values. Natural areas enhance the value of neighboring properties.

Undeveloped natural areas in the Watershed were mapped and prioritized in 2002, and updated in 2007 and 2018 through the Natural Areas Assessment and Protection (NAAP) project of the Huron River Watershed Council. [5] In order to 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.

Thirty-four sites (2,329 acres) in the Watershed were identified as priority natural areas, with six sites (573 acres) ranked as highest priority for protection, 12 sites (150 acres) ranked as medium-high priority for protection, 11 sites (413 acres) ranked as medium-low priority for protection and three sites (136 acres) ranked as lower priority for protection.

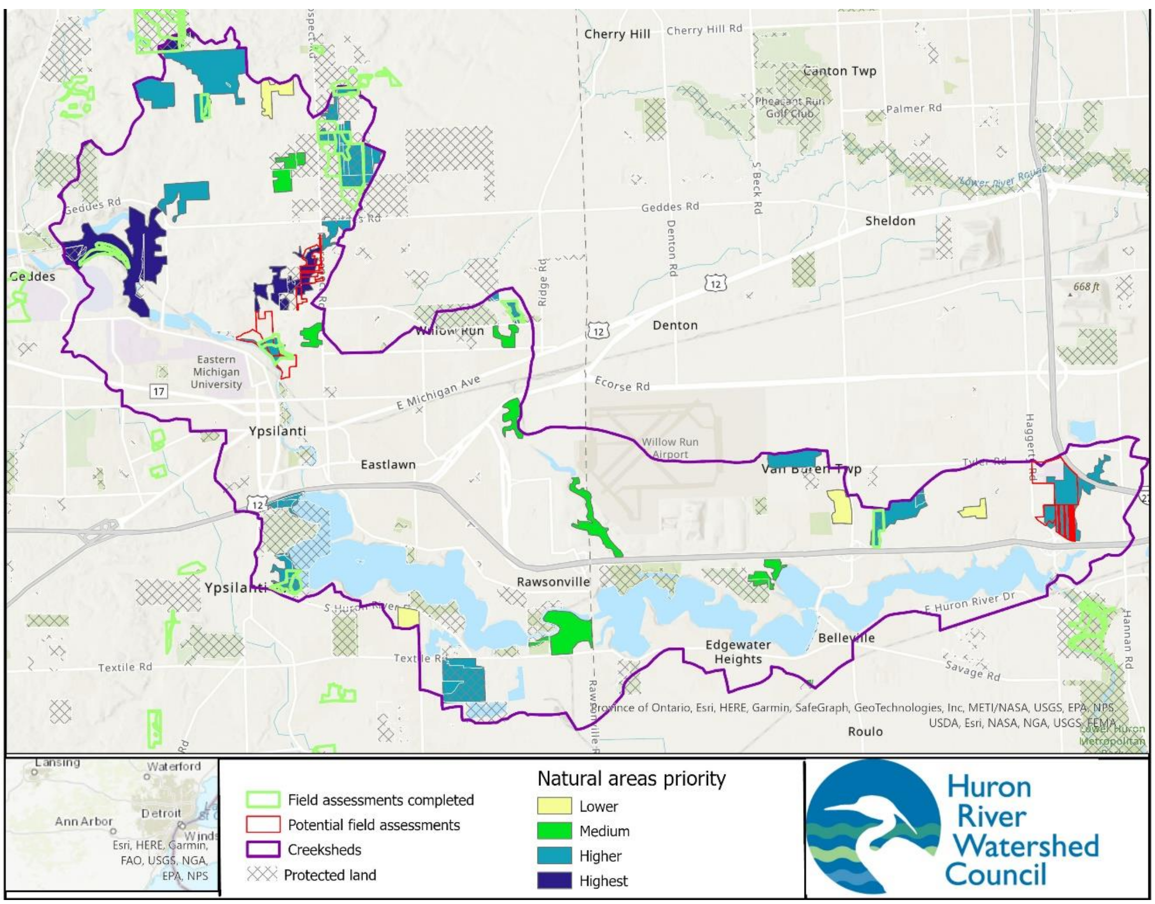
One of the highest priority sites encompasses both sides of Superior Pond and includes over 20 parcels with different landowners. A portion of this natural area is owned by

Trinity Health Hospital and includes a rare prairie fen, as reported by HRWC field assessment volunteers. Over the years, members of the hospital staff and local naturalists, ecologists, and botanists have managed the site for invasive species.

Of the 2,329 acres of natural areas identified as priorities, only 579 acres are protected as parks and other public ownership, preserves owned by conservancies and other nonprofits, and lands with conservation easements. This includes the 175-acre natural area that is part of the LeFurge Woods Preserve of the Southeast Michigan Land Conservancy, as well as a 147-acre natural area designated as “conservation” but with unknown ownership south of Ford Lake.

The parcels outlined in red in Figure 2.7 are the sites that do not have a protected land status and that would be good candidates for HRWC field assessments to determine priority for protection. Protection options for municipalities, state and federal agencies, and nonprofit conservation groups include programs such as the Regional Conservation Partnership Program, property-tax funded land protection millages, grants through foundations, carbon sequestration and storage funding, the Clean Water Act State Revolving Fund, Clean Water Action Section 319 Funding, among others.

Figure 2.7. HRWC’s NAAP priority natural areas overlaid with protected lands. Credit: Conservation and Recreation Lands-“CARL”[6]



[1] USGS National Water Information System. https://waterdata.usgs.gov/mi/nwis/inventory/?site_no=04174500&agency_cd=USGS. Accessed September 2019.

[2] Michigan Department of Natural Resources. 2000. National Inventory of Dams database. Lansing, MI.

[3] Stantec Consulting, Ltd. 2017. *https://www.stantec.com/en/projects/united-states-projects/t/tyler-dam-study-drawdown.* Accessed June 2023.

[4] Michigan Features Natural Inventory, 2023. https://mnfi.anr.msu.edu/resources/county-element-data. Accessed August 2023.

[5] Appel, Michael D, and Rome, Clea D. 2002. Identifying and Ranking Natural Areas in the Huron River Watershed. https://www.hrwc.org/wp-content/uploads/IdentifyingAndRankingNaturalAreasintheHuronRiverWatershed.pdf. Accessed June 2022.

[6] DEQ MiWaters. Conservation and Recreation Lands. http://gisp.mcgi.state.mi.us/arcgis/rest/services/DEQ/MiWaters/MapServer/49. Accessed June 2022.

2.2 Communities and Current Land Use

2.2.1. Political Structure

The drainage area to the Watershed is 36 square miles (23,039 acres), representing approximately 4% of the total Huron River Watershed. All or portions of 7 municipalities (not counting Federal or State or County) are situated in the Watershed: the Cities of Belleville and Ypsilanti, and the townships of Ann Arbor, Romulus, Superior, Van Buren, and Ypsilanti. The Watershed lies both in Washtenaw County (66% of the Watershed) and Wayne County (34%). See Table 1.1 for the full breakdown.

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."[7]

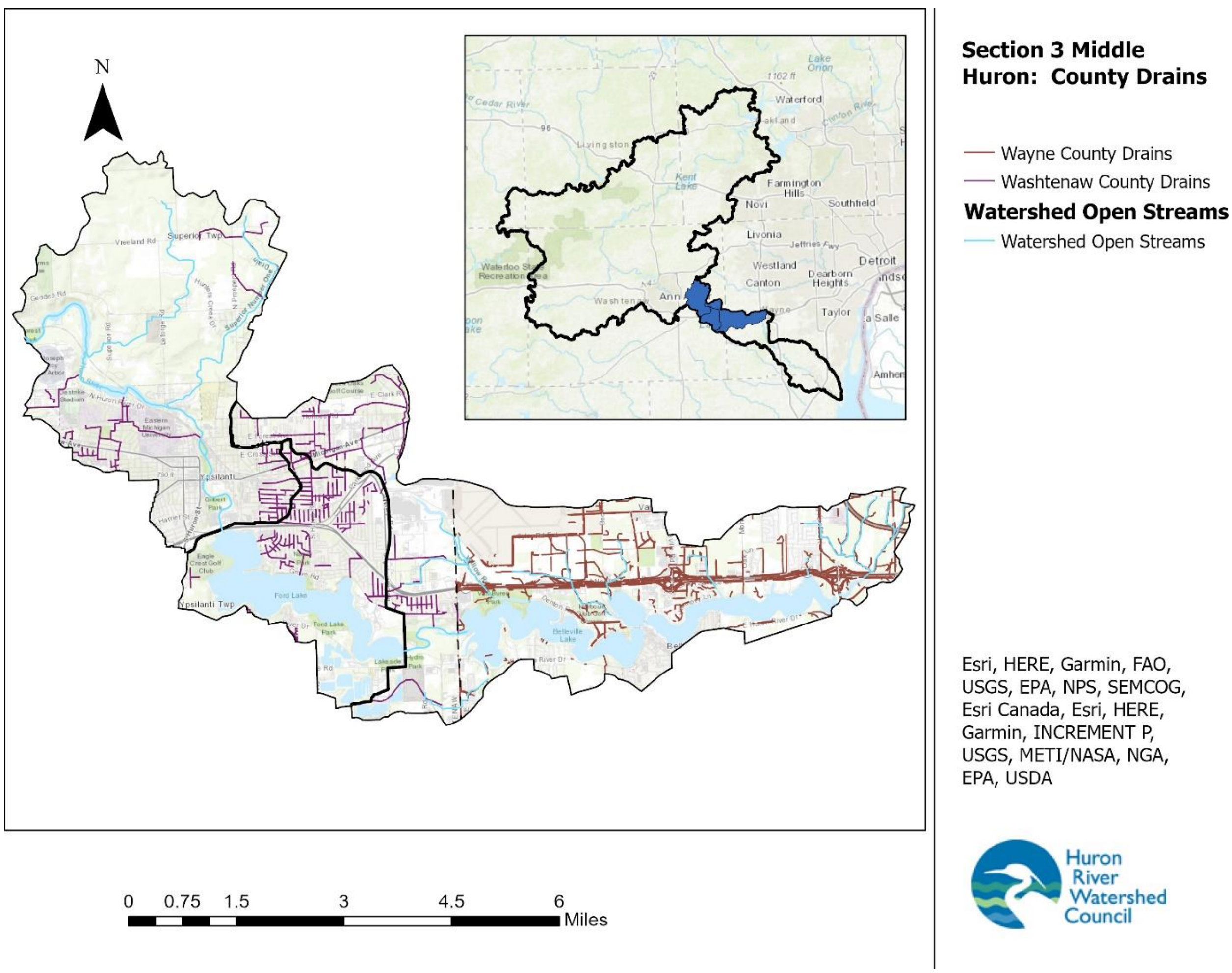
County government assumes responsibility for carrying out certain state policies. In most cases, county governments enforce the state erosion control policy, under the Michigan Soil Erosion and Sedimentation Control Act 347 of 1972 and Part 91 of Act 504 of 2000. Some cities, villages, charter townships, and some general law townships have elected to enforce Part 91 through adoption of a soil erosion and sedimentation control ordinance. These agencies are called Municipal Enforcing Agencies (MEAs). MEAs will review soil erosion and sedimentation control plans, issue permits, and take enforcement actions when necessary to ensure compliance with Part 91 within their jurisdiction. In the Watershed two of the local municipalities are MEAs[8]: City of Belleville, and Ypsilanti Township.

Designated county drains are maintained by the Washtenaw County Office of the Water Resources Commissioner and the Wayne County Drain Commissioner. Figure 2.8 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/Drain Commissioners authority for construction or maintenance of designated county drains for flood control and water management. In Wayne County, nearly all of the open streams flow in the Watershed except for Belleville Lake are County Drains. In Washtenaw County, most of the open streams in the Watershed are not considered a drain and the drains instead are underground pipes (especially in Ypsilanti Township).

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

Figure 2.8. Designated County Drains within the Watershed area (Marked as green and thicker lines).



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.

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.

2.2.2. Growth Trends

Prior to European settlement, the region around the watershed was home to Chippewa and Potawatomi Native American tribes who had long used the land for farming, hunting, and gathering. 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. The settlers moved in, forcibly displacing the original inhabitants and massively altering the ecological landscape. 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 urban and suburban uses in a trend that continues today.

Federal decennial census data shows the historical rate of growth in the Watershed area, and then a SEMCOG model predicts future growth (Table 2.4).[9,10] From 1990 through 2020, the core communities' population modestly increased (22%). This increase should be held in context with a comparison to Section 1 of the Middle Huron (Dexter, Chelsea areas) which has seen a 91% change and Section 2 (Ann Arbor) which has seen a 20% change.

The largest contributor to population increase was Ypsilanti Township, whose population increased by approximately 10,000 people, and Van Buren Township (9,000 people). Superior Township increased by the highest percentage with 70% but the absolute numbers are lower (6,000 people). The City of Ypsilanti was the only to area to have a population decrease (about 4,000 people, -17%)

All of the municipalities, including the City of Ypsilanti, are expected to grow by some positive rate in population by 2030 and 2040, 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 2020-2040 than it was from 1990-2010.

Changes in total housing also reflect the changing population throughout the Watershed. Building of housing closely reflects population growth. [11]

Table 2.4. 1990-2040 Population Changes for Core Communities in the Watershed[12]

	1990 Census	2000 Census	2010 Census	2020 Census	% change 1990-2020	2030 SEMCOG forecast	2040 SEMCOG forecast
City of Belleville	3,270	3,997	3,991	4,008	+23%	3,613	3,724
City of Ypsilanti	24,846	22,237	19,435	20,648	-17%	23,412	24,290
Superior Township	8,720	10,740	13,058	14,832	+70%	16,285	18,689
Van Buren Township	21,010	23,559	28,821	30,375	+45%	33,163	35,398
Ypsilanti Township	45,307	49,182	53,362	55,670	+23%	56,198	60,371
Total of Cities and Townships	103,153	109,715	118,667	125,533	+22%	132,671	142,472
Washtenaw County	282,937	322,770	344,791	372,258	+32%	415,606	444,139
Wayne County (excluding Detroit)	1,083,713	1,109,892	1,106,788	1,154,450	+7%	1,107,172	1,134,274

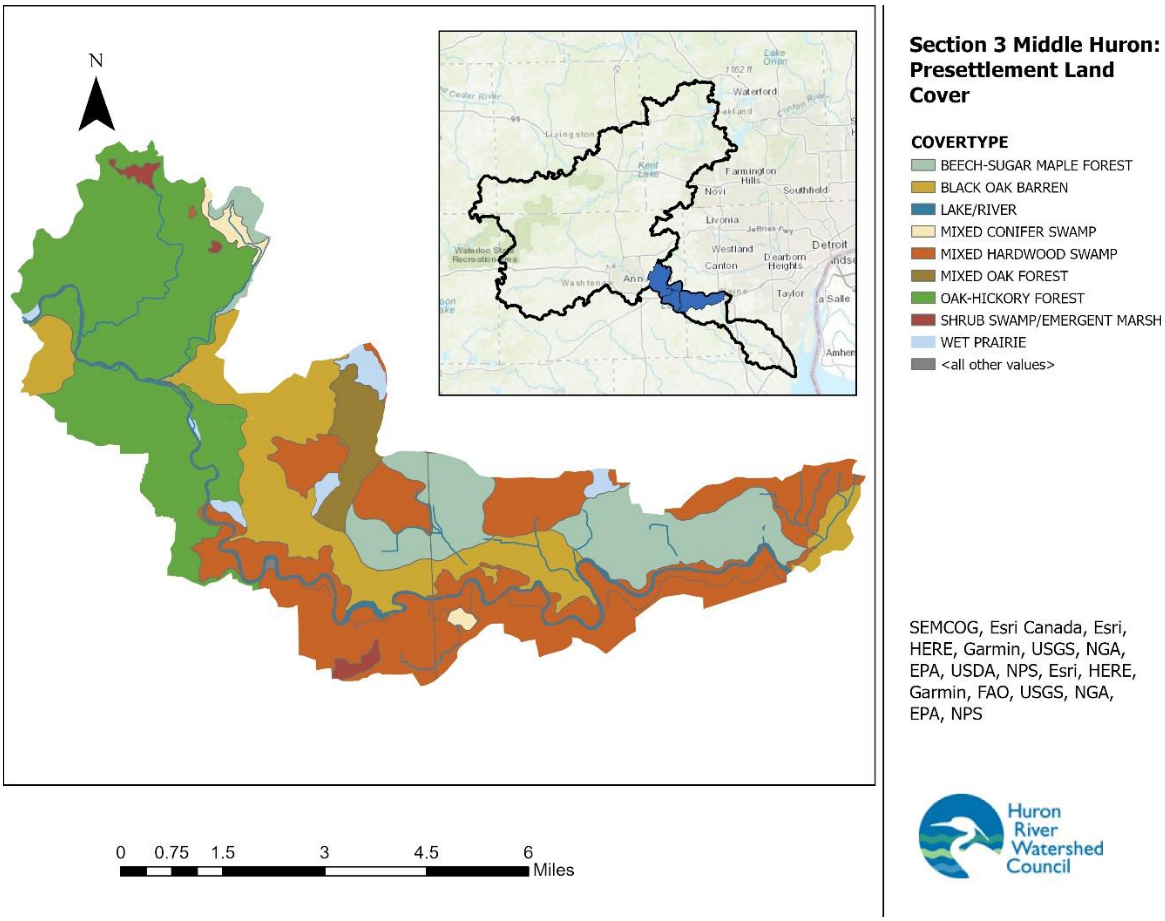
2.2.3. Land Use and Development

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, oak and hickory forests dominated the upper morainal portion of the Watershed. This dominant landscape was interspersed with patches of wetlands, such as shrub swamps and wet prairie (Figure 2.13).

The downriver portion of the Watershed is quite flat (Section 2.1.2. Geology, Soils, and Groundwater) as it is the ancestral lakebed of Lake Erie during the previous Ice Age. The area immediately around the Huron River was covered in hardwood swamps, with black oak barrens in drier uphill soils. The area also had significant amounts of beech-maple forests where Belleville Lake is today.

Figure 2.9. Watershed's Ecosystems, circa 1830's.



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

The most recent land use data indicates the significant changes to the landscape that have occurred since settlement. (Figure 2.10)[13]. A very simple breakdown is that the Watershed (36 square miles) is 9% agriculture/rural residential, 29% natural lands including wetlands, fields, and forests, 12% open water due to Ford and Belleville Lakes, and 37% urban/developed. 13% are other uses that don't fit neatly into these categories like cemeteries, utilities, parks, vacant lots, and golf courses (Tables 2.5).

While 29% of the land is still natural, much of that is heavily affected by development impacts, and there is considerable potential for the reduction of water quality through stormwater runoff and agricultural practices. In addition, the vast majority of those natural lands are designated for some kind of residential, agricultural, or commercial land use (based on local government master plans and zoning ordinances), so their status can easily change when development proceeds forward.

The Watershed is a part of the Middle Huron River, and does not exist in isolation. It receives substantial water from upstream, which comes into the Watershed with some water quality problems of its own.

The land area upstream of the Middle Huron Section 1 is almost 500 square miles, is 9% impervious, and made up of landcover and land use with the following breakdown: 24% forest, 19% agriculture, 5% open water, 1% grassland, 18% wetland, and 33% urban and residential. The Chain of Lakes Watershed Management Plan[14], while getting dated at this point, is still the best source to understand the section of the Huron River immediately upstream of the Middle Huron River.

Section 1 of the Middle Huron is 204 square miles containing 43% natural lands (forest/wetland/grassland), 44% agriculture, and 10% urban and residential.

Section 2 of the Middle Huron is immediately upstream of the Watershed and is 81 square miles containing 17% natural lands (forest/wetland/grassland) 45% agriculture, and 36% urban and residential.

Figure 2.10. Land use and Land cover in 2020.

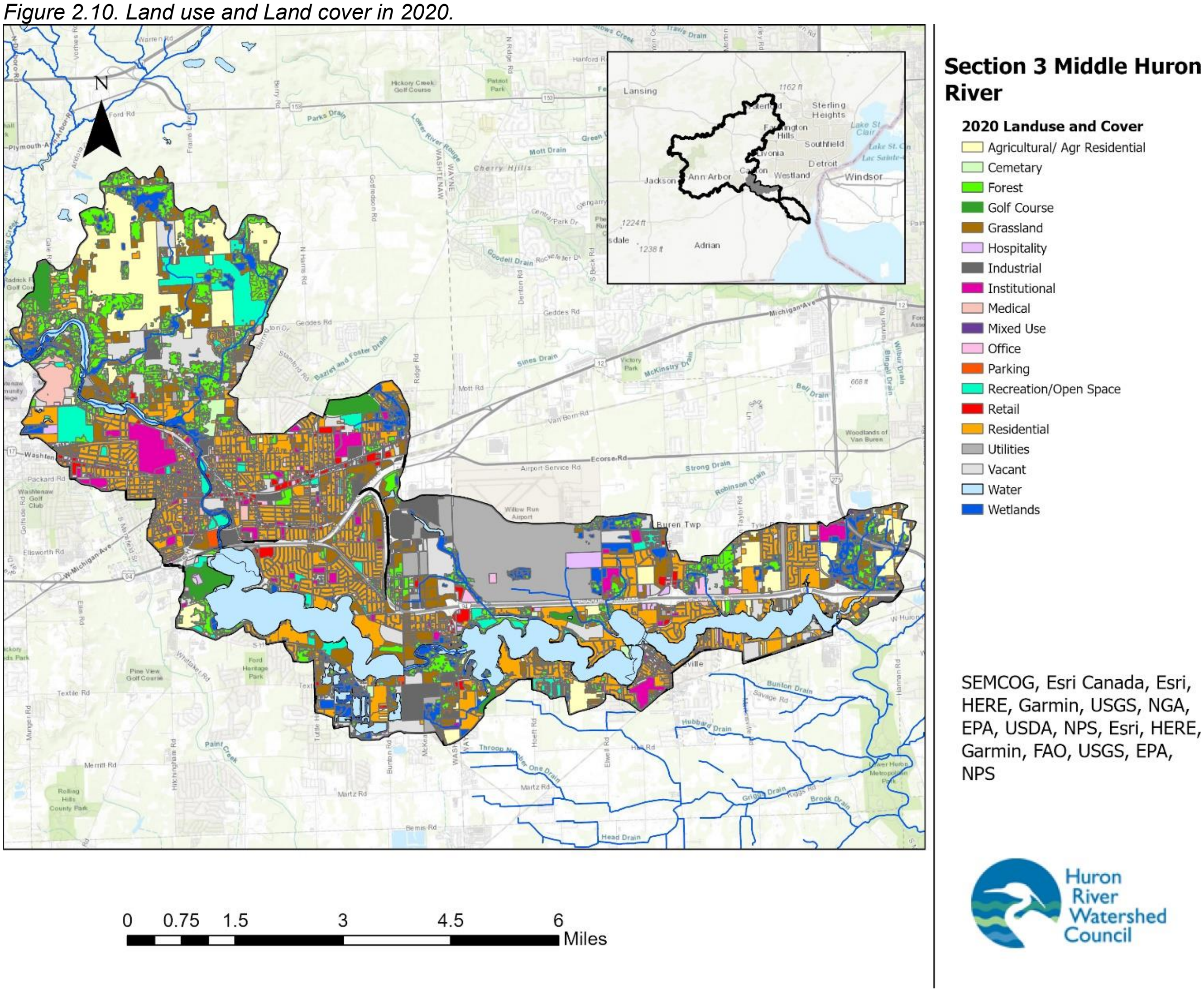


Table 2.5. 2020 Land use and Land cover in the Watershed, broken into the sub-watersheds.

Landuse/ Landcover	**Subcategory**	**Superior Pond/Peninsular Pond/Huron River**		**Ford**		**Belleville**		**The Watershed (all)**	
		Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Watershed
Total		8016.5	100.0	3325.4	100.0	10329.6	100.0	21671.6	100.0
Agricultural / Rural Residential		1337.0	16.7	56.1	1.7	565.4	5.5	1958.5	9.0
Cemetery		59.7	0.7	8.0	0.2	17.8	0.2	85.5	0.4
Extractive		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Developed	*Total Developed*	*2176.8*	*27.2*	*1180.8*	*35.5*	*4653.0*	*45.0*	*8010.6*	*37.0*
	Hospitality	31.4	0.4	9.8	0.3	123.8	1.2	165.0	0.8
	Industrial	150.8	1.9	16.9	0.5	455.7	4.4	623.4	2.9
	Institutional	325.0	4.1	66.7	2.0	284.9	2.8	676.6	3.1
	Medical	195.0	2.4	3.9	0.1	9.9	0.1	208.8	1.0
	Mixed Use	8.1	0.1	2.3	0.1	14.5	0.1	24.9	0.1
	Office	45.5	0.6	14.1	0.4	86.7	0.8	146.3	0.7
	Parking	40.8	0.5	7.2	0.2	5.2	0.1	53.2	0.2
	Utilities	30.6	0.4	18.8	0.6	1580.1	15.3	1629.5	7.5
	Retail	106.2	1.3	48.8	1.5	160.6	1.6	315.6	1.5
	Attached Condo Housing	4.0	0.0	9.7	0.3	23.3	0.2	37.0	0.2
	Mobile Home	0.0	0.0	42.2	1.3	123.7	1.2	165.9	0.8
	Multi-family housing	319.6	4.0	191.0	5.7	272.7	2.6	783.3	3.6
	Single-family Housing	919.8	11.5	749.4	22.5	1511.9	14.6	3181.1	14.7

Table 2.5, continued. 2020 Land use and Land cover in the Watershed, broken into the sub-watersheds.

Landuse/ Landcover	Breakout	Superior/Peninsular/Huron River		Ford		Belleville		The Watershed (all)	
		Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed
Forest	*Total Forest*	*1658.5*	*20.7*	*188.1*	*5.7*	*858.2*	*8.3*	*2704.8*	*12.5*
	Beech Maple	19.3	0.2	0.1	0.0	7.2	0.1	26.6	0.1
	Central Hardwood/Oak	357.1	4.5	78.8	2.4	250.8	2.4	686.7	3.2
	Dry-Mesic Oak Forest	58.6	0.7	0.8	0.0	6.7	0.1	66.1	0.3
	Dry Oak Forest	168.9	2.1	17.1	0.5	135.7	1.3	321.7	1.5
	Maple Basswood	1054.1	13.1	91.3	2.7	456.4	4.4	1601.8	7.4
	Northern Hardwoods	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
	Northern Pine-Oak	0.4	0.0	0.0	0.0	1.4	0.0	1.8	0.0
	Pine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Golf Course		95.4	1.2	116.5	3.5	150.1	1.5	362.0	1.7
Grassland	*Total Grassland*	*803.9*	*10.0*	*301.6*	*9.1*	*919.9*	*8.9*	*2025.4*	*9.3*
	Grass and shrub land	803.0	10.0	301.6	9.1	919.7	8.9	2024.3	9.3
	Pine-Oak Barrens	0.9	0.0	0.0	0.0	0.2	0.0	1.1	0.0
Recreation/ Open Space		633.1	7.9	102.5	3.1	184.9	1.8	920.5	4.2

Table 2.5. 2020 Land use and Land cover in the Watershed, broken into the sub-watersheds.

Landuse/ Landcover	**Breakout**	**Superior/Peninsular/Huron River**		**Ford**		**Belleville**		**The Watershed (all)**	
		Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed
Wetlands	*Total Wetland*	*445.2*	*5.6*	*223.8*	*6.7*	*881.6*	*8.5*	*1550.6*	*7.2*
	Aquatic Bed Wetland	0.0	0.0	18.3	0.6	21.4	0.2	39.7	0.2
	Emergent Wetland	0.0	0.0	43.5	1.3	9.5	0.1	53.0	0.2
	Flats	0.0	0.0	0.0	0.0	0.7	0.0	0.7	0.0
	Floodplain	202.2	2.5	7.0	0.2	181.0	1.8	390.2	1.8
	Lowland Conifer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Lowland Hardwoods	81.2	1.0	55.9	1.7	282.4	2.7	419.5	1.9
	Mixed Wooded Wetland	2.1	0.0	0.0	0.0	8.3	0.1	10.4	0.0
	Rich Swamp	96.3	1.2	59.8	1.8	63.5	0.6	219.6	1.0
	Shrub-Herbaceous Wetland	17.6	0.2	38.4	1.2	66.2	0.6	122.2	0.6
	Shrub/Scrub Wetland	45.8	0.6	0.0	0.0	244.5	2.4	290.3	1.3
	Swamp	0.0	0.0	0.9	0.0	4.1	0.0	5.0	0.0
Water		173.2	2.2	1000.4	30.1	1362.7	13.2	2536.3	11.7
Vacant		633.7	7.9	147.6	4.4	736.0	7.1	1517.3	7.0

2.2.4. Point Sources and Permitting

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 National Pollutant Discharge Elimination System (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.

There are several point source facilities in the Watershed that hold NPDES permits issued by the State of Michigan, and the discharge points were mapped in Figure 2.11. The number of permitted point sources is not static due to expiring old permits and activation of new permits. More information can be found on any point by using EGLE's MiWaters tool. [16]

As of July 2023, according to EGLE's Water Resources Division Permits Section, 12 permits were in issuance that discharge include the Huron River, streams or drains, and impoundments in the Watershed.

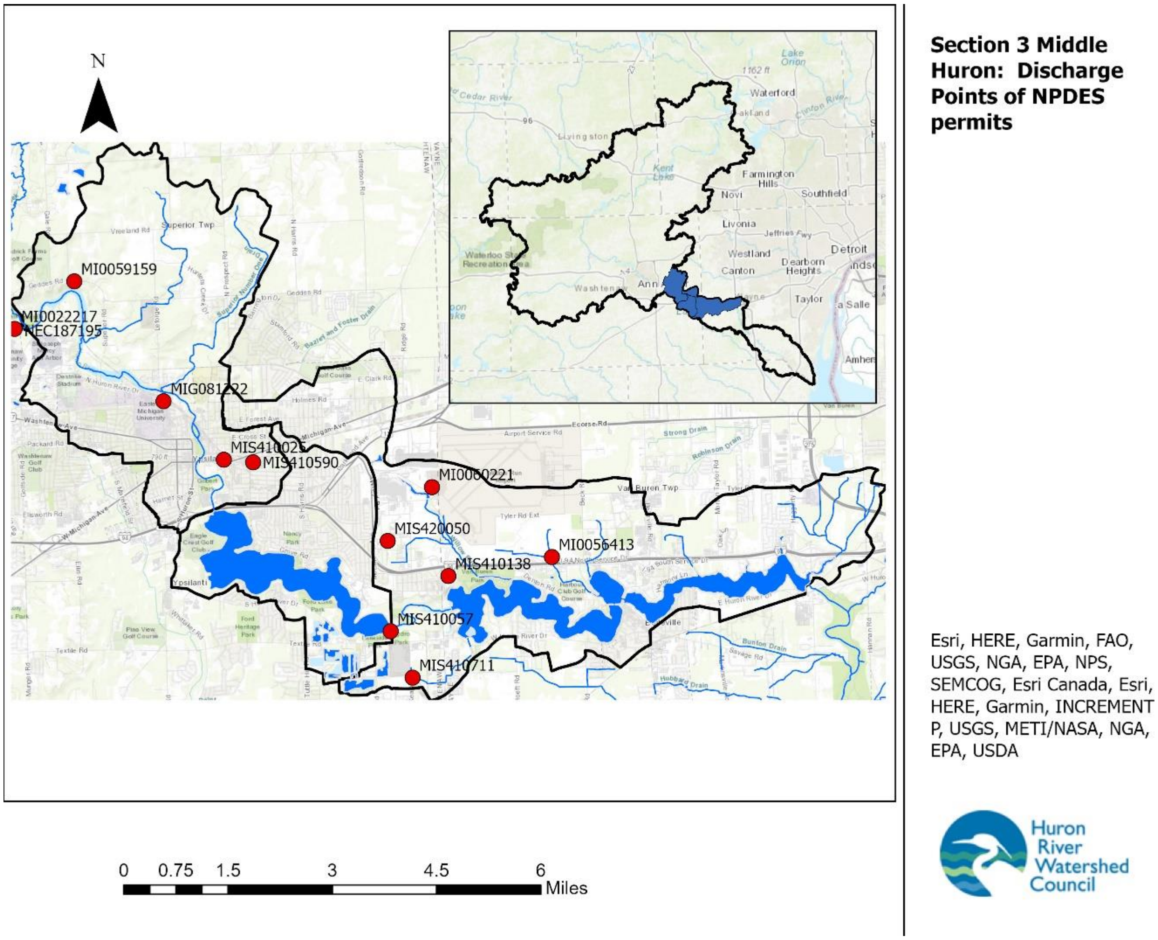
Individual Permits are written to reflect site-specific conditions of a single discharger and is unique to that discharger. There were 3 of these in the Watershed as of July 2023.

- MI0060221—Willow Run Airport MS4
- MI0056413—Wayne Disposal Inc, stormwater
- MI0059159—Rock Ridge Estates, (discharge type not listed)
- MI0022217 and NEC187195—Ann Arbor Wastewater Treatment Plant (just upstream of Watershed), wastewater and industrial stormwater

7 of the permits were for NPDES Certificate of Coverage under General Permit (COC). General permits contain effluent limitations protective of most surface waters statewide but are not tailored to a specific permittee.

- MIG081222- Sunoco, petroleum contaminated wastewater
- MIS410025- Marsh Plating Corp, Industrial stormwater
- MIS410057- Ford-Rawsonville Plant, Industrial stormwater
- MIS410138- Cadillac Asphalt LLC, Industrial stormwater
- MIS410590- R & L Carriers, Industrial stormwater
- MIS410711- WTPS Willis Terminal, Industrial stormwater
- MIS420050- Holbrook Auto Parts, Containment stormwater

Figure 2.11. NPDES permits in the Watershed, as of July 2023.



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

Waste discharges can be treated by publicly owned wastewater treatment plants (WWTP) or on-site decentralized wastewater systems (privately-owned septic systems). The entire Watershed is piped to send wastewater to the Ypsilanti Community Utilities Authority (YUCA) WWTP.

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.

Improperly functioning sewer systems and privately-owned septic systems can have a profound impact on 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 County Health Departments regulate the design, installation, and repair of privately-owned septic systems.

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).

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

2.3.1.1 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.

One method HRWC uses to assess stream habitat is through a procedure called "Measuring and Mapping"[17], which itself is a volunteer friendly version of EGLE's Procedure 51 Habitat Assessment.[18] In this assessment, volunteers conduct a pebble count/substrate size analysis across ten cross sections of the creek, assessing at a minimum 100 pieces of substrate and then computing overall substrate size percentages (% boulder, cobble, rock, gravel, sand, fines/muck). Volunteers also answer qualitative questions regarding amount and quality of riffles, runs, pools, riparian habitat, woody debris, and so on. HRWC use these answers to calculate a stream habitat score with the same metrics used in the P51 assessment.

In recent years, HRWC began using a method called BANCS (Bank Assessment for Non-point source Consequences of Sediment, Appendix C) to evaluate the stability of representative stream reaches (i.e. segments) throughout the Huron River Watershed. 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 creekshed. The erosion estimates 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.

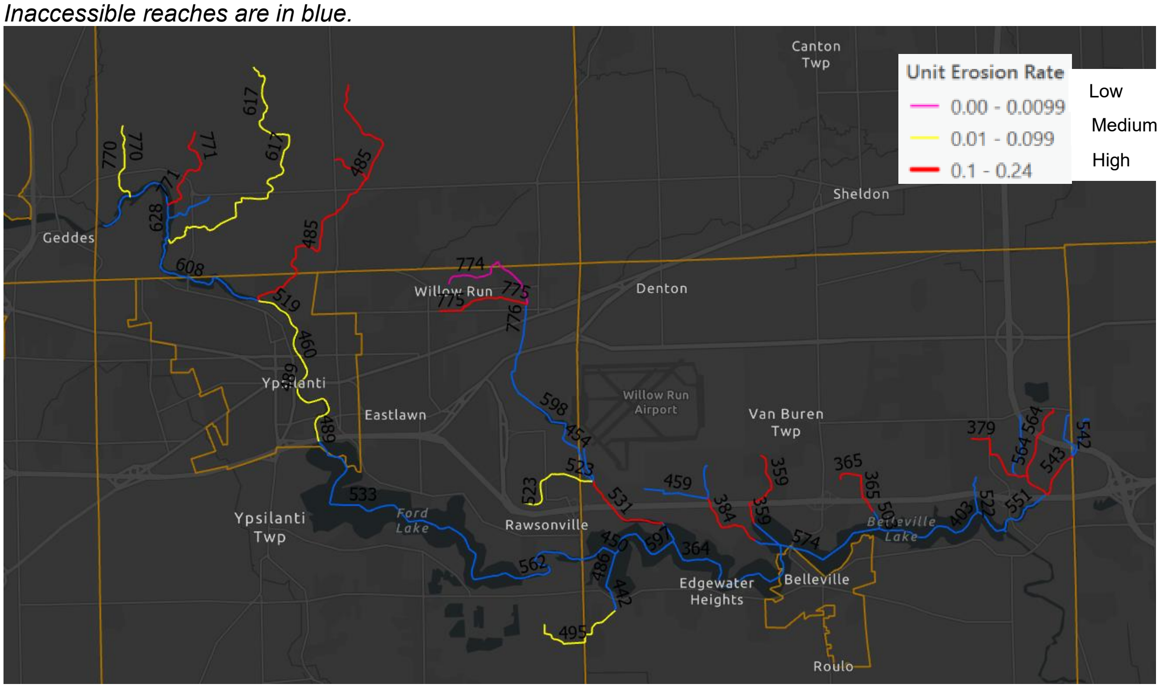
Given the size of the Watershed and total length of streams, as well as the ability to access the streams, HRWC needed to assess a sample of reaches rather than attempt a full census. HRWC evaluated the accessibility of all stream reaches in the watershed and scheduled the assessment of all accessible stream reaches. During the assessment, some reaches were determined to be impassible at points or impossible to find. Most river reaches were too deep to wade, but several important reaches were accessible. Most accessible reaches were assessed. For this Watershed, teams of HRWC field assessors were able to evaluate 11.8 miles of stream/river to estimate erosion rates for 25.1 miles of stream reaches.

Results for each creekshed are presented in section 2.4, but Figure 2.12 shows the evaluated stream reaches and their erosion rates. Within the Watershed, the majority (59%) of stream reaches have high erosion rates (Table 2.6). Most of the remaining reaches have a moderate erosion rate, with only one reach with a low erosion rate, or stable banks. Reaches with high erosion rates tended to be in the mid-range of drainage area size class, as none of the river sites had high rates. The only low erosion rate stream was a small headwater stream. Huron River reaches had moderate erosion rates, which bring mean and median drainage areas up.

Table 2.6. Summary of BANCs results for the Watershed.

Erosion Rate	# of Reaches	% of Assessed	Assessed Reach Length (mi)	% of Total Length	Mean Drainage Area (mi^2)	Median Drainage Area (mi^2)
High	13	59%	13.8	55%	1.36	0.82
Moderate	8	36%	1.4	39%	107.5	2.30
Low	1	5%	9.9	6%	0.35	0.35
Total	22	100%	25.1	100%		

Figure 2.12 Estimated Unit Erosion Rates (in tons/yr/ft of stream) for Evaluated Stream Reaches. Note: Inaccessible reaches are in blue.



2.3.1.2 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.

2.3.1.3 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 with 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[19].

2.3.1.4 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.[20] 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 occurring, 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 deicers 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 deicing applications can reduce over-use of salt and alternative deicers.

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.[21] 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 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 Conductivity is often used in lieu of TDS.

2.3.1.5 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.[22] 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 (results shown in the Middle Huron River Section 2 Watershed Management Plan[23]). Results show that the area 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,[24] HRWC has worked with municipalities to pass ordinances restricting use. Within the Watershed, the City of Ypsilanti and Van Buren Township have adopted ordinances that make it illegal to sell or apply high PAH pavement sealers.

Polyfluoroalkyl substances (PFAS/PFOS) 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. The Huron is now listed for failure to meet the Fish Consumption designated use in the 2022 EGLE Integrated Report[25]. This is a critical area that needs further addressing. See more details in section 2.5.2.4- Fish Consumption Advisory on the Huron River: Perflurooctane Sulfonate (PFOS) Impairment.

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.[26]

In 2004, a targeted study conducted for the City of Ann Arbor assessed city waters for 22 compounds of concern.[27] 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.

2.3.1.6 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.

2.3.1.7 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 there are rapid shifts from these coarse materials to more fine sediments. Excessive deposits of fine sediment are known to impair macroinvertebrate communities.

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 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 results in soil vulnerable to wind and water erosion.

Turbidity is the measure of the relative clarity of water and is a measure of the 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 levels (discussed in a later section) , 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.[28] 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.

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.[29]

2.3.1.8 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[30]. 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.[31]

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).[32]

All waters in the Watershed are warmwater fish streams. However, coldwater fish species are found occasionally in the Watershed, and the presence of EPT (Ephemeroptera-Plecoptera-Trichoptera) and sensitive aquatic insect families at monitoring sites is an indication of adequately cool stream temperatures. Sun exposure on impoundments, 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.

2.3.1.9 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. Cold water species like trout need between 9-12 mg/L, depending on the species. 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.[33]

2.3.2 Biological Parameters

2.3.2.1 Bacteria

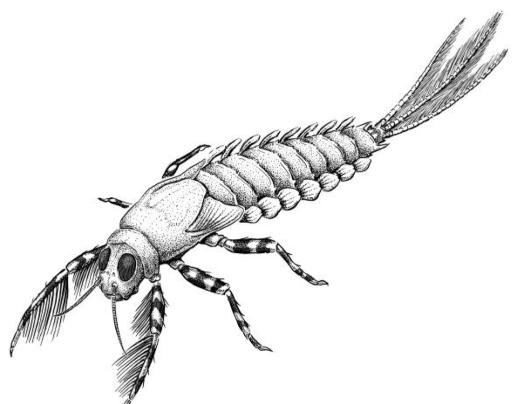
Bacteria are microorganisms that are found everywhere. Coliform is a group of bacteria that includes a smaller group known as fecal coliforms, which are found in the digestive tract of warm-blooded animals. Their presence in freshwater ecosystems indicates that pollution by sewage or wastewater may have 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.[34]

2.3.2.2 Macroinvertebrates

Insects living in the creek compose the benthic macroinvertebrate 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.[35]

Macroinvertebrate data is collected through HRWC River Roundup event, formerly known as HRWC's Adopt-a-Stream, which relies on trained volunteers to monitor more than 80 sites in the Huron River watershed, including 15 in the Watershed of this management plan. 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. Only one site in the Watershed is regularly sampled, on the Huron main branch in Ypsilanti.


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

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.

HRWC also uses Hilsenhoff's Index of Biotic Integrity to understand the level of organic pollution tolerance in the insect community. 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. Organisms ranked 0, 1, or 2 are considered sensitive in HRWC's protocols.[36] Nineteen of the 87 benthic insect families living in the Huron River Watershed are sensitive.[37] HRWC looks at numbers of Sensitive families as well as computing an overall Hilsenhoff IBI which is essentially a weighted average of the Hilsenhoff ranking, with 0 being Excellent and 10 being Very Poor. It is possible that a site with a high total insect family count can still have a poor Hilsenhoff IBI if the insect community there has a high proportion of pollution tolerant taxa.

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.

2.3.2.3 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.[38]

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.[39] 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.

Today, the Huron River throughout most of the Watershed area is considered to be a good smallmouth bass recreational fishery and attracts many shoreline anglers and occasional wading anglers. Ford and Belleville Lake are known for walleye fishing and highly fished by shoreline anglers and by boaters. Details are available in *Creekshed Current Conditions*, Section 2.4.

The Huron River tributaries in the Watershed are considered mostly to be a "second quality warmwater fishery". Second quality warmwater feeder streams are those that contain significant populations of warmwater fish, but game fish populations are limited by such factors as pollution, competition, or inadequate natural reproduction. These tributary streams are often difficult to fish because of their small size; typically less than 15 feet wide.[40]

2.3.3. Limnology
Limnology is the physical, chemical, and biological science of study of freshwater systems, including lakes. Ford and Belleville Lakes are very important features in this Watershed. Thus, a general review of key lake processes and sources of water quality degradation are pertinent here.

Lake Productivity
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).[41]

Generally, a lake with concentrations of phosphorus less than 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.[42] 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.

Lakeshore Erosion and Development

Healthy shorelines are an important and valuable component of the lake ecosystem. The shoreline area is a transition zone between water and land and is a very diverse environment that provides habitat for a great variety of fish, plants, birds, and other animals. A healthy shoreline area is also essential for maintaining water quality, slowing runoff, and limiting erosion. Riparian areas also provide a critical influx of woody debris to our rivers and lakes; dead trees and branches along the shoreline provide critical fish habitat that is necessary for healthy fisheries and a dynamic ecosystem. Woody debris also reduces wave action against the shoreline, allowing aquatic plants to take root and provide more diverse habitat for other species to thrive. However, extensive development, often combined with poor shoreline management practices, can reduce or eliminate natural shoreline habitat and replace it with lawn and artificial erosion control such as seawalls and rock. As a result, shoreline vegetation is dramatically altered, habitat is lost, and water quality declines.

Ford and Belleville Lakes are known to have areas of high bank erosion (likely caused by shoreline development and exasperated by steep bank slopes). A DEQ survey was conducted in 2012 on Ford and Belleville Lakes (details in Section 2.4.3.3), but no other known surveys have been conducted on either lake.

Exotic Invasive Plants

Rooted aquatic plants are a natural and essential part of the lake, just as grasses, shrubs and trees are a natural part of the land. However, sometimes a lake is invaded by an aquatic plant species that is not native to Michigan. Some of these exotic plants, like Curly-leaf pondweed, Eurasian milfoil, Starry stonewort, and European frog-bit can be extremely disruptive to a lake's ecosystem and recreational activities. These exotic plants can take over a lake by crowding out beneficial native plant species. An overabundance of exotic species can also negatively affect fish populations and human recreation.

Aquatic plants have not been well documented in Ford and Belleville Lakes (see section 2.4.2.9, Exotic Invasive Aquatic Plants)

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[7] Michigan Department of Environmental Quality. R 323.1004. Definitions; M to W. Rule 44.

[8] EGLE, Part 91 Soil Erosion and Sedimentation Control Permitting Agencies https://www.michigan.gov/egle/about/organization/water-resources/soil-erosion/part-91-agencies. Accessed April 2023.

[9] Southeast Michigan Council of Governments. https://semcog.org/custom-community-profiles. Accessed 2021.

[10] Southeast Michigan Council of Governments. https://www.semcog.org/population-estimates. Accessed 2021.

[11] Southeast Michigan Council of Governments. https://semcog.org/custom-community-profiles. Accessed 2021.
[12] Southeast Michigan Council of Governments. https://www.semcog.org/population-estimates. Accessed 2021.
[13] Southeast Michigan Council of Government. https://semcog.org/gis. Accessed 2021
[14] Huron River Watershed Council, Huron Chain of Lake Watershed Management Plan. https://www.hrwc.org/wp-content/uploads/2013/08/HCOL_WMP.pdf, Accessed 2022.
[16] Michigan Department of Environment, Great Lakes, and Energy. MiWaters Map, https://mienviro.michigan.gov/ncore/external/home. Accessed May 2023.
[17] Steen, P. 2014. Procedure for the Stream Habitat Assessment. Huron River Watershed Council, https://www.hrwc.org/wp-content/uploads/Measuring-Mapping-Procedure_2014.pdf. Accessed May 2021.
[18] Michigan Department of Environment, Great Lakes, and Energy.2008. Qualitative Biological and Habitat Survey Protocols for Wadeable Streams and Rivers https://www.michigan.gov/documents/deq/wb-swas-procedure51_280711_7.pdf. Accessed May 2021.
[19] Livingston County Department of Public Health Environmental Health Division. 2002. Environmental Awareness Handbook. Livingston County, MI.
[20] Aichele, Steven S. 2005. Effects of Urban Land-Use Change on Streamflow and Water Quality in Oakland County, Michigan, 1970-2003, as Inferred from Urban Gradient and Temporal Analysis. U.S. Geological Survey Scientific Investigations Report 2005-5016.
[21] Dakin, T. and Martin, J. 2003a. Monitoring Gazette, Winter-Spring 2003. Ann Arbor, MI: Huron River Watershed Council.
[22] Mahler et al. 2012. Coal-Tar-Based Pavement Sealcoat and PAHs: Implications for the Environment, Human Health, and Stormwater Management. Environmental Science and Technology **46**, 3039-3045.
[23] Lawson et al. 2020. The Middle Huron Watershed Management Plan, Section 2. https://www.hrwc.org/what-we- do/programs/watershed-management-planning/middle-huron-WMP-section-2/. Accessed May 2021.
[24] Mahler et al. 2014. Concentrations of polycyclic aromatic hydrocarbons (PAHs) and azaarenes in runoff from coal-tar- and asphalt-sealcoated pavement. Environmental Pollution 188**:** 81-87.
[25] EGLE, 2023. Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report. https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/SWAS/2022-Integrated-Report.pdf?rev=0a6b006c0cc44bcd936c75d5608659ed&hash=03A5B2B0F3379B07D369F289BA32C483. Accessed July 2023.
[26] Phillips, P.J., Smith, S.G., Kolpin, D.W., Zaugg, S.D., Buxton, H.T., Furlong, E.T., Esposito, Kathleen, and Stinson, Beverley, 2010, Pharmaceutical formulation facilities as sources of opioids and other pharmaceuticals to wastewater treatment plant effluents: Environmental Science and Technology 210: 4910-4916.
[27] Skadsen, Janice M.,B.L Rice, D. J. Meyering, 2004. "The Occurrence and Fate of Pharmaceuticals, Personal Care Products and Endocrine Disrupting Compounds in a Municipal Water Use Cycle: A Case Study in the City of Ann Arbor." City of Ann Arbor, Water Utilities. < http://www.ci.ann-arbor.mi.us/PublicServices/Water/WTP/EndocrineDisruptors.pdf>
[28] Michigan State Legislature. Part 4. Water Quality Standards. Promulgated pursuant to Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.
[29] Bednarz, R, H. Wandell, P. Steen, P. W. Dimond, J. Latimore, and M. Wilmes. 2015, revised 2019. Cooperative Lakes Monitoring Program Manual. Michigan Department of Environment, Great Lakes, and Energy Report Number MI/DEQ/WRD-15/004.
[30] Dakin and Martin. 2003a.
[31] Wehrly, et. al. 2003. in Huron River Watershed Council, Winter-Spring Monitoring Gazette, 2003.
[32] Michigan State Legislature. The State of Michigan's Part 4 Rules, Water Quality Standards (of Part 31, Water Resources Protection, of Act 451 of 1994).
[33] Michigan State Legislature. Michigan State Legislature. The State of Michigan's Part 4 Rules, Water Quality Standards (of Part 31, Water Resources Protection, of Act 451 of 1994).
[34] Michigan Department of Environment, Great Lakes, and Energy. Online: https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-383659--,00.html. Accessed 2019
[35] Martin, J. and Dakin T. 2003b. The Quality of a Hidden Treasure: the Davis Creek Report. February 2003. Ann Arbor, MI: HRWC.
[36] Hilsenhoff, William L. 1988. Rapid Field Assessment of Organic Pollution with a Family-Level Biotic Index. Journal of the North American Benthological Society 7:65-68.
[37] Dakin and Martin. 2003a.
[38] Michigan Department of Natural Resources. 1995. Huron River Assessment. Fisheries Special Report No. 16

[39] Brown and Funk 1938 in Michigan Department of Natural Resources. 1995. Huron River Assessment. Fisheries Special Report No. 16

[40] Michigan Department of Natural Resources. 2000. Michigan stream classification: 1967 system. Chapter 20 *in* Schneider, James C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. MDNR Fisheries Special Report 25. Ann Arbor, MI: MDNR.

[41] U.S. Environmental Protection Agency. 1980. Modeling Phosphorus Loading and Lake Response under Uncertainty: A Manual and Compilation of Export Coefficients. EPA report No. 440/5-80-011.

[42] U.S. Environmental Protection Agency, Office of Water. 2000. Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs, 1st Edition. Report No. EPA-822-B00-001.

2.4. Creekshed Current Conditions

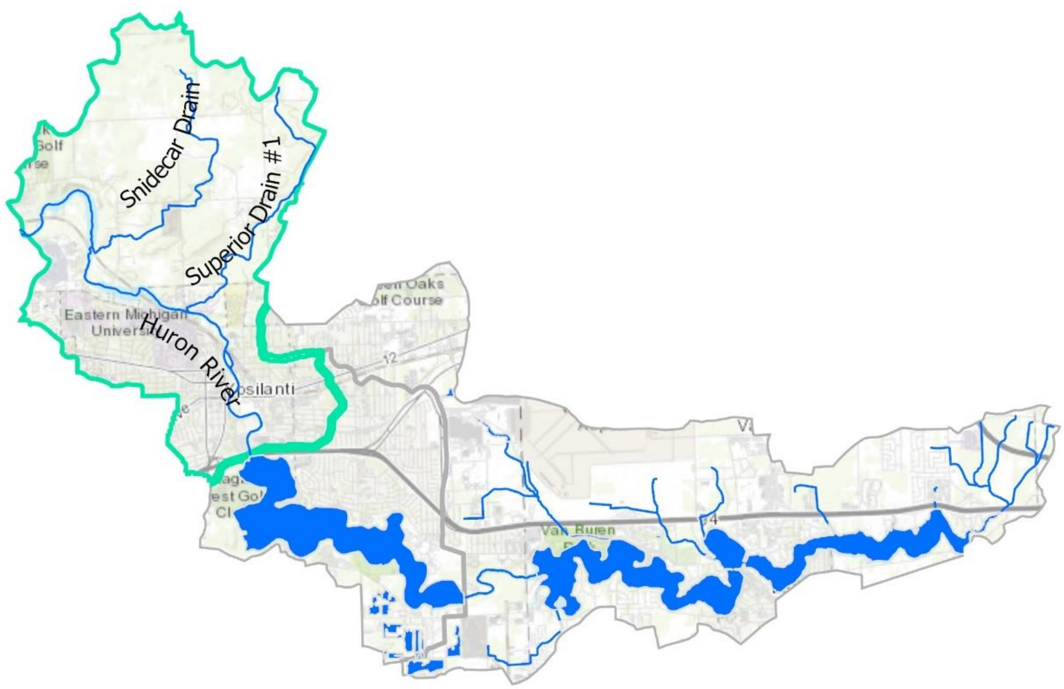
In order to gain a perspective on the past and present general water quality conditions in the Watershed, efforts were made to compile and summarize relevant and readily available existing water quality data. This effort included but was not limited to acquisition of studies conducted by state researchers,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

The Watershed was split into two major sections for this summary: the upstream Huron River and direct drainage as it flows through Superior Township and the City of Ypsilanti, and Ford and Belleville Lake and their direct drainage.

2.4.1 Huron River and direct drainage tributaries

Figure 2.13. Overview of the Huron River and direct drainage tributaries, Middle Huron section 3.



2.4.1.1 Creekshed Natural Areas

The watershed'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 10 percent of this subwatershed remains as intact natural areas. About a quarter of these areas are protected from development. (including LeFurge Woods Preserve). Without designated protection, the rest of the natural areas in this area face an uncertain future. It will be important to keep these lands natural, so they can continue to help keep the Huron healthy.

Fish and insect communities are less diverse when impervious surface exceeds 8-12% of the total watershed area.[43,44] Six percent (1.7 square miles) of this area is impervious. However, the river is impacted by the 9% impervious surfaces upstream of the Watershed as well, which are not considered in this number.

2.4.1.2 Hydrology

The hydrology of the Huron River through this section of the Watershed is discussed and evaluated in section 2.1.4, including for a station at Forest Avenue within the Watershed. The hydrology in the 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, but they do generate a greater amount of flow per area than tributaries upstream. Further, 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.

2.4.1.3 Morphology

Recent conditions:
HRWC evaluated stream morphology for Snidecar and Superior Creeks (drains), two smaller direct drainages to the Huron River, along with three reaches of the river itself (Appendix C). The terrain along the Huron River in this section of the watershed is quite diverse. While the land use near the river is quite developed and urban, the direct riparian corridor has very good riparian cover with a well-connected floodplain. Bank slopes along this section of the river can be high in some places, but are comparatively gentle for most of the reach surveyed. Riverbanks show moderate erosion rates. The Huron River itself has a unit erosion rate of 0.071 tons/year per linear foot of river assessed, which is less than half the average rate of 0.153 tons/yr/ft across all of the assessed reaches of the Watershed (Table 2.7). None of the main branch river reaches had erosion rates in the highest priority category.

The tributary stream reaches, on the other hand, are rated to be quite susceptible to erosion. While there were a few sections with good riparian cover and intact banks, on average, both small, direct-drainage streams and the two named tributaries showed high erosion rates. Combined, the direct drainages had an average unit erosion rate of 0.283 tons/yr/ft, and the two tributaries had erosion rates about half that, but still considered high when compared to other watersheds. These drainages cut through rolling hill terrain in the riparian valley, with agricultural areas upland. Upstream sections appear to have been channelized over the years. Overall, the 2.5 miles of Huron River generates an estimated total of 940 tons/year in eroded soil, while the 11.3 combined miles of tributaries and direct drainages erode a combined estimate of 8,659 tons/year. These erosion rates and amounts are significantly higher than upstream watersheds and the eroded sediment is likely contributing to lake nutrient impairments.

To estimate the nutrient contribution, we applied a rough TP:soil concentration of 0.0005 lb P/lb soil, with a correction of 85% for typically loamy-sand soils in the watershed[45]. Overall, the erosion in the Huron River adds an estimated 799 lbs/yr of phosphorus, while tributaries release an estimated 7,360 lbs/yr.

Table 2.7. General erosion rates for the assessed streams of 2 primary Creeksheds, the main Huron branch, and the smaller direct-to-Huron drainages.

Measurement	**Huron River**	**Direct-to-Huron Drainages**	**Snidecar Creek**	**Superior Creek**
Length Assessed (mi)	1.59	1.07	0.18	2.82
Total Reach Length (mi)	2.52	2.85	3.95	4.47
Erosion Rate (tons/yr/ft)	0.071	0.283	0.053	0.140
Tons per year	940	4,263	1,099	3,297
Total Phosphorus (lbs/yr)	799	3,623	934	2,803

2.4.1.4 Stream Habitat

At a minimum of every five years and occasionally more frequently, HRWC conducts a habitat assessment at one monitoring site in this subwatershed, the Huron River at East Cross Street in Ypsilanti (Riverside Park/Frog Island Park area). The assessment is composed of qualitative observations (riparian width, erosion sites, meandering, woody debris, counts of riffles/pools/runs, desktop observations through aerial photography and GIS) combined with quantitative measurements of stream substrate (substrate size analysis across ten cross section transects).

This location was last monitored for habitat on August 9, 2021. The average width of river here is 133 feet and had an average depth of 3 feet on this date. However, this depth is known to regularly change with weather and flow conditions. A similar study in 2014 had an average depth of 0.8 feet and during higher flows the river will be above the heads of anyone attempting to take the depth. The river has a rocky substrate here, with 12% boulder, 43% cobble, 26% rock (a size in between that of cobble and gravel), 13% gravel, and just a very small amount of sand and muck along the quieter edges or in the gaps between larger rocks.

Along the whole stretch of the Huron River in this Watershed, the river has a moderately deep natural riparian zone on both banks, (thirty to several hundred feet, depending on exact location). One exception to this is an area of mowed grass at Riverside Park in Ypsilanti.

2.4.1.5 Phosphorus

Figure 2.14. Location of the HRWC's Chemistry and Flow Monitoring points in the Middle Huron, section 3.

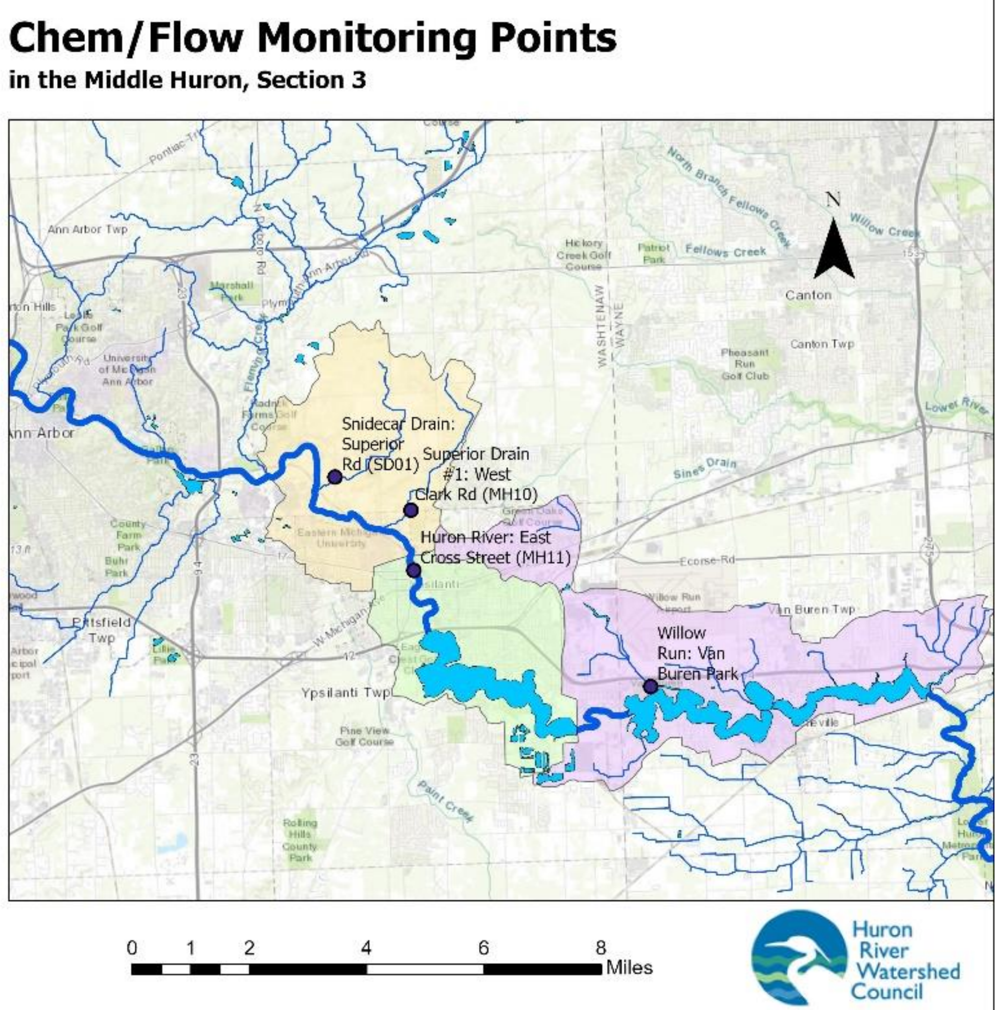
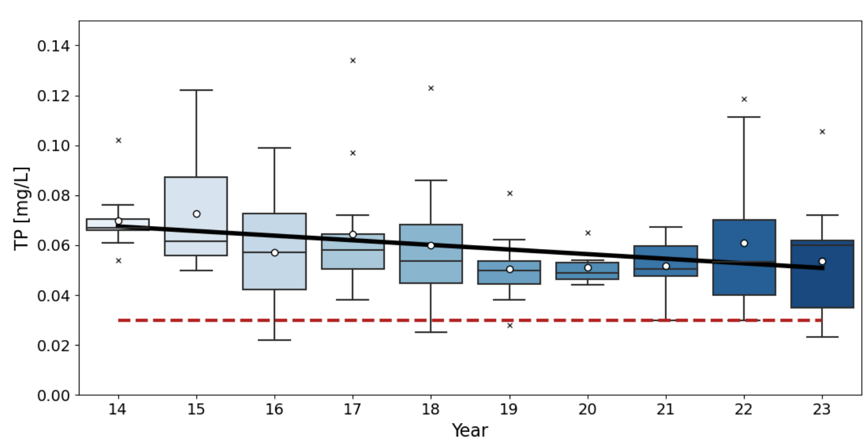


Figure 2.15. Distribution of annual Total Phosphorus (TP) concentrations over time between 2014 and 2023 at the Huron River at East Cross Street (MH11). White circles mark annual mean concentrations and x's denote outliers for each year. The red-dashed line marks the TMDL value of 0.03 mg TP/L.



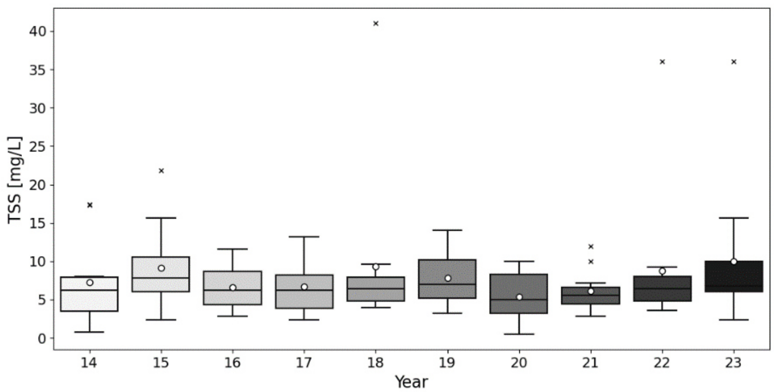
HRWC's Chemistry and Flow Monitoring Program has monitored the Huron River at East Cross Street in Ypsilanti (MH11) twice monthly from April through September since 2014. Over the entire sampling period between 2014 and 2022, total phosphorus (TP) concentrations in the Huron River at East Cross Street have seen a statistically significant decline (n=100, p=0.02). Average TP concentrations have declined from 0.07 mg/l in 2014 to 0.05 mg/l in 2021 and 0.06 mg/l in 2022. Average and median TP concentrations at MH11, both 0.06 mg/l (s=0.02), are still above the Total Maximum Daily Load (TMDL) target for Ford and Belleville Lake of 0.03 mg/l. Only 7 percent of monitored TP values from 2014 to 2022 are at or below the 0.03 mg/l TMDL target. TP data from MH11 illustrates no seasonal trends throughout the growing season. High and low concentrations vary from month to month. Higher TP concentrations at MH11 are generally associated with wet weather events due to increased stormwater runoff from the surrounding urbanized area of Ypsi and upstream from Ann Arbor. However, additional targeted wet weather monitoring could further characterize the influence of stormwater runoff and precipitation on nutrient loading throughout this section of the Huron River.

From 2003 to 2013, HRWC also monitored TP at Superior Drain #1 at West Clark Road (MH10) in Superior Township. HRWC and volunteer teams collected samples at MH10 twice monthly during the growing season (April through September). During that period, TP concentrations averaged 0.09 mg/l (n=80, s=0.3) with a median of 0.07 mg/l. TP values at Superior Drain ranged from 0.02 mg/l to 0.31 mg/l. No significant trends in TP were observed during that period, however, HRWC TP sampling indicates Superior Drain is a likely source of phosphorus loading into the Section 3 Middle Huron Watershed. Nonetheless, additional more recent monitoring could confirm if current TP concentrations remain high at Superior Drain.

HRWC collected two monitoring seasons (April through September) of TP data from Snidecar Drain at Superior Road (SD01) in 2016 and 2017. TP concentrations at Snidecar Drain saw an average of 0.20 mg/l (n=22, s=0.2) and a median of 0.11 mg/l. Values ranged from 0.04 mg/l to 0.67 mg/l, all above the TMDL target of 0.03 mg/l.

2.4.1.6 Suspended Solids

Figure 2.16. Annual distributions of TSS concentrations measured at the Huron River at East Cross Street (MH11) between 2014 and 2023. White circles denote annual means and x's denote outliers.



From 2014 to present, HRWC's Chemistry and Flow Monitoring Program has collected total suspended solids (TSS) data from the Huron River at East Cross Street during the growing season. TSS data at MH11 reveals low sedimentation throughout this stretch of the Huron River. Across 99 samples collected during the monitoring period, 98 percent were below 25 mg/l, which indicates low sediment loading in this area across all conditions and water levels. During the nine-year sampling period, TSS values for the Huron River at East Cross Street ranged from 0 to 41 mg/l and averaged 8 mg/l (s=6). TSS at MH11 illustrates no observable, statistically significant trend.

HRWC's Chemistry and Flow Monitoring Program monitored TSS at Superior Drain #1 from 2003 to 2013. Of the 81 measured TSS values, 84 percent of values were below 25 mg/l. However, TSS values at Superior Drain reached over 100 mg/l on two occasions, likely during or after high precipitation events. One TSS sample in 2011 during high flow conditions reached over 700 mg/l, which may indicate high sedimentation potential from Superior Drain following extreme weather events. Overall, TSS at Superior Drain averaged 26 mg/l (s=83) and had a median of 10 mg/l.

In 2016 and 2017, HRWC collected biweekly TSS data at Snidecar Drain (SD01) from April through September. The limited data show some sedimentation across conditions and seasons at Snidecar Drain. TSS data at SD01 averaged 69 mg/l (s=92) with a median of 26 mg/l. Just over half of the measured TSS values (52%) were above 25 mg/l and a quarter (24%) were over 100 mg/l. Across the two-year sampling period, TSS at Snidecar Drain peaked at 294 mg/l, revealing some sediment loading during high flow conditions.

2.4.1.7 Nitrate and Nitrite

From 2014 through the present, HRWC has monitored nitrate and nitrate twice monthly where the Huron River crosses East Cross Street in Ypsilanti (MH11). Nitrate and nitrite concentrations at MH11 remain below the EPA's Maximum Contaminant Levels (MCL), with a range of 0.0 to 0.07 mg/l for nitrite (n=94) and 0.5 to 2.8 mg/l for nitrate (n=100) from 2014 to 2022. During the monitoring period, nitrite averaged 0.01 mg/l (s=0.01) and nitrate averaged 1.2 mg/l (s=0.4). Over the eight years of monitoring, no trend has been observed for either nitrate or nitrite.

The two tributaries to the Huron River in this area –Snidecar and Superior drains – both have nitrate and nitrite ranges below EPA's MCLs for these parameters. Both Snidecar and Superior drains have average nitrate concentrations of 0.3 mg/l and average nitrite concentrations of 0.01 mg/l. At both sites, there are no observable trends in nitrate and nitrite concentrations over the respective monitoring periods.

2.4.1.8 Conductivity

HRWC's long-term monitoring site on the Huron River at East Cross Street in Ypsilanti (MH11) has been monitored for conductivity since 2014 using handheld water quality sondes from YSI. Of the 104 conductivity measurements, 50 (49%) exceed the 800 µS threshold used by HRWC. However, the average and median conductivity values for MH11 fell just below that threshold at 771 µS (s=157) and 791 µS, respectively. Overall, conductivity values during the eight-year monitoring period range from 412 µS to 1570 µS, which was the only reading to reach beyond 1000 µS. Given MH11 is within the urbanized areas of Ypsilanti and downstream of Ann Arbor, it is likely that pollutant sources from urban areas are leading to elevated conductivity levels at MH11 and within the Section 3 Huron River Watershed. During the monitoring period, there has been no observable trend in conductivity values at the MH11 site.

During HRWC's ten-year monitoring period at Superior Drain from 2003 to 2013, stream conductivity remained consistently low. Conductivity values ranged from 310 µS to 990 µS, with an average of 611 µS (s=125). Only 2 readings (4%) were over 800 µS.

Conductivity measurements were taken at Snidecar Drain in 2016, 2017, and 2020. Among the three years of monitoring (n=28), conductivity at Snidecar Drain ranged from 257 µS to 1263 µS. Conductivity values are slightly elevated with 40 percent of readings above the 800 µS threshold. However, both mean and median conductivity values at Snidecar Drain are slightly below that threshold at 753 µS (s=218) and 772 µS, respectively.

2.4.1.9 pH

HRWC's Chemistry and Flow Monitoring Program has monitored pH where the Huron River crosses East Cross Street in Ypsilanti (MH11) since 2014. During the monitoring period, pH values fall within the prescribed range under the Michigan Water Quality Standards for surface waters. From 2014 to 2022, pH values ranged from 7.4 to 8.5, with an average of 8.2 (s=0.2). Tributaries into this section of the Huron River, including Snidecar and Superior drains, also have pH values within a normal range for surface water with respective average values of 8.2 (s=0.1) and 7.6 (s=0.3).

2.4.1.10 Temperature

Temperature data has been collected by HRWC's Chemistry and Flow Monitoring Program along the Huron River near Riverside Park and East Cross Street in Ypsilanti (MH11) since 2014. The monitoring season runs April through the end of September. The average water temperature of the Huron River at MH11 is 69.6 degrees Fahrenheit (s=10.2) as measured between 2014 to 2022. During that period, temperatures ranged from 41.5 to 83.3 degrees Fahrenheit. Due to seasonal variability, there is no observable trend in temperature at MH11.

HRWC also connected temperature data using handheld YSI multimeters at Superior and Snidecar drains over more limited monitoring periods. Data collected at Superior Drain from 2003 to 2013 show an average water temperature of 60.1 degrees Fahrenheit (s=6.1) across 69 measurements. Temperature values reached a maximum of 71.6 degrees Fahrenheit and a minimum of 43.3 degrees Fahrenheit at Superior Drain and are within expected seasonal values for surface water temperatures.

At Snidecar Drain, temperature measurements were collected from April through September in 2016 and 2017 and briefly in July and August of 2020. Across 28 measurements from Snidecar Drain, temperature values averaged 64.6 degrees Fahrenheit (s=6.8) with a median of 66.4 degrees Fahrenheit. The range of temperature values at Snidecar Drain is slightly narrower than at MH11 and Superior Drain with values ranging from 46.6 degrees Fahrenheit to 73.2 degrees Fahrenheit.

2.4.1.11 Dissolved Oxygen

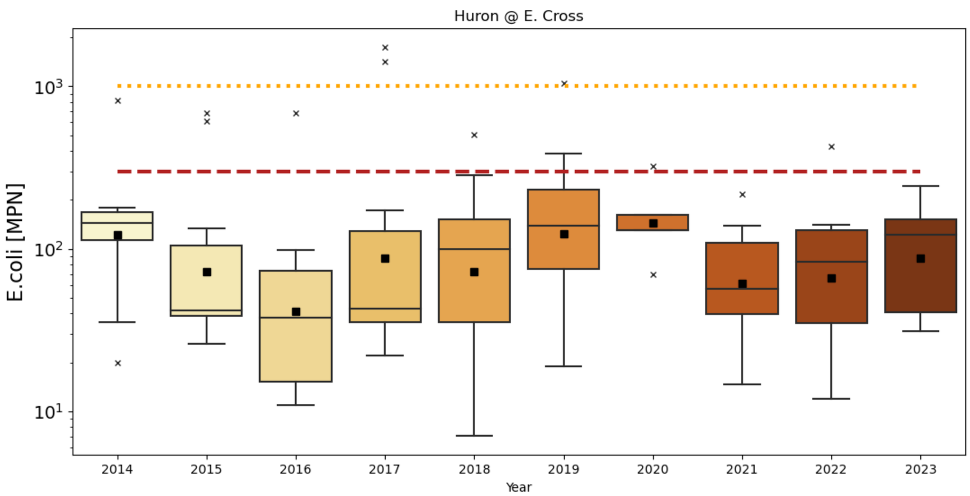
In-stream dissolved oxygen (DO) measurements for the Huron River at East Cross Street (MH11) are collected every other week from April through September by HRWC's Chemistry and Flow Monitoring Program. From 2014 to 2022, DO at MH11 (n=100) met and exceeded Michigan's DO standard of 5 mg/l across 98 percent of measurements. DO values at MH11 ranged from a minimum of 3.67 mg/l in 2015 to 14.17 mg/l in 2019. Across the eight-year monitoring period, DO values at MH11 averaged 9.28 mg/l (s=1.84) with a median of 8.81 mg/l, which are high enough DO values to sustain life and contribute to healthy aquatic conditions along with Huron River.

At Superior Drain, HRWC collected DO measurements across the growing season from 2003 to 2006 and again in 2008 and 2009. Across the monitoring record (n=35), DO averaged 7.82 mg/l (s=1.25) and ranged from 5.5 mg/l to 11.41 mg/l. Given all collected measurements are above 5 mg/l, dissolved oxygen at Superior Drain appears to be within healthy ranges for surface water and to sustain aquatic life. However, HRWC could collect more recent data to ensure DO levels at Superior Drain remain high across the growing season.

HRWC also has a few years of DO data at Snidecar Drain at Superior Road. In 2016, 2017 and 2020, HRWC collected 28 DO measurements at Snidecar Drain averaging 6.99 mg/l (s=2.66). 25 percent of measured DO values at Snidecar Drain fell below the 5 mg/l DO standard, indicating issues with stream oxygenation during the dry summer months. DO values fell as low as 2.37 mg/l in July 2020 and reached up to 11.17 mg/l in May 2017.

2.4.1.12 Bacteria

Figure 2.17. Annual distributions of E. coli bacterial counts in the Huron River at East Cross Street (MH11) from 2014 – 2023. Black squares represent annual geometric means and x's denote outliers. The yellow-dotted line and red-dashed lines mark the state's single sample partial body contact recreational standard of 1000 MPN/100 mL and full body contact recreational standard of 300 MPN/100 mL, respectively.



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.

HRWC's Chemistry and Flow Monitoring Program has monitored *E. coli* counts within the Section 3 Huron River since 2014. From 2014 to 2020, biweekly single grab samples were collected from the Huron River at East Cross Street (MH11) during the growing season. In 2021 and 2022, triplicate samples were collected at MH11 biweekly from April through September.

Single grab samples at MH11 from 2014 to 2020 had average and median *E. coli* counts below both the state partial body contact and full body contact standards at 183 counts per 100 ml (s=305) and 90 counts per 100 ml, respectively. During the seven-year sampling period (n=74), 13 percent of samples were above the full body contact, single-event standard of 300 *E. coli* per 100 ml and 4 percent of samples were above the partial body contact standard of 1000 *E. coli* per 100 ml.

During the triplicate sampling in 2021 and 2022, HRWC saw *E. coli* results consistent with its previous single grab samples. Across 24 sampling events, HRWC saw only 1 geomean in April 2022 (427 cfu/100 ml) over the full body contact standard of 300 *E. coli* per 100 ml. Triplicate samples were consistently below that standard across all seasons, with an average value of 91 cfu/100 ml and a median value of 70 cfu/100 ml. Overall, HRWC's *E. coli* monitoring data indicates water quality compatible with recreational activities such as paddling and swimming during dry weather conditions in the main branch of the Huron River within the Section 3 Middle Huron Watershed. However, following rain storms for up to 48 hours, contact should be avoided as E. coli levels during these periods may be elevated above state health standards.

HRWC also collected single *E. coli* grab samples at Superior Drain from 2006 to 2013. Across eight years of sampling (n=64), HRWC saw consistently high *E. coli* counts at Superior Drain. 66 percent of samples were at or above the full body contact standard and 23 percent of samples were above the partial body contact standard. *E. coli* sample counts averaged 959 cfu/100 ml (s=1795), with a maximum value of 12,400 cfu/100 ml and a median value of 405 cfu/100 ml, both above the full body contact standard.

HRWC monitored for *E. coli* at Snidecar Drain in 2016, 2017, and 2020. From 2016 to 2017, HRWC collected biweekly single grab samples for *E. coli* during the growing season. This two-years of *E. coli* monitoring (n=21) at Snidecar Drain revealed that nearly half of all samples (48%) were at or above the full body contact standard of 300 *E. coli* per 100 ml. *E. coli* counts during the two-year period averaged 696 cfu/100 ml (s=844) and reached a maximum of 2603 cfu/100 ml.

In 2020, HRWC conducted a targeted EGLE-funded *E. coli* study at select sites across the Huron River watershed, including Snidecar Drain. Triplicate samples during that five-week sample period indicated continued high *E. coli* counts at Snidecar Drain. Weekly geomeans ranged from 286 cfu/100 ml to 4,139 cfu/100 ml. The 30-day geomean at Snidecar Drain was 1,099 cfu/100 ml, which is above both the full and partial body contact standards. The 2020 study also included a microbial source tracking (MST) assessment of Snidecar Drain for human, bovine, and canine markers. Results indicated non-detects for the bovine marker and *Bacteroides thetaiotaomicron (B. theta)* human-associated marker. However, samples detected the presence of the HF183 human marker and the canine marker, revealing potential sewage and pet waste sources within the Snidecar Drain creekshed. There are two biosolid application sites in this watershed according to MiEnviro mapping tool that are possible sources (2665-LE-01, 2886-RG-01).[46]

Additional monitoring of Snidecar and Superior drains could further characterize the scale and source of bacterial contamination in these creeksheds. Targeted wet weather monitoring in these creeksheds could evaluate the influence of hydrology and storm events on *E. coli* counts.

2.4.1.13 Macroinvertebrates

As a proxy to overall stream health, HRWC records the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and calculates a metric score based on Hilsenhoff's Index of Biotic Integrity[47]. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality, and the lower the value of the Hilsenhoff IBI score. 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.

HRWC monitors the Huron River at the East Cross Street intersection. Compared to an average of scores from 62 sites monitoring by HRWC, socre at east Cross Street were less than average from 2020-2022.Ten aquatic insect families were found on average (compared to 11.2 across the whole Huron Watershed) and 4 of those were EPT families (compared to 4.5 average EPT families across the whole Huron Watershed).

The Hilsenhoff IBI rates the site as Good, averaging 5.3 on a scale of 0 (Pristine) to 10 (Highly Degraded). Long term trends (1997-2023) indicate that the macroinvertebrate population here is not significantly changing.

HRWC also looks for highly pollution sensitive stonefly families in January, before the insects emerge as adults. Stoneflies were found at this location in 2021 and not in 2023. Historically, they have been found in 9 out of 17 samples (1997-2023).

Overall, the macroinvertebrates indicate that the habitat and water quality conditions at this location are suitable for aquatic life. It is not impaired, but neither is it exceptionally healthy or noteworthy.

2.4.1.14 Fish

The Huron River throughout most of the Watershed is considered a popular warmwater recreational fishery for shore anglers. Plentiful parks along the riparian corridor allow for free and easy access.

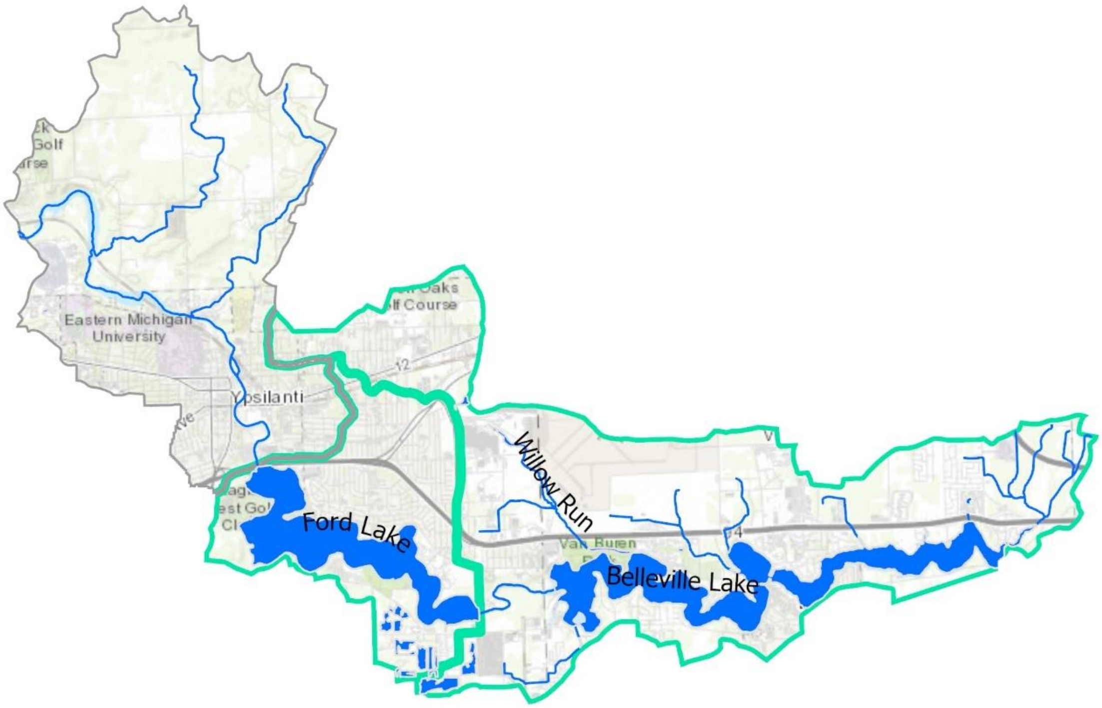
A 2.7 hour MDNR electroshocking sample in the Huron at M-12 and upstream for 1200 feet in 2001 resulted in 4,242 fish comprised of 26 species. The report states:
"The catch by numbers was dominated by greenside darter (35% of the total catch) which, along with spotfin shiner (19%), logperch (14%), northern hog sucker (14%), and smallmouth bass (8%) made up over 90% of the total catch."[48]

The river was reported as lacking cover and deeper water to shelter larger individuals.

From 2014-2017, as a response to MDNR's report on the lack of fish habitat through this section, HRWC conducted a habitat improvement project where larger trees were felled with a trunk notch, anchored along the riverbank, and angled downstream to create habitat diversity and faster flow in smaller areas so finer sediment could be washed away to reveal gravel and deeper areas. Additionally, a rock vane was put in Riverside Park by the park's gazebo to constrict water flow, and several boulders were placed along the edge of the rock vane. This created deeper holes (3-5 feet deep depending on flow conditions) and a diversity in stream substrate (boulders instead of gravel and sand). HRWC conducted fish monitoring, both pre- and post-project in 2014 and 2017. Notable changes include increased numbers of smallmouth bass, northern hogsucker, walleye, and golden redhorse. The rock vane and deeper holes in particular were found to provide habitat for many of these larger fish.

2.4.2 Ford Lake, Belleville Lake, and Tributaries

Figure 2.18. Overview of Ford, Belleville Lake, Willow Run, and other tributaries



2.4.2.1 Watershed Natural Areas

The Ford Lake subwatershed is highly developed and impacted by high amounts of impervious surface cover. Approximately 35% of the sub-watershed is classified as developed and 30% of the area is water; together, forests, wetlands and grassland areas make up approximately 22% of land cover in the sub-watershed (Figure 2.10).

The Belleville Lake drainage is the most developed subwatershed in the Section 3 Middle Huron Watershed and is also challenged by the degree of impervious surface cover in this area. Approximately 45% of the Belleville Lake sub-watershed is classified as developed and 13% of the area is water; remaining natural areas comprise approximately 26% of land cover (Figure 2.10).

HRWC's bioreserve map identifies three natural areas in the Ford Lake subwatershed and three natural areas in the Bellville Lake subwatershed that are rated as medium ecological value area (Figure 2.7). Parcels within these natural areas should be prioritized for protection to minimize further development and maintain ecosystem services in this urbanized system.

2.4.2.2 Hydrology

Both Ford and Belleville Lake are human-made impoundments on the Huron River. Ford Lake was created by the Ford Lake Dam (sometimes called the Rawsonville Dam), one of nine dams in the Section 3 Middle Huron River Watershed (Figure 2.8). The Ford Lake Dam was constructed in the 1930's to provide hydroelectric power to Henry Ford's Motor Plant in Ypsilanti, Michigan. In 1969, Ypsilanti Township took over ownership and operation of the dam and 1,000 acres of land around the dam and Ford Lake. The dam continues to generate hydroelectric power today.[49] The Ford Lake impoundment is approximately 975 acres (surface area), with a maximum depth of 30 feet. There are no direct tributary drainages to the Ford Lake subwatershed.

Downstream of Ford Lake, Belleville Lake is a 1,200-acre impoundment on the Huron River created in 1926 with the construction of the French Landing Dam by Detroit Edison, also for electric power generation. In 1972, Van Buren township acquired the dam and subsequently restored its power generation capacity.[50] Unlike Ford Lake impoundment, there are several small direct drainage tributaries on the north and eastern side of Belleville Lake, including Willow Run.

2.4.3.3 Shoreline Habitat

Shoreline armoring reduces littoral habitat and can increase wave energy on lakes, leading to excess erosion of the lake bottom and disturbing native macrophytes and emergent vegetation. Submerged logs along the shoreline are important for animal habitat (fish, birds, reptiles, amphibians) as well as reducing the power of erosive wave action.

The Michigan Department of Natural Resources (MDNR) conducted a shoreline habitat survey of Ford Lake in 2006.[51] Staff drove boats around the lake and counted the number of small and large docks, dwellings, submerged trees, and calculated the percent of the armored shoreline on the 9.3 miles of shoreline. The survey found 168 docks, 116 dwellings, 244 logs over 6 inches in diameter were counted in the water (1 tree per 200 feet of shoreline), and a little over 30% of the shoreline was determined to be armored in some fashion.

The numbers of dwellings, docks and amount of shoreline armored on Ford Lake were on the low side for a heavily developed lake in southeast Michigan.

The MDNR conducted a similar shoreline habitat survey of Belleville Lake in 2012 and reported that 55% of the 10.8 miles of shoreline in the lake's western basin were armored, with 266 houses, 268 docks, and 269 submerged trees (1 tree per 212 feet of shoreline). 88% of the 7.8 miles of shoreline on the eastern basin was armored with 286 houses, 218 docks, and 80 submerged trees (one tree per 512 feet of shoreline).[52]

Research indicates that development of more than about 25% of a lake's shoreline has detrimental effects on a fish community through nearshore habitat degradation associated with the development and a reduction in woody material recruitment into the water.[53] Both of the basins on Belleville Lake have 2-3 times this recommended maximum development level while Ford Lake is right about at the 25% mark. Development is lower on Ford Lake likely because of the steep banks around much of it.

The amount of submerged, nearshore woody material is considered very low in Ford Lake and the western basin of Belleville Lake. It is even lower to almost nonexistent in the more highly developed Belleville Lake eastern basin.

Neither the Ford Lake or Belleville Lake survey involved counts, analysis, or mapping of erosive shoreline areas. HRWC has received several anecdotal reports of erosion on the south shores of Ford and Belleville lakes, and those slopes are said to be quite steep in sections, but there is no known study, mapping, or available photographs of these points. A study of this nature is in high need.

HRWC's methodology to assess stream banks (BANCs, see next section) is not appropriate to use on lakeshore banks, however, but other available methods are, such as the Score the Shore method from the Cooperative Lakes Monitoring Program.[54]

2.4.3.4 Stream Morphology and Habitat

Recent conditions:
HRWC did not identify any tributary streams to Ford Lake that could be evaluated for stream morphology.

One tributary (Willow Run) and several direct drainages to Belleville Lake were identified and evaluated however using the BANCs methodology (Appendix C). Reaches in this section of the Watershed were often difficult to access as some were fenced off due to proximity to the Willow Run Airport or other infrastructure or industrial facilities. There are no river reaches in this section of the watershed, with the exception of the connecting channel between the lakes. That channel was deemed too deep to wade.

There is one named tributary, Willow Run, in the Watershed. Only some parts of this tributary were accessible. Reaches in the tributary vary from channelized farm drains in the headwaters north of US-12, to highly altered and armored channels along the airport (aerial observation only). Further downstream, the channel has good riparian vegetation, but the banks appear to be eroding rapidly due to altered hydrology upstream.

Willow Run has a unit erosion rate of 0.150 tons/year per linear foot of river assessed, which is slightly less than the average rate of 0.153 tons/yr/ft across all of the assessed reaches of the Watershed (Table 2.8). Of the five Willow Run reaches assessed, three reaches had erosion rates in the highest priority category, with one each in the moderate and low priority categories.

Direct drainage reaches, on the other hand, all but one (the only reach south of the lakes) appear to be quite susceptible to erosion. These drainages travel through either densely populated residential areas or current or previous farm fields. Streams in these older residential areas seem to largely have been altered and moved to make room for development. Soil in the farm areas is comprised of a higher amount of sand than in upriver areas, making banks more susceptible to erosion. Combined, the direct drainages had an average unit erosion rate of 0.174 tons/yr/ft.

Overall, the 4.9 miles of Willow Run generates an estimated total of 3,857 tons/year in eroded soil, while the 6.9 combined miles of direct drainages erode a combined estimate of 6,376 tons/year. These erosion rates and amounts are also significantly higher than upstream watersheds and the eroded sediment is likely contributing to lake nutrient impairments.

To estimate the nutrient contribution, we applied a rough TP:soil concentration of 0.0005 lb P/lb soil, with a correction of 85% for typically loamy-sand soils in the watershed[45]. Overall, the erosion in Willow Run adds an estimated 3,278 lbs/yr of phosphorus, while tributaries release an estimated 5,419 lbs/yr.

Table 2.8. General erosion rates for the assessed streams of 1 primary Creekshed and the smaller direct-to-Huron drainages.

Measurement	Direct-to- Huron Drainages	Willow Run
Length Assessed (mi)	3.07	1.94
Total Reach Length (mi)	6.94	4.86
Erosion Rate (tons/yr/ft)	0.174	0.150
Tons per year	6,376	3,857
Total Phosphorus (lbs/yr)	5,419	3,278

2.4.2.5 Phosphorus

Current Monitoring

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) conducts biannual monitoring of phosphorus in Ford Lake and Belleville Lake between April and September to track progress towards meeting TMDL goals established for Ford and Bellville Lakes in 1995. A Water Resources Division Staff Report released by EGLE in 2019 details the most recent results of biannual monitoring in 2014, 2016, and 2018. During this time, EGLE monitored four sites on Ford Lake and four sites on Bellville Lake.[55] Surface grab samples were collected for total phosphorus and ortho phosphate at all sites; at certain sites, samples were also collected in the middle of the water column and near the bottom of the lake.

EGLE reports that overall, TP concentrations in Ford and Belleville Lakes have not changed significantly since monitoring was initiated in 1994, despite reductions in TP concentrations in the Huron River upstream of the impoundments. Sampling results indicate that total phosphorus ranged widely in Ford Lake both within annual seasons and across the entirety of the sampling period from 30 µg/L in June of 2016 to 87 µg/L in August of 2018, however summer phosphorus concentrations were generally higher than spring concentrations across the sampling period (2014 – 2018).

Like Ford Lake, phosphorus concentrations in Belleville Lake were consistently higher in the summer months compared to the spring. In 2018, average TP concentrations in Belleville Lake were higher in spring vs. the summer monitoring period. However, EGLE reports that this increase in spring TP corresponded to releases of effluent from the YUCA Wastewater Treatment Plant between September 2017 and January 2018. Overall, average TP concentrations collected in Belleville Lake across the sampling period were higher than target goals established for the TMDL (30 µg/L) nearly 90% of the time (15 of 17 sampling dates).

EGLE concluded in their 2019 report that it was likely that internal phosphorus loading is occurring in both Ford and Bellville Lakes and is contributing to continued eutrophic conditions in the impoundments despite reductions in TP inputs from the Huron River since the implementation of the TMDL. Higher concentrations of TP in the summer months compared to the spring in both lakes further support this conclusion: In Ford Lake, EGLE's monitoring indicates that the impoundment experiences anoxic conditions in the hypolimnion during periods throughout the monitoring season (April – September), which can "trigger" a release of phosphorus from benthic sediments and lead to an increase in phosphorus in the system (internal loading). Anoxia is more likely to occur in the summer months when water temperatures are higher.

Willow Run, a direct drainage into Belleville Lake, was monitored by HRWC for total phosphorus in 2016 and again in 2022. From April through September, biweekly grab samples were collected from Willow Run at Van Buren Park in Van Buren Township. Across 24 samples, total phosphorus (TP) concentrations averaged 0.06 mg/l (s=0.1) with a median of 0.04 mg/l, which is slightly above the 0.03 mg/l Total Maximum Daily Load (TMDL) target for Belleville Lake. Overall, a little over one third of samples (38%) had TP concentrations at or below the TMDL target for Belleville Lake. During the 2016 and 2022 sampling efforts, Willow Run TP concentrations mostly ranged from 0.02 mg/l to 0.10 mg/l, however, one sample from September 2016 reached 0.55 mg/l.

Historic Data

In December of 1993, a 12-month phosphorus loading analysis was initiated by the Michigan Department of Environmental Quality 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 (Appendix D). According to MDEQ, the TMDL should assure the attainment of water quality standards for Belleville Lake, and significantly reduce problems in Ford Lake, 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."

Dr. John Lehman with the University of Michigan conducted a study on the nutrient dynamics and algae growth in Ford and Belleville Lakes and the Huron River upstream. [56] As part of this study, Dr. Lehman and his team sampled twelve sites along the Huron River and sites in Barton Pond and the two lakes. Sampling of these sites occurred between June 2003 and October 2005 once or twice weekly in the summer months, weekly in spring and fall, and biweekly in winter months. Parameters measured at the river sites included several forms of phosphorus and nitrogen, dissolved organic matter, specific conductance and pH. The main conclusion of Dr. Lehman's study is that internal phosphorus cycling is a major source of phosphorus in Ford and Belleville Lake.

Specific results of Dr. Lehman's mass balance study included the following:

1) From June 2003 to December 2004, 33427 kilograms (KG) of total phosphorus (TP) entered Ford Lake. During the same time period, Ann Arbor Waste Water Treatment Plant (AAWWTP) reports discharging 12427 KG TP to the Huron River (37%).
2) Of the 12427 KG P that AAWWTP discharged to the Huron River, only 8854 KG (71%) emerged from Superior Pond. This represents 26% of the load to Ford Lake.

3) More TP entered Ford Lake during May 2004 as a result of the 22 May flood than had been discharged by AAWWTP in the previous year.
4) From June 2003 to March 2005, 4279 KG of dissolved P (DP) was discharged from Barton Pond into the Huron River above Ann Arbor. During the same time, 12205 KG DP was present below Geddes Pond and upstream of the AAWWTP outfall. This represents an increase of 7926 KG added within Ann Arbor above its WWTP.
5) Also from June 2003 to March 2005, 22804 KG DP exited Superior Dam, an increase of 10599 KG from upstream of the WWTP (N.B. This is less than the reported discharge by AAWWTP owing to retention within Superior Pond).
6) 23002 KG DP entered Ford Lake, an increase of 198 KG from Superior Rd to Spring St.
7) For Particulate P (PP; DP + PP = TP), 16771 KG discharged from Barton Pond; 12043 KG discharged from Geddes Pond. This is a net loss of 4728 KG PP removed by Argo and Geddes Ponds. The balance between PP retention and DP release resulted in the net addition of 3198 KG P to the River within Ann Arbor.
8) From June 2003 to March 2005, 16190 KG discharged from Superior Dam. This is an increase of 4147 KG compared to upstream of the AAWWTP. The N/P ratio of this added particulate matter is too low for it to be biological matter. It is almost surely eroded soil. 18349 KG PP entered Ford Lake. This is an increase of 2159 KG. The N/P ratio of this particulate matter is too low for it to be biological matter. It is soil, too.
9) 41351 KG TP entered Ford Lake and 32445 KG exited. This was a removal of 8906 KG or a retention of 21.5%. The proportioning between dissolved and particulates was such that 19.3% of DP and 24.3% of PP were retained.

2.4.2.6 Bacteria

Belleville Lake is monitored for *E. coli* bacteria by the Wayne County Health Department in accordance with the Michigan Department of Environment, Great Lakes, and Energy's (EGLE) Surface Water Quality Monitoring Program. The Water Quality Standard (WQS) for *E. coli* as defined under the Natural Resources and Environmental Protection Act requires that "all waters of the state protected for total body contact recreation shall not contain more than 130 *E. coli* per 100 milliliters (mL), as a 30-day geometric mean […] At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 ml."[57]

Van Buren Park on Belleville Lake has been monitored consistently for *E. coli* since 2005. Between 2005 and 2018, the public park beach has been closed due to high bacteria levels 13 times, for a total of 111 days. According to current data available by EGLE's BeachGuard database, the most recent closure on September 5th, 2018 lasted 26 days, the longest closure since July of 2008.[58] On September 4th, *E. coli* counts at Van Buren Township Park Beach were 481 *E. coli* per 100mL of water, exceeding the maximum state WQS of 300 *E. coli* / 100mL.

HRWC's Chemistry and Flow Monitoring Program monitored Willow Run, a tributary to Belleville Lake, for *E. coli* at Van Buren Park during the 2016 and 2022 growing seasons. Samples collected at Willow Run for *E. coli* were single grab samples. HRWC's collected around 12 samples each season, for a total of 23 *E. coli* samples. *E. coli* counts at Willow Run averaged 378 counts per 100 ml (s=537) with a median of 229 counts per 100 ml. *E. coli* samples ranged from 17 counts per 100 ml to 2420 counts per 100 ml. Overall, 65 percent of *E. coli* samples at Willow Run were below the full body contact standard of 300 counts per 100 ml and 91 percent of samples were below the partial body contact standard of 1000 counts per 100 ml. As a result, *E. coli* counts at Willow Run appear to be low, however, additional state-approved triplicate sampling could be conducted to validate the single grab sample results.

There are no known bacterial studies on Ford Lake. There are no public swimming beaches on Ford Lake.

2.4.2.7 Macroinvertebrates

As a proxy to overall stream health, HRWC records the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), and calculates a metric score based on Hilsenhoff's Index of Biotic Integrity. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality, and the lower the value of the Hilsenhoff IBI score. 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.

HRWC procedures require wadable water and thus there are no macroinvertebrate studies on Ford or Belleville Lake.

In 2010 and 2011, HRWC sampled for macroinvertebrates three times in Willow Run, but then stopped monitoring at this location because the site was too difficult for volunteers to regularly access. Based on three samples only, the location is considered to have a considerably less than average macroinvertebrate populations as compared to the other 62 sites HRWC monitors. 6.3 aquatic insect families were found on average (compared to 11.2 across the whole Huron Watershed) and 2 of those were EPT families (mayfly family Baetidae and caddisfly Hydropyschidae; compared to 4.5 average EPT families across the whole Huron Watershed). The Hilsenhoff IBI rates the site as Very Good, averaging 4.4 on a scale of 0 (Pristine) to 10 (Highly Degraded). The discrepancy between family diversity and IBI score may indicate water that is of good quality to support life but has a lack of different habitat types that would support a broader diversity of insect families.

2.4.2.8 Fish

Current Monitoring

A Do Not Eat Fish Advisory for all fish species was established for Ford Lake and the greater Huron River in 2018 due to PFOS contamination (a form of PFAS, Per- and Polyfluorinated Substances). A 2021 study by the Ecology Center, Friends of the Rouge and HRWC tested fish organs and filets for PFAS.[59] Panfish samples from Ford Lake showed up to 125 parts per billion in organ tissue, among the highest levels detected in the study. Estimated contaminate levels observed in Ford Lake filets remain lower than state advisory levels of 300 parts per billion but are well above what recent research indicates is safe for human consumption.[60] PFAS remains an emerging contaminant and research on safe levels of PFAS for human contact and consumption is ongoing. As recently as 2022, the US Environmental Protection Agency (EPA) released new health advisory levels for four PFAS chemicals that indicate that PFAS is toxic to humans at extremely low levels, and the agency proposed drinking water standards for six compounds in March 2023.[61] These new rules, if accepted as proposed, will have profound, cascading implications for PFAS exposure considerations in multiple sectors of ecosystem management.

Historic Data

The Michigan Department of Natural Resources (MDNR) reports that Ford and Belleville Lake Fishery has been intensively managed since the 1970's.[62] Several species were stocked following chemical treatment in 1973 to eliminate all fish in Ford Lake, including "tiger muskellunge, walleye, smallmouth and largemouth bass, hybrid sunfish, channel catfish, bluegills, and black crappie."

The MDNR conducted a study on the fish population of Ford Lake in 1998 to gauge the levels of white perch inhabiting the lake, fearing they may become nuisance."[63] Besides the white perch, Ford Lake had not seen any gains or losses in fish species during the previous twenty-two years. Fish species found through electrofishing were "carp, gar, log perch, pumpkinseed sunfish, bluegill, yellow perch, green sunfish, largemouth bass, smallmouth bass and walleye." White perch were not found at high enough levels to classify them as "nuisance."

Creel surveys conducted by the MDNR from 2000-2006 indicated that Bellville and Ford Lakes had the highest and second-highest levels of per-acre fishing pressure of all lakes surveyed.[64] In Ford Lake, surveys also indicated that there was an "extremely high percentage of large predators." These predators were likely putting pressure on panfish species and contributing to lower numbers of large panfish in 2006 compared to previous surveys. The 2006 survey also indicated that, following stocking in the 1970's and 1980's, walleye appear to have established a self-sustaining population in Ford Lake.

The MDNR conducted a fisheries survey of Belleville Lake in 2012.[65] Survey results provided further evidence to the hypothesis that there had been an increase in the percentage of predator species in Belleville Lake over time, which had contributed to declines in quality of the panfish fishery, namely bluegill. The MDNR reported that Belleville Lake hosts a "very popular walleye fishery" and successful populations of small and largemouth bass. Overall, channel catfish were found to make up the greatest percentage of predator biomass in Belleville Lake.

2.4.2.9 Exotic Invasive Aquatic Plants

The Midwest Invasive Species Information Network (MISIN) mapping tool compiles known invasive species locations and abundances from numerous projects including that of EGLE and the MDNR, Cooperative Invasive Species Management Areas (CISMAs), and the Cooperative Lakes Monitoring Program (CLMP).[66]

Plant monitoring efforts on Ford and Belleville have been sparse. According to MISIN, EGLE Aquatic Invasive species staff recorded Eurasian Watermilfoil as “Dense” in two locations on the northern end of the Ford Lake on 6/5/2014.

EGLE Aquatic Invasive species staff recorded Eurasian Watermilfoil as “Patchy” and Curly Leafed Pondweed as “Sparse” in central Belleville Lake on 6/5/2014.

There are no other recorded entries for Ford Lake or Belleville Lake, though it seems probable, given high boating traffic and direct connection to the Huron River, that the lakes have larger invasive species issues than what the data suggests.

2.4.2.10 Additional Water Quality Parameters on Ford and Belleville Lakes

EGLE conducts biannual monitoring of phosphorus in Ford Lake and Belleville Lakes between April – September to track progress towards meeting TMDL goals. Additional water quality metrics are collected during monitoring, including total suspended solids (TSS), nitrite/nitrate, conductivity, pH, temperature, transparency, chlorophyll-a, and dissolved oxygen. Data collected on Ford and Belleville Lake at four monitoring sites during the 2014-2018 monitoring period is reported in EGLE’s 2019 Water Resources Division Staff Report.[67] HRWC interpreted the data presented in EGLE’s 2019 report to include highlights for each water quality parameter detailed below. Data from other sources may be included in these breakdowns as well, with references given as appropriate.

TSS

Over the monitoring period, TSS concentrations ranged from a low of 1 mg/L to a high of 41 mg/L in Ford Lake (n=165), and a low of 1 mg/L to a high of 31 mg/L in Belleville Lake (n=161). Average concentrations were 7.5 and 8.9 mg/L in Ford and Belleville Lakes, respectively. TSS concentrations were highest in both Ford and Belleville Lakes in the month of September, when average concentrations were approximately 10.36 mg/L in Ford Lake and 13.2 mg/L in Belleville Lake, and median concentrations were 11.0 mg/L and 12.5 mg/L, respectively.

Nitrate and Nitrite

Nitrate concentrations ranged from a minimum of 0.01 mg/L to 2.3 mg/L in Ford Lake (n=156) and 0.01 mg/L to 0.7 mg/L in Belleville Lake (n=144), with an average of 0.50 and 0.31 mg/L, respectively. Over the monitoring period, the highest average concentrations of nitrate in both Ford and Belleville Lakes were observed in the month of April, when average and median concentrations were approximately 0.70 mg/L in Ford Lake, and 0.63 mg/L in Belleville Lake. On average, concentrations were lowest in both lakes in August.

Nitrite concentrations ranged from 0.004 mg/L to 0.34 mg/L in Ford Lake (n=161) and 0.002 mg/L to 0.055 mg/L in Belleville Lake (n=141), and an average of 0.02 ug/L in both lakes. In general, average nitrite concentrations in both lakes were lowest in April (0.01 mg/L) and increased throughout the summer months.

Conductivity

Specific conductivity data was collected along a depth profile using a Yellow Springs Instrument (YSI) and is reported in uS/cm. Values reported are averages of the depth profile data, across all sites on Ford or Belleville Lake. Throughout the monitoring period, specific conductivity was highest in Ford Lake in July at 828.4 uS/cm and lowest in May at 740.9 uS/cm. Median values were 823 uS/cm and 674 uS/cm, respectively. Average conductivity was also highest in July in Belleville Lake at 809.4 uS/cm (median=810 uS/cm); on average, the lowest conductivity in Belleville Lake was observed in June (726.1 uS/cm, median of 721 uS/cm).

pH

Like conductivity, pH (SU) data was collected along a depth profile using a YSI. Values are reported as averages across the depth profile data, across all sites on Ford or Belleville Lake. Throughout the monitoring period, average monthly pH varied little in either lake. On average, pH ranged from a low of 8.12 in May to a high of 8.26 in April in Ford Lake; in Belleville Lake, average values were lowest in June at 8.09 and highest in April at 8.29.

Temperature Profiles/Dissolved Oxygen

HRWC developed temperature/dissolved oxygen profiles from the data made available in EGLE's 2019 Water Resources Division Staff Report. Values were averaged across the monitoring period (2014, 2016, 2018) by month (April – September) for the deepest EGLE monitoring sites in Ford Lake (F4) and the deepest site in Belleville Lake (B4). The monitoring shows that Ford Lake becomes anoxic during periods throughout the monitoring season, with anoxia occurring most frequently in July and August and largely recovering in September. Belleville Lake goes anoxic sooner in the summer, getting close to 0 mg/L in dissolved oxygen in May and June, achieving full anoxia in July, and then recovering in September.

Figure 2.19. Ford Lake Temperature and Dissolved Oxygen Depth Profiles: Average values from 2014,2016, 2018.

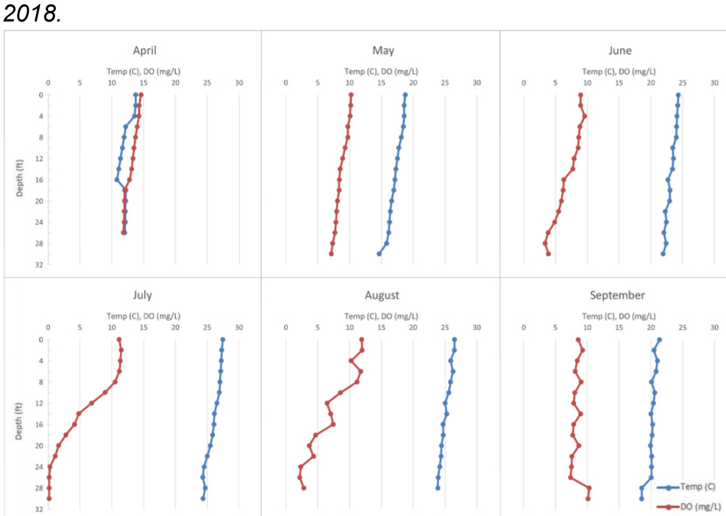
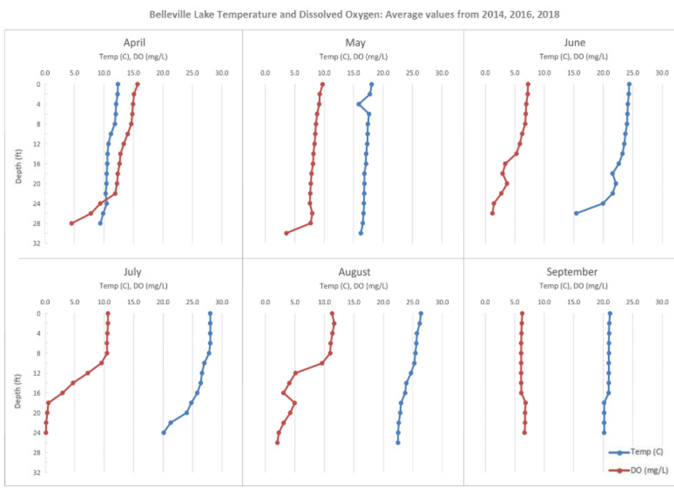


Figure 2.20. Belleville Lake Temperature and Dissolved Oxygen Depth Profiles: Average values from 2014,2016, 2018.



Ypsilanti Township maintains a water monitoring system on Ford Lake and reports dissolved oxygen and temperature at varying depths. Data and contact information are available at https://ytown.org/hydro-dam-station.

Secchi Disk Transparency

Secchi depths are measured by EGLE as part of biannual water quality monitoring conducted on Ford and Belleville Lakes following implementation of the 1995 phosphorus TMDL. In EGLE's 2019 Water Resources Division Staff Report detailing data from the 2014, 2016, and 2018 monitoring season, EGLE reports no noticeable trends in average Secchi disk measurements across the monitoring period for either lake.

Trained volunteers measured Secchi depth on Ford Lake through the Michigan Clean Water Corp's Cooperative Lakes Monitoring Program (CLMP) from May through September 2016. The average Secchi depth reported was 7.2 feet, compared to a historic average of 4.8 feet (May – September 1976 – 1981), also measured through the CLMP.[68]

Chlorophyll-a

Chlorophyll-a was measured by EGLE using a bottle sampler that captured water across the photic zone for a depth integrated analysis followed by lab analysis. In Ford Lake, Chlorophyll-a concentrations ranged from 2.7 to 79 µg/L between 2014-2018, across all sampling sites, with an average concentration of 15.46 ug/L. In Belleville Lake, concentrations ranged from 3.5 to 44.0 ug/L with an average of 16.92 ug/L. Average Chlorophyll-a concentrations were highest in both lakes in the month of August, 25.17 ug/L in Ford Lake and 24.23 ug/L in Belleville, with median values of 16 ug/L and 24.0 ug/L, respectively. Average concentrations were lowest in Ford Lake in April, at 8.41 ug/L with a median value of 8.27 ug/L. Average concentrations were lowest in Belleville Lake in May, at 11.74 ug/L with a median value of 12.0 ug/L.

Trophic Status

In the 2014-2018 EGLE study, EGLE calculated Overall Carlson's Trophic Status Index (TSI) for one site in Ford Lake, F-4, located downstream of the Ford Lake impoundment, and for one site in Belleville Lake, B-4, over the monitoring period from 2014-2018; TSI scores indicate that both Ford and Belleville Lake are eutrophic systems.

2.4.2.10 Additional Water Quality Monitoring on Willow Run

Willow Run is a tributary that flows into Belleville Lake. The creek had been used as a dumping ground for manufacturing since 1941 with most of the hazardous waste poured into the Willow Run Sludge Lagoon, Tyler Pond and Edison Pond. In 1994, a collaboration between multiple shareholders in federal, state and local government; business; and academia came together to create a plan to clean-up the Willow Run Creek Site to avert designation as a US EPA "Superfund" site for hazardous waste. The site was remedied over the course of four years by treating and confining the dried, hazardous sediments to a landfill site according to MDEQ requirements.[69] Willow Creek is scheduled for further work in the near future as the Washtenaw County Water Resources Commissioner intends to remove Tyler and Beyer dams and restore the channel and floodplain (see section 2.1.3.1, Dams and Impoundments).

Willow Run was monitored at Van Buren Park biweekly in 2016 and 2022 by HRWC's Chemistry and Flow Monitoring Program for a wide range of water quality parameters, listed below.

TSS
During the 2016 and 2022 sampling season, HRWC saw TSS concentrations at Willow Run range from 8 mg/l to 337 mg/l. On average, TSS values were around 26 mg/l (s=29) with a median value of 8 mg/l. 22 out of 23 collected samples were below the target TSS concentration of 80 mg/l, indicating low sedimentation during baseflow conditions. However, one TSS sample at 337 mg/l reveals potential high sediment runoff into Belleville Lake during precipitation or high flow events.

Nitrate and Nitrate
Nitrate concentrations across all 24 samples from Willow Run were below the EPA's Maximum Contaminant Level (MCL) of 10 mg/l. Nitrate at Willow Run averaged 0.9 mg/l (s=0.3) and ranged from 0.0 mg/l to 1.4 mg/l. Nitrite concentrations from Willow Run in 2016 and 2022 were also below EPA's MCL of 1 mg/l. 24 nitrite samples averaged 0.01 mg/l (s=0.01) with a median of 0.01 mg/l. Values ranged from 0.0 mg/l to 0.02 mg/l, indicating low nitrate concentrations at Willow Run.

Conductivity
HRWC used handheld YSI multimeters to test conductivity (n=23). On average, conductivity values at Willow Run exceeded the 800 µS threshold used by HRWC. 80 percent of conductivity measurements from Willow Run were above the 800 µS threshold and, as a result, values averaged 942 µS (s=176). Over the two monitoring seasons, conductivity values ranged from 574 µS in April 2022 to 1123 µS in July 2016. The consistently high conductivity values at Willow Run indicate possible pollutant loading into Belleville Lake, potentially from Willow Run Airport or the nearby I-94 highway.

pH
HRWC used handheld YSI multimeters to test pH. pH values at Willow Run averaged 8.2 (s=0.1) and ranged from 8.02 to 8.44, which is within the prescribed range under the Michigan Water Quality Standards for surface waters.

Temperature
Willow Run's water temperature was monitored using a YSI multimeter. HRWC collected 23 temperature measurements that averaged 65.5 degrees Fahrenheit (s=9.1). Surface water temperature at Willow Run across the two monitored seasons ranged from 44.2 degrees Fahrenheit in early April 2016 to 79.5 degrees Fahrenheit in late July 2016.

Dissolved Oxygen
Within Willow Run dissolved oxygen levels appear to be within healthy ranges to support aquatic life. Across all 23 measurements collected by HRWC's Chemistry and Flow Monitoring Program in 2016 and 2022, DO remained above 5 mg/l. DO values averaged 10.0 mg/l (s=1.6) and ranged from 7.1 mg/l in late July 2016 to 13.2 mg/l in early April 2022.

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[43] Arnold, C.L. and C.J. Gibbons, 1996. Impervious surface coverage: the emergence of a key environmental indicator. Journal of the American Planning Association 62(2), pp. 243-258.
[44] Schueler, T., 1994. The Importance of Imperviousness. Watershed Protection Techniques 1(3): 100-111.
[45] Frere, M.H., Ross, J.D., and Lane, L.J. 1980. The nutrient submodel. In: Knisel, W., ed., CREAMS, A Field Scale Model for Chemicals, Runoff and Erosion From Agricultural Management Systems. U.S. Dept. Agric. Cons. Res. Report 26, vol. 1, ch. 4, p. 65-86.
[46] MiEnviro Portal. Accessed June 2024. https://mienviro.michigan.gov/nsite/map/results
[47] Hilsenhoff, William. 1987. "An Improved Biotic Index of Organic Stream Pollution". *The Great Lakes Entomologist*. **20** (1).
[48] Michigan Department of Natural Resources. 2004. Fish Collection System. Water Survey: Huron River 8/15/2001.
[49] Ypsilanti Charter Township Hydro Dam Station, https://ytown.org/hydro-dam-station. Accessed May 2023.
[50] Van Buren Charter Township, Belleville Lake, https://www.vanburen-mi.org/departments/municipal_services/belleville_lake_.php. Accessed April 2023.
[51] Braunscheidel, J. J., Michigan Department of Natural Resources. Ford Lake, Washtenaw County, Fisheries Survey. May 15-19,2006 and June 14, 2006.
[52] Braunscheidel, J. J., Michigan Department of Natural Resources: Status of the Fishery Resource Report. May, 2012. Belleville Lake, Huron River Watershed.
[53] O'Neal, R.P., and G.J. Soulliere. 2006. Conservation guidelines for Michigan lakes and associated natural resources. Michigan Department of Natural Resources, Fisheries Special Report 38, Ann Arbor.
[54] Michigan Clean Water Corps. Score the Shore: Lakeshore Habitat Assessment procedures. https://micorps.net/lake-monitoring/clmp-documents/. Accessed August 2023.
[55] Michigan Department of Environment, Great Lakes, and Energy Water Resources Division. November, 2019. Staff Report, Nutrient Chemistry Survey of Ford and Belleville Lakes, Washtenaw and Wayne Counties, April – September 2014, 2016, 2018.
[56] Lehman, John. 2005. "Mass Balance Study of the Middle Huron River 2003-2004: Highlights of Key Findings to Date Relevant to Middle Huron Partners." http://www.umich.edu/~hrstudy/, April 25, 2005.
[57] Michigan Department of Environment, Great Lakes, and Energy Water Resources Division. July 2019. Staff Report, Michigan Beach Monitoring Year 2018 Annual Report.
[58] Michigan Department of Enivronment, Great Lakes, and Energy Beach Guard Database. https://www.egle.state.mi.us/beach/BeachDetail.aspx?BeachID=291. Accessed April 2023.
[59] Ecology Center Healthy Stuff Lab, Friends of the Rouge, Huron River Watershed Council, 2023. Community-Based Study on PFAS in Fish, testing fish in the Huron River and Rouge River watersheds of Southeast Michigan. https://www.ecocenter.org/our-work/community-based-science/fishing-pfas-rouge-and-huron-rivers. Accessed August 2023.

[60] Barbo, N., Stoiber, T., Naidenko, O.V., Andrews, D.Q. Locally caught freshwater fish across the United States are likely a significant source of exposure to PFOS and other perfluorinated compounds. Environmental Research, Volume 220, 2023, 115165, ISSN 0013-9351, https://doi.org/10.1016/j.envres.2022.115165.

[61] United States Environmental Protection Agency. https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas. Accessed 6/15/23.

[62] Braunscheidel, J. J., Michigan Department of Natural Resources. Ford Lake, Washtenaw County, Fisheries Survey. May 15-19,2006 and June 14, 2006.

[63] MDNR: Fish Collection System. July, 1998. Water Survey: Ford Lake.

[64] MDNR: Fish Collection System. Summer, 2006. Angler Creel Survey: Ford Lake, Washtenaw County

[65] Braunscheidel, J. J., Michigan Department of Natural Resources: Status of the Fishery Resource Report. May, 2012. Belleville Lake, Huron River Watershed.

[66] Midwest Invasive Species Information Network (MISIN). https://www.misin.msu.edu/browse/. Accessed April, 2023.

[67] Michigan Department of Environment, Great Lakes, and Energy Water Resources Division. November, 2019. Staff Report, Nutrient Chemistry Survey of Ford and Belleville Lakes, Washtenaw and Wayne Counties, April – September 2014, 2016, 2018.

[68] Michigan Clean Water Corps Data Exchange. https://micorps.net/about-data-exchange/. Accessed April 2023.

[69] The Willow Run Creek Site Remediation Project. “Success Through Partnership.”

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) comes from synthesis and inference of the results presented in this chapter. It is not meant to be comprehensive of all possible impairments to aquatic systems, but those of concern to this Watershed.

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: Nutrient Loading	
Sources	**Causes**
1. NPDES permitted facilities	Nutrients in effluent
2. Fertilizers from residential, commercial, and golf courses	Mowed stream banks Nutrient control ordinances lacking teeth or too permissive Overuse/improper application of fertilizers
3. Excessive runoff from developed 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
6. Pet and wildlife waste	Wildlife in storm drains Improper disposal of pet waste Artificial ponds and mowed grass increases habitat for waterfowl, wildlife
7. Agricultural runoff	Exposed soils
8. Loss of ecosystem services that attenuate polluted runoff	Conversion of natural areas (natural green infrastructure) to agriculture, housing, transportation, commercial, manufacturing, etc. and “gray,” built infrastructure

Impairment 2: Altered Hydrology	
Sources	**Causes**
1. Loss of riparian vegetation	Conversion of riparian woodlands, wetlands, grasslands, and flood plains to agriculture and development.
2. Runoff from developed areas	Impervious surfaces Removal of woodland/forest, wetlands, and other pervious areas
3. Runoff from construction sites, new development	Removal of woodland/forest, wetlands, and other pervious areas Decentralized development increasing imperviousness Lack of resources for enforcement/inspection Site exemptions Lack of education on alternatives
4. Engineered drains and streams	Loss of connection between stream and floodplain from channelization Loss of storage and infiltration capacity Removal of riparian buffer
5. Impoundment of streams	Dam construction

Impairment 3: Sedimentation, Soil Erosion	
Sources	**Causes**
1. Loss of native vegetation and soils	Conversion of natural area and ecologically developed soil system to agriculture and development.
2. Eroding lakeshores, stream banks, and channels	Flashy flows Channelization Drain maintenance Eroding crossing embankments Clear cutting/lack of riparian buffers Removal of woody debris in shallows of lakes Wave action from wind and boats
3. Construction sites	Clear cutting/lack of riparian buffers Lack of resources for enforcement/inspection Insufficient penalties for noncompliance with ordinances Exposed soils Site exemptions
4. Developed areas	Impervious surfaces Clearcutting/lack of riparian buffers
5. Roads	Poorly designed/maintained road stream crossings Poor road maintenance
6. Sediments in impoundments	Legacy sedimentation, settling, then resuspension Ineffective maintenance of dams
7. Agricultural field runoff	Exposed soils

Impairment 4: Pathogens	
Sources	**Causes**
1. Illicit Discharges	Aging development sanitary sewer infrastructure

Impairment 4: Pathogens	
Sources	**Causes**
4. Pet and wildlife waste	Wildlife in storm drains Improper disposal of pet waste (runoff from paved areas) Ponds and mowed grass increase habitat for waterfowl, wildlife
5. Livestock waste from agricultural operations	Cattle access to stream Runoff from pasture lands

Impairment 5: Salts, Organic Compounds and Heavy Metals	
Sources	**Causes**
1. Legacy pollution	PCBs in numerous water bodies (Table 1.3) PFOS from industrial facilities; fire-fighting foam; Illegal dumping
2. Developed areas	PAH pollution from coal tar driveway sealants Pharmaceuticals/Endocrine Disruptors in the water Waste incineration (atmospheric deposition) Illegal dumping Illicit connections
3. Roads	Auto emissions Poor road maintenance
4. NPDES permitted facilities	Inadequate inspection
5. Turfgrass chemicals from residential, commercial lawns	Improper lawn care Illegal disposal
6. Agricultural runoff	Rain Runoff

Impairment 6: High Water Temperature	
Sources	**Causes**
1. Loss of upland and riparian native vegetation and soils	Conversion of natural areas and soils to development and agriculture
2. Directly connected impervious areas	Heated stormwater from urban areas Lack of groundwater recharge
3. Eroded soil areas	Soil erosion from channel and upland
4. Solar heating	Lack of vegetated canopy in riparian zone Impounded waters

Impairment 7: Debris/Litter	
Sources	**Causes**
1. Roadways, parks, urban areas, residential areas	Illegal littering/dumping Unsecured garbage containers and vehicles 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" contribute a disproportionately large amount of pollutants of concern to the identified water quality problems.

2.5.2.1 Phosphorus Critical Areas

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 (Appendix D). This revised version lowered the phosphorus concentration target to 30 µg/L in Ford Lake, while keeping the Belleville Lake target at 30 µg/L. It also established annual loading targets rather than seasonal targets.

According to EGLE, meeting the goals of the TMDL should result in the attainment of the Other Indigenous Aquatic Life and Wildlife designated use for Ford and Belleville Lakes, by 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 other sections of the watershed, and the remainder (57%) was from nonpoint sources. Most of the load contributed from this watershed comes from these nonpoint sources. According to the EGLE model, agriculture makes up 44% of the nonpoint sources. Of the three middle Huron watersheds, the upper watershed (Section 1) has the largest agricultural area and the greatest percent of cover.

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 (one or multiple decades).

The revised TMDL sets annual and daily load targets for Ford Lake and Belleville Lake (Table 2.10). 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. Since the lake concentrations are very slow to change, it is likely that it will require decades of low loading, in addition to active lake management, to reduce in-lake phosphorus concentrations.

2.5.2.2 Bacteria Impairments

The latest TMDL for the Watershed is Michigan's statewide TMDL for bacteria (Appendix F), which was approved by the U.S. EPA on July 29, 2019, and there was an addendum released in 2022.[68] The data show that both Snidecar Drain and the Huron River in AUID 040900050403 (Figure 1.2, Table 1.2) exceeded the 30-Day Standard and are non-attaining for full body contact. Snidecar Drain is also impaired for partial body contact. No implementation plan has yet been developed by affected stakeholders.

To remove the reaches 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 is used.

Van Buren Township Park on Belleville Lake has been monitored consistently for *E. coli* since 2005. Between 2005 and 2018, the public park beach has been closed due to high bacteria levels 13 times, for a total of 111 days. According to current data available by EGLE's Beach Guard database, the most recent closure on September 5th, 2018 lasted 26 days, the longest closure since July of 2008.[69] On September 4th, *E. coli* counts at Van Buren Township Park Beach were 481 *E. coli* per 100mL of water, exceeding the maximum state WQS of 300 *E. coli* / 100mL.

A study of what could be done at Van Buren Township Park to improve *E. Coli* conditions would be valuable and is recommended.

2.5.2.3 Fish Consumption Advisory on the Huron River: Perflurooctane Sulfonate (PFOS) Impairment

The Huron River from North Wixom Road in Milford to I-275 near New Boston currently fails to meet the Fish Consumption designated use in the 2022 EGLE Integrated Report, including the Huron River section contained in the Watershed of this Management Plan. According to the Integrated Report, "A water body is considered to not support the fish consumption designated use if either the MDHHS has issued a site-specific fish consumption advisory for that water body or ambient water column concentrations exceed WQS (water quality standard)."

In August 2018, EGLE reported high levels of polyfluoroalkyl substances (PFOS, a family of synthetic chemicals) were found in dangerous concentrations in the tissues of fish from Kent Lake. Further testing revealed high levels in numerous places in the Huron and the Michigan Department of Health and Human Services issued a "Do Not Eat Fish" advisory for the length of the Huron River as noted previously. Groundwater and surface water testing was conducted.

In 2019, surface water samples collected by EGLE from Willow Run Creek indicated elevates levels of numerous PFAS compounds, including PFOS (92 ppt), PFOA (6 ppt), and other now-regulated chemicals. Numerous other PFAS compounds that are unregulated but possibly toxic have been detected. Currently, Willow Run is one of the highest sources of PFAS to the main stem of the Huron River by concentration. The RACER Willow Run is listed as an MPART PFAS site. Remediation activities are currently managed through the RACER Trust. Since 1980, the Site has been regulated as a facility under the Resource Conservation and Recovery Act (RCRA). The area of greatest concentration is not open to the public and is not a major direct contact concern.

EGLE's work on PFAS in the Huron River Watershed and the entire state is ongoing and rapidly changing. Up to date information can most reliably be found on the Michigan PFAS Action Response Team website, https://www.michigan.gov/pfasresponse/.

Legacy pollution issues are complicated and expensive. Ongoing operations that release PFOS to the environment can be fixed, such as the first high source of PFOS found in the Huron Watershed from an industrial facility in Wixom, which was able to drastically reduce their input. Yet contaminated groundwater poses a high challenge for cleanup and it is not clear when PFOS levels in the Huron will fall enough for the "Do Not Eat" fish advisory to be lifted. This could be an issue that persists for decades to come. In any case, in terms of needed next steps, further water monitoring is needed to discover new sources of PFOS and to expand testing of PFOS in fish fillets to better understand how the bioaccumulation in fish population changes over time.

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[68] Michigan Department of Environment, Great Lakes, and Energy. 2022. Statewide E. coli Total Maximum Daily Load (TMDL) Addendum – 2022. https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/SWAS/TMDL-Ecoli/statewide-ecoli-tmdl-2022-addendum.pdf. Accessed August 2023

[69] Michigan Department of Environment, Great Lakes, and Energy Beach Guard Database. https://www.egle.state.mi.us/beach/BeachDetail.aspx?BeachID=291. Accessed April 2023.

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.[2] 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.[3] 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)[4] 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.[5] [6] [7] [8] [9]

3.2.1 Regional Climate Summary

- The average air temperature across southeast Michigan increased by 2.8°F from 1952 through 2022.
- 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 southeast Michigan increased by 19.69% from 1952 through 2022 and in Ann Arbor, increased by 48% from 1951 through 2021, 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.[10]
- 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). [11]

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.[12] [13] [14]

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 2.8°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 2021, 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.[15]

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.[16] [17]

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.[18]

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 48% (14.5”) from 1951 through 2021. An increase in precipitation was observed in all four seasons, with the winter seeing the greatest percentage increase of 65.3% (3.8”). 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 the end of century suggests such precipitation events will most likely be in the form of rainfall.[19]

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 the 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. The drought conditions of 2021, along with the extreme rain events of June 25th-26th, are a prescient example of the types of weather conditions that will become more likely in the future.

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 occur 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 year 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 which humans fail to substantially reduce global carbon emissions by 2050.[20]

3.2.3.5 Increased Meteorological Variability

Emerging research indicates that climate change is increasing variability in weather patterns around the globe and within the Great Lakes region. While averages in temperature and precipitation have changed over time, extreme events have, by many metrics become more extreme and more frequent at rates outpacing changes in averages.[21] For the Great Lakes region and the watershed, the practical implication is to plan for more powerful storms with greater potential for interceding dry periods, as explained above, along with greater intraseasonal variability.

An anecdotal example of such conditions occurred in the summer of 2021. The watershed experienced a rapid swing in conditions from moderate drought in June to above-normal water levels overnight during a major downpour. Two later storms resulted in 3-4 inches of rain within 12- to 24-hours each. Following NOAA Atlas-14 precipitation frequency estimates, the watershed therefore experienced at least three “50-year storms” over three months.

3.2.3.6 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.[22] [23] 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.[24] 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.[25]

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.

The IPCC Sixth Assessment Working Group 3 Report: Mitigation of Climate Change synthesized and reiterated the need for natural areas protection, for environmental and water quality, but also for the purpose of carbon emissions reduction. Globally, land protection is second only to solar power in its potential to reduce carbon emissions. There are therefore both local and global imperatives to take action to protect natural ecosystems throughout the Huron River watershed. Southeast Michigan wetlands may be of particular value, with high capacity to sequester carbon from the atmosphere, filter toxins from the air and water, while reducing flood risks and erosion.[26]

3.3.1 Effects on Forests

Changing temperatures may change the distribution of trees and plants as well as their growing season.[27] [28] [29]

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.[30] 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.[31] 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.[32]

3.3.1.1 Increased Stressors on Forests

Changes in climate will allow nonnative, invasive plants, insects, and pathogens to expand their ranges.[33] [34] [35] 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.[36]. Increased spring precipitation has been favorable to bur oak blight in Iowa and some parts of Illinois.[37] Forest pests and pathogens also disproportionately stressed ecosystems.[38] [39]

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. [40] [41] 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.[42] 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.[30]

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.[43]

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.[44] 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.[44]

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.[45]

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.[46] [47] [48]

3.3.2.2 Effects 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.[49] [50]

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.[51]

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.[52]

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.[53] 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.[54]

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.

3.3.4.1 Related to Agricultural Landscapes

Riparian zones in agriculture areas such as those in the Upper Middle Huron are especially vulnerable to erosion due to climate change without improvements in management practice.

Soil erosion by water is one of the major environmental threats to sustainable crop production.[55] [56] It also adversely affects drainage networks, water quality, and recreation.[57] [58] Increasing heavy precipitation frequency and magnitude increases soil erosion and the sediment transport capacity of surface runoff from agricultural lands, which could increase total soil erosion and sedimentation into the Huron River and its tributaries.[59] Therefore, increasing soil erosion rates will not only reduce agricultural productivity, but will also accelerate the loss of carbon stocks and stored soil nutrients.[60] In turn, this diminishes the cohesiveness of soil, creating a positive feedback for greater erosion.[61]

The proportion of U.S. land area that experienced extreme precipitation remained steady until the 1980s but increased rapidly since then.[62] In the coming century, this expansion is expected to continue to increase. Because much of the historical change has occurred within the lifetimes of active farmers and growers, it is common that practices learned during or before the 1980s are still being applied to areas now at much higher risk of erosion. Conservation strategies that are still being implemented to reduce erosion and increase carbon sequestration often use obsolete estimates of expected conditions. Strategies should be improved by considering current and projected future climate extremes and changing local factors. In the Huron River watershed, this warrants greater collaboration and awareness-building among farmers, scientists regulators, and conservation organizations. Additional protective measures will be needed to safeguard progress that has been made to reduce erosion and water quality degradation.[63]

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 Watershed area are extensively subsurface drained areas and these drains could carry nitrate from saturated soil conditions and heavy precipitation events, conditions expected to become more likely in the future.[64]

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. [65]

The heavy rain event of June 26th, 2021 provided an example of the heavy rain on dry soils scenario. Multiple observational stations throughout the watershed recorded 4 to 6 inches of precipitation in 24 hours, with some stations recording the majority of that rainfall within a 3-hour period. Depending on the specific station precipitation total and the duration considered, the precipitation event was a 100- to 1000-year storm.[66] But at least two other similar magnitude rain events have been observed in southeast Michigan since 2014, indicating the past recurrence intervals, which do not account for future climate change projections, are now extremely likely to underrepresent the actual annual recurrence probability of these heavy storms. This rain event followed months of moderate drought conditions as described by the National Integrated Drought Monitoring System.[67] Rapid sediment transport was observed in many locations along creeks through agricultural areas in the Huron and neighboring watersheds. Turbidity in the Huron River was observed to be very high for at least 72 hours following the rain event, with Mill Creek contributing a significant sediment plume to the main stem of the Huron. Casual observations made by recreators in the river corridor reported significant woody debris and sediment buildup, creating safety hazards for paddlers. In addition to triggering advisories for paddlers to avoid the river during high flow, several paddlers reported avoiding the river due to its opaque appearance. These conditions following heavy rain on dry events are likely to continue to increase in frequency in the future. Effects in the Upper Middle Huron observed during this event, such as runoff loads, erosion, and sediment transport, provide a qualitative indication of vulnerabilities likely to become substantially more severe.

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 that were previously inhospitable to them.[68]

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.[69]

3.3.5.5 Harmful Algal Blooms

Globally, climate change is driving increases in magnitude, duration, number of affected waterbodies, and health risks of harmful algal blooms.[70] Unless additional conservation actions are taken, the growing frequency and severity of intense spring rainstorms 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. Prolonged warm periods during the summer, and reduced ice formation over lakes, allows lake temperatures to stratify earlier in the summer season, reducing vertical mixing in the water column.

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.[71] [72]

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.[73]

While Huron River watershed drinking water sources are not particularly vulnerable to HABs (only Ann Arbor draws its 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.[74]
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 be more likely on sections of the Huron River in the future.[75]

Ford Lake and Belleville Lake are commonly afflicted by algal blooms and harmful algal blooms. Both lakes are artificial, created by dams that have trapped phosphorus in the sediment for decades. Both lakes are located below the majority of agricultural activity and nutrient loading in the Huron River. Both lakes have seen prolonged summer warming periods with decreasing winter ice cover, conditions that can lead to increased likelihood of algal blooms. While there is no local action to reduce the incidence of water temperatures, runoff can be reduced through natural areas protection, and GSI implementation, limiting nutrient loading to the lakes and, in turn, limiting a key factor in the seasonal development of algal blooms.

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.[76]

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.[77] The Middle Huron Watershed includes many urbanized areas that have a significant number of intersections 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. In 2011, as construction just ended on an equalization basin meant to contain a 25-year storm event, the area was hit with a 100-year storm that flooded the new basin out. Staff were forced to bypass treatment units to relieve the hydraulic loading, releasing wastewater effluent that did not go through tertiary treatment to Mill Creek. Staff have learned to watch weather reports and anticipate operations in advance of storms to prevent failure from happening again. In Dexter, projects done to repair manholes and sewer lines have been effective in stopping storm surges from infiltrating the wastewater system.

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.[78] 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

The dam failures along the Tittabawassee River in May, 2020 have brought renewed attention to dam safety. 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, making precise planning for dynamic conditions extremely challenging. 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.

Peninsular Paper Dam (Pen Dam) in Ypsilanti is of particular concern and HRWC is actively supporting the City of Ypsilanti to remove the dam. Pen Dam is a high-hazard dam since loss of life is probable following catastrophic failure. In 2022, EGLE downgraded the condition of the dam from “fair” to “low,” underscoring the urgency to remove the dam. Planning and assessment efforts to remove the dam are well underway with an anticipated removal of the dam in 2025. Impoundment restoration activities will run concurrently to dewatering of the impoundment and demolition of the dam and will continue for several years after the removal of the spillway.

As of 2023, the operators of French Landing Dam are working with Van Buren Township officials to relicense the dam for hydropower generation through the Federal Energy Regulatory Commission (FERC). The relicensing procedure is comprehensive and has revealed several opportunities to improve safety for recreation and flow management near French Landing Dam. In particular, the portage around this dam is considered the most dangerous along the entire Huron River Water Trail. The entire portage trail is subject to routine vandalism, and the downstream portage launch is a narrow set of wooden steps anchored to a concrete retaining wall. Given the position and dimension of the portage, along with flow management of the dam, it’s common for the wooden steps to be suspended several feet from sure footing for launching small watercraft. All options should be considered for improving, fortifying, or relocating the portage access points, as climate change will likely make flows even less predictable and more dangerous to people accessing the portage.

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 are 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.

HRWC's Natural Areas Assessment Program has mapped the remaining natural areas in the watershed and ranked them by a host of ecological criteria, as described in Chapter 2.1.3.2. Figure 2.6 provides a good guide to determining the most important areas of natural green infrastructure to protect. Another set of data to consider comes from The Nature Conservancy, and it maps, on a national scale, natural areas that provide resilience to climate change. A "Resilient" area is a place buffered from climate change because it contains many connected micro-climate that create different climate options for species in which to seek refuge from extreme weather changes. "Climate corridors" are narrow conduits in which movements of plants and animals becomes highly concentrated. A "Climate Flow Zone" is like a corridor but less concentrated. Areas with "Confirmed Diversity" contain known locations of rare species or unique communities based on ground inventory.[79]

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.[80]

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 to 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.[81]

3.4.3 Dam Operator Communication and Dam Management

French Landing Dam (Belleville Lake Dam) has created concerns for public safety and flow management. On numerous occasions since 2020, unexpected releases from French Landing Dam have noticeably lowered water levels on Belleville Lake and caused flooding downstream. Some minor private infrastructure, like private docks, tables, and signage, has been washed downstream following these events. In at least one case, the release was linked to a need to avoid complications within the dam, but communication to the Metroparks, state officials, and HRWC was limited, interfering with the ability of community partners to communicate what was happening and why. Improved communication from dam operators to municipal officials, regulatory officials, community partners remain a central need of watershed management in this area.

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 greater insurance coverage 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 of 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.[82] As a part of this group, the operators of Ford Lake Dam, owned by Ypsilanti Township, have been especially communicative and serve as an instrumental example for other dam operators on the river.

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.[83] The summer climate of Michigan will likely hit and subsequently pass what most people feel are optimal summer temperatures.[84] In combination with abundant recreational waters, the Great Lakes region is predicted to remain attractive for tourism, residence, and business where 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.[85] 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.[86]

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 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 Fifth National Climate Assessment is currently in development. Private consultation with key authors of several draft chapters indicate the findings of the Fifth Assessment will reaffirm the findings of the Fourth Assessment that are relevant to local watershed management planning.

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

The Sixth Assessment Report from the United Nations Intergovernmental Panel on Climate Change was completed through 2021 and 2022. The Working Group I contribution to the Sixth Assessment Report, *Climate Change 2021: The Physical Science Basis* was released on 9 August 2021. The Working Group II contribution, *Climate Change 2022: Impacts, Adaptation and Vulnerability* was released on 28 February 2022. The Working Group III contribution, *Climate Change 2022: Mitigation of Climate Change* was released on 4 April 2022. Taken together, these three reports provide a comprehensive summary of the state of climate science and potential solutions. The reports focus on global analyses and global perspective but also inform actionable goals for local and statewide jurisdictions. https://www.ipcc.ch/assessment-report/ar6/

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1 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

2 Baule, W. et al. Synthesis of the Third National Climate Assessment for the Great Lakes Region. 2015. Great Lakes Integrated Sciences and Assessments. Michigan State University and University of Michigan, East Lansing, MI and Ann Arbor, MI, USA. https://glisa.umich.edu/media/files/Great_Lakes_NCA_Synthesis.pdf

3 Waters, C.N. et al., 2016: The Anthropocene is functionally and stratigraphically distinct from the Holocene. Science, 351(6269), aad2622–aad2622, doi:10.1126/science.aad2622.

4 Vose, Russell S.; Applequist, Scott; Squires, Mike; Durre, Imke; Menne, Matthew J.; Williams, Claude N., Jr.; Fenimore, Chris; Gleason, Karin; Arndt, Derek (2017): NOAA's Gridded Climate Divisional Dataset (CLIMDIV). Michigan Climate Division 10: Southeast Lower Michigan. NOAA National Centers for Environmental information. doi:10.7289/V5M32STR Data provided by the Great Lakes Integrated Sciences and Assessments center, 2019.

5 Hayhoe, K., D.J. Wuebbles, D.R. Easterling, D.W. Fahey, S. Doherty, J. Kossin, W. Sweet, R. Vose, and M. Wehner, 2018: Our Changing Climate. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 72–144. doi: 10.7930/NCA4.2018.CH2

[6] Data and climate summaries compiled by the Great Lakes Integrated Science and Assessment team at the University of Michigan in 2019. https://glisa.umich.edu

[7] Dynamical Downscaling for the Midwest and Great Lakes Basin." Future projections are based on the dynamically downscaled data set for the Great Lakes region developed by experts at the University of Wisconsin-Madison. There are a total of six downscaled models that represent how a variety of different variables are projected to change (mid-century, 2040-2059, compared to the recent past, 1980-1999). The ranges are comprised of the lowest and highest values from all six dynamically downscaled data sets. The regional data are available for download at: http://nelson.wisc.edu/ccr/resources/dynamical-downscaling/index.php.

[8] Winkler, J.A., Andresen, J.A., Hatfield, J.L., Bidwell, D., & Brown, D. (Eds.). (2014). Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment. Washington, DC: Island Press

[9] Frankson, R., K. Kunkel, S. Champion, and J. Runkle, 2017: Michigan State Climate Summary. NOAA Technical Report NESDIS 149-MI, 4 pp.

[10] Hayhoe, K., D.J. Wuebbles, D.R. Easterling, D.W. Fahey, S. Doherty, J. Kossin, W. Sweet, R. Vose, and M. Wehner, 2018: Our Changing Climate. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 72–144. doi: 10.7930/NCA4.2018.CH2

[11] Data and climate summaries compiled by the Great Lakes Integrated Science and Assessment team at the University of Michigan in 2019. https://glisa.umich.edu

[12] National Oceanic and Atmospheric Administration National Centers for Environmental Information Global Historical Climatology Network Station Observations (GHCN). More information about this station located in Ann Arbor, MI from 1981-2010 is available at: https://glisa.umich.edu/station/c00200230

[13] Under the World Climate Research Programme (WCRP) the Working Group on Coupled Modelling (WGCM) established the Coupled Model Intercomparison Project (CMIP) as a standard experimental protocol for studying the output of coupled atmosphere-ocean general circulation models (AOGCMs). CMIP provides a community-based infrastructure in support of climate model diagnosis, validation, intercomparison, documentation and data access. This framework enables a diverse community of scientists to analyze GCMs in a systematic fashion, a process which serves to facilitate model improvement. Virtually the entire international climate modeling community has participated in this project since its inception in 1995. The Program for Climate Model Diagnosis and Intercomparison (PCMDI) archives much of the CMIP data and provides other support for CMIP. PCMDI's CMIP effort is funded by the Regional and Global Climate Modeling (RGCM) Program of the Climate and Environmental Sciences Division of the U.S. Department of Energy's Office of Science, Biological and Environmental Research (BER) program.

[14] Dynamical Downscaling for the Midwest and Great Lakes Basin." Future projections are based on the dynamically downscaled data set for the Great Lakes region developed by experts at the University of Wisconsin-Madison. There are a total of six downscaled models that represent how a variety of different variables are projected to change (mid-century, 2040-2059, compared to the recent past, 1980-1999). The ranges are comprised of the lowest and highest values from all six dynamically downscaled data sets. The regional data are available for download at: http://nelson.wisc.edu/ccr/resources/dynamical-downscaling/index.php.

[15] Data and climate summaries compiled by the Great Lakes Integrated Science and Assessment team at the University of Michigan in 2019. https://glisa.umich.edu

[16] Data and climate summaries compiled by the Great Lakes Integrated Science and Assessment team at the University of Michigan in 2019. https://glisa.umich.edu

[17] National Oceanic and Atmospheric Administration (NOAA) ThreadEx Long-Term Station Extremes for America". ThreadEx is a data set of extreme daily temperature and precipitation values for 270 locations in the United States. For each day of the year at each station, ThreadEx provides the top 3 record high and low daily maximum temperatures, the top 3 record high and low daily minimum temperatures, the top 3 daily precipitation totals, along with the years the records were set for the date (NCAR, 2013). ThreadEx data for the Detroit area from 1966 to 2016: http://threadex.rcc-acis.org/

[18] Data and climate summaries compiled by the Great Lakes Integrated Science and Assessment team at the University of Michigan in 2019. https://glisa.umich.edu

[19] Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, B. DeAngelo, S. Doherty, K. Hayhoe, R. Horton, J.P. Kossin, P.C. Taylor, A.M. Waple, and C.P. Weaver, 2017: Executive summary. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, doi: 10.7930/J0DJ5CTG.

[20] Kirchmeier-Young and Zhang. 2020. Human influence has intensified extreme precipitation in North America. Proceedings of the National Academy of Sciences Jun 2020, 117 (24) 13308-13313; DOI: 10.1073/pnas.1921628117

[21] Walter A. Robinson (2021) Climate change and extreme weather: A review focusing on the continental United States, Journal of the Air & Waste Management Association, 71:10, 1186-1209, DOI: 10.1080/10962247.2021.1942319

[22] National Oceanic and Atmospheric Administration Hydrometeorological Design Studies Center Atlas 14 Precipitation Frequency Estimates. Data available at: hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

[23] F. Huff and J. Angel 1992. "Rainfall Frequency Atlas of Midwest." Midwestern Climate Center and Illinois State Water Survey. NOAA National Weather Service. Champaign, Illinois. https://www.isws.illinois.edu/pubdoc/B/ISWSB-71.pdf

[24] Shuang-Ye Wu (March 14th 2012). Projecting Changes in Extreme Precipitation in the Midwestern United States Using North American Regional Climate Change Assessment Program (NARCCAP) Regional Climate Models, Greenhouse Gases - Emission, Measurement and Management, Guoxiang Liu, IntechOpen, DOI: 10.5772/32667.

[25] Wu, S. Changing characteristics of precipitation for the contiguous United States. Climatic Change 132, 677–692 (2015). https://doi.org/10.1007/s10584-015-1453-8

[26] Grubb, M., C. Okereke, J. Arima, V. Bosetti, Y. Chen, J. Edmonds, S. Gupta, A. Köberle, S. Kverndokk, A. Malik, L. Sulistiawati, 2022: Introduction and Framing. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.003

[27] Handler, S. et al. 2014. Michigan forest ecosystem vulnerability assessment and synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-129. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 229 p.

[28] Schwartz, M.D., R. Ahas, and A. Aasa. 2006. Onset of spring starting earlier across the Northern Hemisphere. Glob. Chang. Biol. 12:343–351.

[29] Schwartz, M.D., T.R. Ault, and J.L. Betancourt. 2013. Spring onset variations and trends in the continental United States: Past and regional assessment using temperature-based indices. Int. J. Climatol. 33:2917–2922.

[30] USGCRP (2014) Pryor, S. C., D. Scavia, C. Downer, M. Gaden, L. Iverson, R. Nordstrom, J. Patz, and G. P. Robertson, 2014: Ch. 18: Midwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 418-440.

[31] Angel, J., C. Swanston, B.M. Boustead, K.C. Conlon, K.R. Hall, J.L. Jorns, K.E. Kunkel, M.C. Lemos, B. Lofgren, T.A. Ontl, J. Posey, K. Stone, G. Takle, and D. Todey, 2018: Midwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 872–940. doi: 10.7930/NCA4.2018.CH21

[32] (2014) Pryor, S. C., D. Scavia, C. Downer, M. Gaden, L. Iverson, R. Nordstrom, J. Patz, and G. P. Robertson, 2014: Ch. 18: Midwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 418-440.

[33] Dukes JS, Pontius J, Orwig D et al (2009) Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: what can we predict? Can J For Res 39:231–248

[34] Ryan MG, Vose JM (2012) Effects of climatic variability and change. In: Vose JM, Peterson DL, Patel-Weynand

T (eds) Effects of climatic variability and change on forest ecosystems: a comprehensive science synthesis for the U.S. forest sector. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, pp 7–95

[35] Weed AS, Ayres MP, Hicke JA (2013) Consequences of climate change for biotic disturbances in North American forests. Ecol Monogr 83:441–470

[36] Rustad L, Campbell J, Dukes JS, Huntington T, Fallon Lambert K, Mohan J, Rodenhouse N (2012) Changing climate,changing forests:the impacts of climate change on forests of the northeastern United States and easternCanada.U.S.
Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, p 48

[37] Harrington TC, McNew D, Yun HY (2017) Bur oak blight, a new disease on Quercus macrocarpa caused by
Tubakia iowensis sp. nov. Mycologia 104(1):79–92

[38] Sturrock R, Frankel S, Brown A et al (2011) Climate change and forest diseases. Plant Pathol 60:133–149

[39] Weed AS, Ayres MP, Hicke JA (2013) Consequences of climate change for biotic disturbances in North American forests. Ecol Monogr 83:441–470

[40] Ryan MG, Vose JM (2012) Effects of climatic variability and change. In: Vose JM, Peterson DL, Patel-Weynand
T (eds) Effects of climatic variability and change on forest ecosystems: a comprehensive science synthesis
for the U.S. forest sector. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, pp 7–95

[41] Hellmann JJ, Byers JE, Bierwagen BG, Dukes JS (2008) Five potential consequences of climate change for invasive species. Conserv Biol 22:534–543

[42] Brandt L, He H, Iverson L, et al. (2014) Central Hardwoods ecosystem vulnerability assessment and synthesis: a report from the Central Hardwoods Climate Change Response Framework project. U.S. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, p. 254

[43] Winkler, J.A., Andresen, J.A., Hatfield, J.L., Bidwell, D., & Brown, D. (Eds.). (2014). Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment. Washington, DC: Island Press

[44] National Audubon Society. 2009. Northward shifts in the abundance of North American birds in early winter: A response to warmer winter temperatures?

[45] La Sorte, F.A., and F.R. Thompson III. 2007. Poleward shifts in winter ranges of North American birds. Ecology 88(7):1803–1812.

[46] Krosby M, Theobald DM, Norheim R, McRae BH (2018) Identifying riparian climate corridors to inform climate adaptation planning. PLoS ONE 13(11): e0205156. https://doi.org/10.1371/journal.pone.0205156

[47] McGuire J L, Lawler J J, McRae B H, Nunez T A and Theobald D M ~ 2016 Achieving climate connectivity in a fragmented landscape PNAS 113 7195–200

[48] Keeley, A., et al. 2018. New concepts, models, and assessments of climate-wise connectivity Environmental Research Lette 13 073002

[49] Wisconsin Initiative on Climate Change Impacts first report, Wisconsin's Changing Climate: Impacts and Adaptation, 2011

[50] Steen, P.J., Wiley, M.J. and Schaeffer, J.S. (2010), Predicting Future Changes in Muskegon River Watershed Game Fish Distributions under Future Land Cover Alteration and Climate Change Scenarios. Transactions of the American Fisheries Society, 139: 396-412. doi:10.1577/T09-007.1

[51] Alissa M. Ganser, Teresa J. Newton, and Roger J. Haro, "The effects of elevated water temperature on native juvenile mussels: implications for climate change," Freshwater Science 32, no. 4 (December 2013): 1168-1177.

[52] Huron River Watershed Council. 2013. Climate Resilient Communities: Improving information access and communication among dam operations of the Huron River main stem. https://www.hrwc.org/wp-content/uploads/2013/03/Instream%20Flows.pdf

[53] Hayhoe, K., D.J. Wuebbles, D.R. Easterling, D.W. Fahey, S. Doherty, J. Kossin, W. Sweet, R. Vose, and M. Wehner, 2018: Our Changing Climate. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 72–144. doi: 10.7930/NCA4.2018.CH2

[54] Morelli, T., and Cartwright, J., 2018, Vernal pool threats: How might climate change alter vernal pool management considerations? Presented at Of Pools and People: Translating Vernal Pool Research into Desired Management Outcomes, Ashland, MA, October 25 2018. Supplemental maps of climate-change projections relevant to vernal pool hydroperiods.

[55] Pimentel, D., and M. Burgess, 2013: Soil erosion threatens food production. Agriculture, 3 (3), 443–463. doi:10.3390/agriculture3030443

[56] Lal, R., and B. A. Stewart, Eds., 1990: Soil Degradation. Springer, New York, 345 pp. doi:10.1007/978-1-4612-3322-0

[57] Sharpley, A., 2016: Managing agricultural phosphorus to minimize water quality impacts. Scientia Agricola, 73, 1–8. doi:10.1590/0103-9016-2015-0107

[58] Issaka, S., and M. A. Ashraf, 2017: Impact of soil erosion and degradation on water quality: A review. Geology, Ecology, and Landscapes, 1 (1), 1–11. doi:10.1080/24749508.2017.1301053
[59] Yasarer, L. M. W., and B. S. M. Sturm, 2016: Potential impacts of climate change on reservoir services and management approaches. Lake and Reservoir Management, 32 (1), 13–26. doi:10.1080/10402381.2015.1107665
[60] USGCRP, 2018: Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report. U.S. Global Change Research Program, Washington, DC, 877 pp.
[61] Gowda, P., J.L. Steiner, C. Olson, M. Boggess, T. Farrigan, and M.A. Grusak, 2018: Agriculture and Rural Communities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 391–437. doi: 10.7930/NCA4.2018.CH10
[62] EPA, 2016: Climate Change Indicators: Heavy Precipitation. U.S. Environmental Protection Agency (EPA)
[63] Maresch, W., M. R. Walbridge, and D. Kugler, 2008: Enhancing conservation on agricultural landscapes: A new direction for the Conservation Effects Assessment Project. Journal of Soil and Water Conservation, 63 (6), 198A–203A. doi:10.2489/jswc.63.6.198A
[64] Hatfield, J.L., L.D. McMullen, and C.S. Jones. 2009. Nitrate-nitrogen patterns in the Raccoon River Basin related to agricultural practices. J. Soil Water Cons. 64:190-199
[65] Nearing, Mark & Jetten, V.G. & Baffaut, Claire & Cerdan, Olivier & Couturier, Alain & Hernandez, Mariano & Le Bissonnais, Yves & Nichols, Mary & Nunes, J.P. & Renschler, Chris & Souchère, Véronique & Oost, Kristof. (2005). Modeling Response of Soil Erosion and Runoff to Changes in Precipitation and Cover. Catena. 131-154. 10.1016/j.catena.2005.03.007.
[66] National Oceanic and Atmospheric Administration Hydrometeorological Design Studies Center Atlas 14 Precipitation Frequency Estimates. Data available at: hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html
[67] National Integrated Drought Information System. Current conditions. https://www.drought.gov/current-conditions. Accessed June 2021.
[68] Smith, K.R., A.Woodward, D. Campbell-Lendrum, D.D. Chadee, Y. Honda, Q. Liu, J.M. Olwoch, B. Revich, and R. Sauerborn, 2014: Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel,A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 709-754.
[69] Cameron, L., A. Ferguson, R. Walker, D. Brown, & L. Briley, 2015: Climate and health adaptation profile report: Building resilience against climate effects on Michigan's health. Accessed at: www.michigan.gov/climateandhealth.
[70] Ho, J.C., Michalak, A.M. & Pahlevan, N.: Widespread global increase in intense lake phytoplankton blooms since the 1980s. Nature 574, 667–670 (2019) doi:10.1038/s41586-019-1648-7
[71] Michalak, A.M., E. Anderson, D. Beletsky, S. Boland, N.S. Bosch, T.B. Bridgeman, J.D. Chaffin, K.H. Cho, R. Confesor, I. DaloÄŸlu, J. DePinto, M.A. Evans, G.L. Fahnenstiel, L. He, J.C. Ho, L. Jenkins, T. Johengen, K.C. Kuo, E. Laporte, X. Liu, M. McWilliams, M.R. Moore, D.J. Posselt, R.P. Richards, D. Scavia, A.L. Steiner, E. Verhamme8, D.M. Wright, M.A. ZagorskiÂ 2013 Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions. Proc. Nat. Acad. Sci. 110 (16) 6448-6452
[72] Watson SB, Miller C, Arhonditsis G, et al. The re-eutrophication of Lake Erie: Harmful algal blooms and hypoxia. Harmful Algae. 2016;56:44-66. doi:10.1016/j.hal.2016.04.010
[73] Michalak, A.M., E. Anderson, D. Beletsky, S. Boland, N.S. Bosch, T.B. Bridgeman, J.D. Chaffin, K.H. Cho, R. Confesor, I. DaloÄŸlu, J. DePinto, M.A. Evans, G.L. Fahnenstiel, L. He, J.C. Ho, L. Jenkins, T. Johengen, K.C. Kuo, E. Laporte, X. Liu, M. McWilliams, M.R. Moore, D.J. Posselt, R.P. Richards, D. Scavia, A.L. Steiner, E. Verhamme8, D.M. Wright, M.A. ZagorskiÂ 2013 Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions. Proc. Nat. Acad. Sci. 110 (16) 6448-6452
[74] Watson SB, Miller C, Arhonditsis G, et al. The re-eutrophication of Lake Erie: Harmful algal blooms and hypoxia. Harmful Algae. 2016;56:44-66. doi:10.1016/j.hal.2016.04.010
[75] EPA, 2016. Climate Change and Harmful Algal Blooms. https://www.epa.gov/nutrientpollution/climate-change-and-harmful-algal-blooms

[76] Huron River Watershed Council. 2013. Climate Resilient Communities: Improving information access and communication among dam operations of the Huron River main stem. https://www.hrwc.org/wp-content/uploads/2013/03/Instream%20Flows.pdf

[77] Maxwell, K., S. Julius, A. Grambsch, A. Kosmal, L. Larson, and N. Sonti, 2018: Built Environment, Urban Systems, and Cities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 438–478. doi: 10.7930/NCA4.2018.CH11

[78] Kirchmeier-Young and Zhang. 2020. Human influence has intensified extreme precipitation in North America. Proceedings of the National Academy of Sciences Jun 2020, 117 (24) 13308-13313; DOI: 10.1073/pnas.1921628117

[79] Anderson, M.G., Barnett, A., Clark, M., Prince, J., Olivero Sheldon, A. and Vickery B. 2016. Resilient and Connected Landscapes for Terrestrial Conservation. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA.http://easterndivision.s3.amazonaws.com/ Resilient_and_Connected_Landscapes_For_Terrestial_Conservation.pdf

[80] Green Infrastructure Cost-Benefit Resources. EPA. 2016. https://www.epa.gov/green-infrastructure/green-infrastructure-cost-benefit-resources Accessed June 2020.

[81] EPA. Soak Up the Rain. Rain Gardens and Green Infrastructure. https://www.epa.gov/soakuptherain/soak-rain-rain-gardens. Accessed 2019.

[82] Huron River Watershed Council. 2013. Climate Resilient Communities: Improving information access and communication among dam operations of the Huron River main stem. https://www.hrwc.org/wp-content/uploads/2013/03/Instream%20Flows.pdf

[83] Robinson C, Dilkina B, Moreno-Cruz J (2020) Modeling migration patterns in the USA under sea level rise. PLoS ONE 15(1): e0227436. https://doi.org/10.1371/journal.pone.0227436

[84] Nicholls, S., 2012: Outdoor Recreation and Tourism. In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center, http://glisa.msu.edu/docs/NCA/MTIT_RecTourism.pdf

[85] Winkler, J.A., Andresen, J.A., Hatfield, J.L., Bidwell, D., & Brown, D. (Eds.). (2014). Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment. Washington, DC: Island Press

[86] Economic Benefits and Fiscal Impact of Parks and Open Space: A Report by The Trust for Public Land. 2010. https://www.tpl.org/how-we-work/fund/conservation-economics

Chapter 4: Action Plan for the Middle Huron Watershed, Section 3

Watershed management planning provides the opportunity for communities and other stakeholders to assess the current condition of their watershed, and 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 recommendations and evaluating the effects by regularly monitoring the river or population for change and degree of improvement. Much progress has been made since this WMP was originally drafted in 1994 and then updated in 2000, 2008, and now 2023.

The long-term goals as first established in 1994 were as follows:
1) Reduce flow variability
2) Reduce nonpoint source loading
3) Protect and restore natural features
4) Increase public awareness
5) Gain broad implementation of the watershed management plan.

The goals for 1994 are still very relevant today for the Middle Huron Section 3. HRWC and partner monitoring shows that many of the same factors are still a problem, although new wrinkles like PFOS contamination and Climate Change have added complication to the discussion.

To provide nuance and explanation for the current times, HRWC with input from stakeholder community built a rubric showing the logical flow from the Causes of watershed degradation, to the Threats that come from those causes, and then to the resulting Impacts (Table 4.1). Alleviating these Impacts would be akin to achieving short-term goals, which then added together as a whole would move the Watershed much closer to the widespread fulfillment of all of the long-term goals.

Table 4.1. Summary of Causes, Threat, Impacts, and Recommendations in the Middle Huron River, Section 3.

These three overarching **Causes….**	…. Produce these six primary **Threats**….	….Resulting in these negative **Impacts** to the Huron River Watershed….	...with these **Impacts** specific to The Middle Huron, Section 3.	...Alleviated by these **Recommendations** (Links to Table 4.2)
I. People removing natural lands and developing them as seen through…. • Draining wetlands • Removing forests and natural areas • Damming and straightening rivers • Building and operating Industrial facilities • Practicing agriculture • Creating impervious surfaces II. People causing climate change through greenhouse gas emission…. • Increasing overall precipitation • Higher variability of precipitation (more droughts, more floods) • Increasing temperatures • Changing seasonality and altered precipitation forms (ice, sleet, rain)	1. Altered water quantity and variability	a. Flooding imperils human life, infrastructures, and causes sewer overflows (also increasing 5, E. Coli).	• Flooding on Willow Run washed away road and parts of Beyer dam (3.2.3.6, Flooding) • High flows cause challenging dam operations (3.3.6 Effects on Infrastructure; 3.4.1.1 Implications for Dams; 3.4.3 Dam Operator Communication and Dam Management)	• Develop a long-term temperature, precipitation, water level, and flow network (S6) • Develop and implement a Green Infrastructure strategy and program (PE4) • Maintain and Implement Stormwater Management Plans (C) • Climate Action Planning (G)
		b. Stream flashiness (water routing and timing issue); increases the problems posed by all the other primary threats (habitat, nutrients, chemicals, E Coli)	Runoff entering the Huron River (Forest Ave) at higher rate than in other places in the Huron River Watershed (2.1.3, Hydrology)	
		c. Bank erosion increases problems posed by 2 (habitat loss) and 3 (nutrients); also a threat to human infrastructure	High erosion on particular stream segments (2.3.1.1, Stream Morphology and Substrate)	• Conduct lakeshore assessments (S3) • Stream and Lakeshore Buffer Enhancement Program (PE5) • Targeted stream channel restoration (MR1) • Shoreline erosion control and habitat restoration (MR3)
		d. Altered river substrate & loss of instream woody debris; increasing problems posed by 2 (habitat loss)	Armored shorelines and lack of nearshore habitat on Ford and Belleville Lake (2.4.2.3, Shoreline Habitat).	
		e. Increased winter rains resulting in lower snowpack, decreased groundwater recharge, and reduction in drinking water quality.		
		f. Extreme variability between drought and excessive precipitation harms sensitive ecosystems (e.g. fens, bogs, wet prairies, northern hardwood forests)		
		g. Loss of water based recreation (a result of all above Impacts)	Dangerous conditions on French Landing Dam portage (2.1.3.1, Dams and Impoundments)	Fix French Landing Dam Portage (MR2)

These three overarching **Causes….**	…. Produce these six primary **Threats**….	….Resulting in these negative **Impacts** to the Huron River Watershed….	...with these **Impacts** specific to The Middle Huron, Section 3.	...Allieviated by these **Recommendations** (Links to Table 4.2)
I. People removing natural lands and developing them as seen through…. • Draining wetlands • Removing natural areas • Damming and straightening rivers • Building and operating Industrial facilities • Practicing agriculture • Creating impervious surfaces II. People causing climate change through greenhouse gas emission…. • Increasing overall precipitation • Higher variability of precipitation (more droughts, more floods) • Increasing temperatures • Changing seasonality and altered precipitation forms (ice, sleet, rain)	2. Destroyed and degraded habitat	a. Alterations to species composition and ecosystems including losses of native species (resulting in threatened & endangered species) and increases of invasive and exotic species; futhermore, it compounds impacts from Threats 1, 3, and 5.	• Threatened species in the Watershed (2.1.4.1, Threatened, Endangered, and special Concern Biota) • Natural areas that are not protected (2.1.4.2, Critical Habitat and Ecosystem Services) • Dams- Superior, Peninsular, Tyler and Beyer Dams, etc. (2.1.3.1 Dams and Impoundments) •Lack of woody debris along Ford, Belleville shorelines (2.4.2.3 Shoreline Habitat)	• Assessment and Prioritization of Natural Areas (S5) • Pass and Enforce River Friendly Ordinances (PE3) • Dam Removal (MR4) • Natural Areas Protection (D) • PE4 (already described above)
		b. Loss of greenhouse gas sinks	Landuse change (2.2.3, Land Use and Development)	
		c. Increased water temperatures	• Impoundments increasing water temperatures (2.1.3.1, Dams and Impoundments; 2.4.2.10, Additional Water Quality Monitoring on Ford and Belleville Lake) • Loss of shoreline shading (2.4.2.3, Shoreline Habitat)	
		d. Reduced groundwater recharge through natural area loss results in greater threat to drinking water sources.		
		e. Loss of water based recreation, bird watching, hiking, etc. A result of all Impacts above		

<table>
<tr><th>These three overarching Causes….</th><th>…. Produce these six primary Threats….</th><th>….Resulting in these negative Impacts to the Huron River Watershed….</th><th>...with these Impacts specific to The Middle Huron, Section 3.</th><th>...Alleviated by these Recommendations (Links to Table 4.2)</th></tr>
<tr><td rowspan="8">I. People removing natural lands and developing them as seen through….
• Draining wetlands
• Removing forests and natural areas
• Damming and straightening rivers
• Building and operating Industrial facilities
• Practicing agriculture
• Creating impervious surfaces

II. People causing climate change through greenhouse gas emission….
• Increasing overall precipitation
• Higher variability of precipitation (more droughts, more floods)
• Increasing temperatures
• Changing seasonality and altered precipitation forms (ice, sleet, rain)</td><td rowspan="3">3. Increased sediment and nutrient load</td><td>a. Eutrophication and Algae Blooms</td><td>• Ford and Belleville Lake nutrients (2.5.2.1 Phosphorus Critical Areas)
• Algae blooms (Phosphorus 2.4.2.5)
• Snidecar and Superior Drains with high phosphorus and TSS (2.4.1.5, Phosphorus; 2.4.1.6, Suspended Solids);</td><td rowspan="3">• Review and comment on all new discharge permits in TMDL area (PE1)
• Continue Ypsilanti Township's work on Rawsonville Dams bottom draws to oxygenate Ford Lake (A)
• Maintain and implement stormwater management plans (B)
• Enforce rules, standards and ordinances for stormwater management (C)
• PE4; PE5; MR3 (already described above)
• Study DO on Snidecar Drain (S2)</td></tr>
<tr><td>b. Dissolved oxygen loss causes reduction of ecosystem quality across all biotic life, and most visibly, increased fish kills</td><td>•Low summer DO (2.4.2.10, Additional Water Quality Monitoring on Ford and Belleville Lake)
• Low DO in Snidecar Drain (2.4.1.11 Dissolved Oxygen)</td></tr>
<tr><td>c. Loss of water based recreation. A result of all Impacts above.</td><td>Algae blooms (Algae blooms (Phosphorus 2.4.2.5)</td></tr>
<tr><td rowspan="4">4. Synthetic chemical contamination (PFAS, microplastics, PAHs, Mercury/PCBs)</td><td>a. Increased risk to human health through direct contact and through drinking water</td><td rowspan="4">"Do Not Eat Fish" Advisory from PFOS contamination (2.3.1.5, Organic Compounds and Heavy Metals)</td><td rowspan="4">Monitoring fish for PFAS/PFOS (S4)</td></tr>
<tr><td>b. Reduction of wildlife health</td></tr>
<tr><td>c. Reduction and in some cases complete loss of human fish consumption</td></tr>
<tr><td>d. Loss of water based recreation. A result of all Impacts above.</td></tr>
<tr><td>5. E Coli and pathogen contamination</td><td>a. Increased risk to human health through contact in waterbodies, loss of water based recreation, and increased drinking water treatment costs.</td><td>Tributaries with high E. Coli monitoring results (2.4.1.12 Bacteria); Van Buren Beach closures (2.4.2.6, Bacteria)</td><td>• Conduct bacterial source identification (S1)
• Pet waste ordinance education and enforcement (D)
• Place doggie bag stations at target locations (F)
• B, C, PE3, PE4 (already described above)</td></tr>
</table>

These three overarching **Causes….**	…. Produce these six primary **Threats**….	….Resulting in these negative **Impacts** to the Huron River Watershed….	...with these **Impacts** specific to The Middle Huron, Section 3.	...Alleviated by these **Recommendations** (Links to Table 4.2)
III. Social inequities and environmental health disparities	6. Climate change and degraded water quality disproportionately burden overburdened and underserved communities	• Inequities in the spatial distribution of projects to improve watershed health and water quality • Lack of environmental justice considerations in the watershed management planning, with traditional decision-makers (e.g., local government, elected officials, academics) holding power and influence in the process • Barriers that inhibit participation of community members in the ideation and implementation of projects to improve watershed health and water quality • Low adaptive capacity in overburdened and underserved communities, which limits ability for communities to adapt to climate change and respond to emerging watershed threats	There are numerous under-resourced communities and overburdened populations residing in the Middle Huron, Section 3.	• Engagement of residents and community members via listening sessions, surveys, and other methods to identify community water priorities, values, and opportunities (PE2). • Consideration of environmental justice and other socioeconomic data by watershed decision makers in the ideation of BMPs and projects to improve watershed health and water quality • Meaningful and accessible involvement of overburdened and underserved communities in the creation of laws, policies, and projects affecting and benefiting the river • Development and cultivation of community partnerships to help drive local leadership in BMPs and projects to improve watershed health and water quality, leading to long-term adoption and maintenance.

4.2 Recommended Actions to Achieve Watershed Goals and Objectives.

4.2.1 Recommended Prioritization

To best achieve the long-term goals and alleviate the impacts listed above, in consideration of the new data and problems that have arisen and been laid out in Chapters 1-3 of this plan, the 2023 authors and stakeholders have developed a series of recommendations for implementation from 2024-2034. Table 4.2 is a series of actions organized by stakeholder and category.

HRWC actions are those that HRWC can and should take the lead on, though often these actions require support from other plan stakeholders. As HRWC is the author and likely primary user of this management plan, these are presented first. They are broken into three categories: Study, Policy and Education, and Maintenance and Restoration. The order in which they are presented does imply a certain amount of priority, where actions listed first within each category are expected to be able to be implemented first and most easily, in some cases with money and programs already on hand and established. Recommendations harder to implement due to cost or being less developed, more conceptual ideas are listed more closely to the bottom of each category.

Stakeholder actions are those that are the primary responsibility and priority of the non-HRWC stakeholders of this plan, such as the Counties, Cities, and Townships within the Watershed. HRWC often serves in an advisory or partnership role for these recommendations. These actions are not listed in any particular priority or category because the priority will be different for each stakeholder, depending on the threats they are facing.

Each of the actions are described more specifically below the table.

Table 4.2. Summary of 10-Year Watershed Improvement Strategy, 2024-34

Lower ← Priority → Higher

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2024-2034	Lead Agency*	1. Success Measures 2. Link to Threats and Impacts (Table 4.1)
HRWC—Study					
S1. Conduct bacterial source identification and remediation	Bacteria/ multiple	2024-2030	$120k	HRWC, municipalities	1. # human sources IDed and remediated; reduced bacteria concentrations 2. 5e
S2. Summer Dissolved Oxygen Study on Snidecar Drain and Superior Drain	Dissolved Oxygen	2025-2026	$3k	HRWC	1. 2 weeks continuous DO data collected in July or August 2. 3b
S3. Conduct lakeshore assessments	All	2025-2026	$20k	HRWC, municipalities	1. Identification of erosion sites 2. 1c, 1d
S4. Monitor fish for PFAS/PFOS	PFAS/PFOS	Every third year 2025, 2028, 2031	$50k / yr ($150,000 total)	HRWC	1. PFAS/PFOS in whole fish in ppb 2.4a,b,c,d
S5. Assessment and Prioritization of Natural Areas	All	2022-2032	$100k	HRWC	1. # natural areas assessed; prioritization scheme created 2. 2a,b,c,d
S6. Develop a long-term temperature, precipitation, and flow network	Altered flow regimes	2028-2033	$175k upfront, $30k/yr for upkeep	HRWC, University of Michigan	1. # automated stations developed; continuous real-time flow, precip, temperature data 2. 1a

Lower ← Priority → Higher

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2024-2034	Lead Agency*	1. Success Measures 2. Link to Threats and Impacts (Table 4.1)
HRWC—Policy and Education					
PE1. Review and comment on all new discharge permits in TMDL area	Phosphorus/ new sources	2024-34	Small staff cost each year	HRWC, partners	1. No newly permitted dischargers of phosphorus effluent 2. 3a,b,c
PE2. Development of resident based listening sessions and community partnerships	All	2024-2034	$50-100k	HRWC, Municipalities	1. # of sessions; # community partnerships. 2. 6a
PE3. Pass and Enforce River Friendly Ordinances	All/Multiple	2024-34	$105k	Municipalities, HRWC	1. Ordinances and policies passed 2. 2a,b,c,d; 3a,b,c; 5a
PE4. Develop and implement a Green Stormwater Infrastructure strategy and program	All/ Runoff	2024-26 plan 2026-34 implement	$200k - $20M	HRWC, Municipalities, Washtenaw County	1. Reduced impervious surfaces; Increased baseflow and reduced flow variability; reduced nutrient and bacteria concentrations and loading; monitoring 2. 1a,b; 2a,b,c,d; 3a,b,c; 5a
PE5. Stream and Lakeshore Buffer Enhancement Program	All/ Runoff	2025-30	$100K	HRWC, Washtenaw County, municipalities	1. Linear feet established; % streams properly buffered;% natural lake shore; monitoring 2. 1c,d; 2a,b,c,d;

Lower ← Priority → Higher

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2024-2034	Lead Agency*	1. Success Measures 2. Link to Threats and Impacts (Table 4.1)
HRWC—Maintenance and Restoration					
MR1. Targeted Green Infrastructure and Stream Channel Restoration.	Biota/ sediment/Phosphorus/Pathogens	GSI: 2024-2030 Stream Restoration: 2030-2034	$500k - $5M	HRWC, municipalities, WCWRC and WCDC	1. Increased DO levels; improved channel morphology; reduced sediment and nutrients improved biota 2. 1c,d
MR2. Shoreline erosion control and habitat restoration	Biota/ sediment/Phosphorus/Pathogens/Water Temperature	2026-2034	$10k - $5M	HRWC, municipalities	1. Decrease in lake phosphorus; increased lake DO levels; improved biota; increased Secchi; removal of shoreline invasive species 2. 1,c,d; 3a,b,c
MR3. Dam Removal	Biota/ sediment/Phosphorus/		$2-10M depending on dam size	HRWC, municipalities	1. Dams removed, feet of channel restored, acres of floodplains restored 2.2a,b,c,d
HRWC Recommendation Summary		2024-34	2M - 50M		
Stakeholder Recommendations					
A. Continue Rawsonville Dam's bottom draws to oxygenate Ford Lake.	Phosphorus/ Dissolved Oxygen	2024-2034	$20-30k	Ypsilanti Township	1. # of days of algae blooms 2. 3a,b,c

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2024-2034	Lead Agency*	1. Success Measures 2. Link to Threats and Impacts (Table 4.1)
B. Fix French Landing Dam Portage	Safety issue	2025-2026	$50k	Van Buren township	1. Increased safety of recreational users. 2. 1e
C. Maintain and implement stormwater management plans	All/ stormwater	2024-34	$1M-$10M	Municipalities, county agencies,	1. Numerous. See individual stormwater plans; references provided in text 2. 3a,b,c
D. Enforce rules, standards and ordinances for stormwater management	All/ new stormwater	2024-34	$1M - $5M	WCWRC, WCDC	1. Reduced runoff and nutrient/bacteria concentrations; monitoring 2. 3,a,b,c
E. Natural Areas Protection	All/Multiple	2024-34	$10M	Municipalities, land conservancies	1. # of acres of natural areas put into permanent protections from development 2. 2a,b,c,d
F. Pet waste ordinance education and enforcement	Pathogens/ Pet waste	2025-34	$18,000	Municipalities	1. Resident knowledge from survey; call volume; violation # 2. 5a
G. Place doggie bag stations at target locations	Pathogens/ Pet waste	2025-34	$27,500	County, municipalities	1. Stations established; use rate; pounds removed; monitoring 2. 5a

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2024-2034	Lead Agency*	1. Success Measures 2. Link to Threats and Impacts (Table 4.1)
H. Climate Action Planning	Altered flow regimes/ Nutrients/ Runoff	2024-2034	$1M-$1B	Municipalities	1. # of ordinances adopted to reduce GHG emissions and increase climate resilience; Reduction of impervious surfaces 2. 1a,b
Priority 2 Activities Summary	**Total**	**2024-34**	$13M -$25M plus variable costs of Climate Actin Planning		

* Agency Acronyms:

HRWC: Huron River Watershed Council
WCWRC: Washtenaw County Water Resource Commissioner
WCDC: Wayne County Drain Commissioner

4.2.2. HRWC- **S**tudy Recommendations

S1. Conduct bacterial source identification and remediation

In section 2.4.1.12 and 2.5.2.2, the authors show that Snidecar Drain and Superior Drain are listed for bacterial impairment, and Van Buren beach on Belleville Lake has been often closed, sometimes at length, for high bacterial levels. The Huron River downstream of these tributaries is normally below the full body contact standard, though occasional samples after heavy storms will be elevated above state health standards. Microbial source tracking was conducted in 2020 in Snidecar Drain showing pet and human sources. However, that was the extent of determining *E. Coli* sourcing in the Watershed, and there would be benefit in targeting Superior Drain and the many smaller tributaries entering Belleville Lake.

This 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 the County Drain Commissioners, Health, and or Public Works Departments will contact any suspected homeowner to remediate any failing septic systems or illicit connections, or work toward fixing leaking sewer lines.

HRWC and local partners should also execute outreach and education strategies to property owners in the impaired creekshed on pathogen problems. Municipalities can also contribute to this effort with pet waste ordinances and education (Recommendation E) and maintained pet waste stations and signage (Recommendation F).

Timeframe: 2024-2030
Milestones:

- 2024-2026: Write a Lower Middle Huron *E.Coli* monitoring and implementation plan, released as a technical update to this plan.
- 2026-2028: Identification of bacteria impairments
- 2028-2029: Conduct follow-up monitoring and education

Cost: Staffing costs for planning and writing; fecal indicator bacteria monitoring, analysis, source identification, homeowner outreach, and follow-up: $120,000;
Potential funding sources: Section 319
Success Measures: Number of human sources identified and remediated; bacteria monitoring (see chapter 5)

S2. Summer Dissolved Oxygen Study on Snidecar and Superior Drains.

As mentioned in section 2.4.1.11 on Dissolved Oxygen, DO was measured in Snidecar Drain in 2016, 2017, and 2020, and 25% of the 28 measurements fell below the 5 mg/L DO standard, indicating issues with stream oxygenation. These were just exploratory measurements however, and HRWC could benefit from a more concentrated 2 week study with a continuous DO logger to properly understand if DO levels are a continual problem. The data would be shared with EGLE to assist in assessing the water body for designated uses.

HRWC should also monitor the nearby creek of Superior Drain. While exploratory DO measurements did not indicate a problem with DO levels, only 35 measurements were taken and nothing has been sampled since 2009. Superior Drain faces many of the same water quality threats as Snidecar.

Timeframe: 2025
Milestones:
- Development of monitoring plan
- Installation of a continuous DO logger
- Analysis and sharing of the data

*Cost: $3k. $1.5k for a DO logger, and $1.5k s*taffing and travel costs.
Potential funding sources: Section 319 or general HRWC funds.
Success Measures: % of time or measurements that DO is less than 5 mg/L.

S3. Conduct lakeshore assessments

During the writing of this watershed management plan, HRWC received a large number of citizen accounts of shoreline erosion on a wide variety of points on Ford and Belleville Lake. While HRWC did perform a large bank erosion study on river sections for the writing of this WMP, assessing the shoreline of these large lakes was not part of the work scoped out for the EGLE grant and as such HRWC does not have specific reports on the scale of the lake erosion issue.
However, the high number of stakeholders and citizens bringing these erosion issues to HRWC attention highlights the need for a systematic survey of the area to locate problem areas and report them to EGLE and the municipalities involved.

There are procedures available to paddle the length of the lakeshore and assess lakeshore health (including bank erosion severity). HRWC proposes to carry out these studies around both Ford and Belleville Lake and then write a report ranking the problem areas. These areas would then be targets for natural shoreline restoration and stabilization (Recommendation MR3).

Timeframe: 2025-2026
Milestones:
- Development of monitoring plan
- Production of final report
- Fund raising for restoration projects

Cost: $20k. Staffing costs for planning, assessment, and writing; travel costs for summer interns
Potential funding sources: Section 319
Success Measures: Evaluation of erosive sites; funding found for at least two restoration projects.

S4. Monitor fish for PFAS/PFOS

In August 2018, EGLE reported high levels of PFAS/PFOS in dangerous concentrations in the tissues of Kent Lake, on the Huron River. In the time since, testing how shown that PFOS is widespread throughout fish in the Huron River system. The Huron throughout the Watershed is not considered to be meeting the fish consumption designated use and a “Do Not Eat Fish” advisory is active in the system.

It is not clear when PFOS level in the Huron will fall enough for the advisory to be lifted and the designated use to be met. As some sources are found and remedied, other sources are still coming to light, and the sources are a mix of legacy contamination and current operations. There needs to be further efforts applied to locate these PFOS sources.

In 2022, HRWC worked jointly with The Ecology Center and Friends of the Rouge in a study aimed at understanding PFOS in fish.[1] In the Huron, specially trained volunteers collected fish throughout the main branch of the river, including at Peninsular Dam and in Ford Lake. The results show PFOS in every fish at levels high enough to be considered unsafe.

This study would be a useful one to repeat every 3 years going forward. It has several advantages over other state level efforts. First, it heavily engages the local fishing community, bringing awareness of the issue to the people most affected by the consumption advisory. Second, the study is small enough to give quick sample turnaround time, giving more timely data than samples from the state which can languish as they await processing. Third, the long-term nature of the study will enable HRWC to determine if new sources of PFOS are appearing in the watershed, and the general location of the sources.

Timeframe: Every third year: 2025, 2028, 2031
Milestones: Conduct monitoring and develop report for each year, tracking long term trends as they become available.
Cost: Staffing costs for planning and training volunteer anglers, lab fees. $50k/sampling year for a total of $150,000.
Potential funding sources: Foundations

S5. Assessment and prioritization of natural areas for conservation and protection

As discussed, in section 2.1.4.2, the Watershed’s remaining natural areas are of utmost importance to protect for their ecosystem services. Of the 2,329 acres of natural areas in the Watershed, only 579 acres are protected as public and park lands or owned or managed by conservancies and other nonprofits. HRWC has used GIS methods to determine the relative importance of these natural areas (Figure 2.7) but has only visited a small number of them to conduct on-the-ground assessments of their plant communities, hydrological characteristics, and other important components.

Many more field visits of likely high quality natural areas are possible. In addition, more GIS modelling opportunities have been developed to provide ecosystem services valuation on a per-parcel basis. There exists a need to add further GIS and field-based prioritization to show which of the natural land parcels are most important to preserve in order to retain the ecosystem services they provide, HRWC should request that EGLE conduct the Landscape Level Wetland Functional Assessment (LLWFA) for the whole Watershed area. The LLWFA results could be added to HRWC’s prioritization scoring methods.

Timeframe: 2024-2028
Milestones:

- 2024-2026: Enhance GIS modelling to provide ecosystem services valuation by parcel in the Watershed.
- 2024-2026: EGLE conducts LLWFA. HRWC incorporates results in prioritization scoring.
- 2026-2028: Conduct natural area surveys in the Watershed.
- 2028: Develop a set of recommendations for the WMP stakeholders that map and list the priority natural areas in the watershed.

Cost: $100k
Potential funding sources: NRCS (Regional Conservation Partnership Program), Clean Water Act section 319, Clean Water and Drinking Water State Revolving Loan Fund, foundations
Success Measures: # of field assessments; ranking model or scheme; final prioritized list developed

S6. Develop a long-term temperature, precipitation, and flow network across the Watershed.

As discussed in Chapter 3.4.1.2, 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 designing infrastructure to handle storms that are not accurate with a changing climate. This is a particular challenge for dam operators, as mentioned in Chapter 3.4.3, who need real-time flow data and modern communication tools to properly watch for floods and upstream dam failures. Furthermore, with greater rainfall comes more erosion, which causes greater sediment and nutrient flow through the waterways.

Therefore there exists a need to collect current weather and flow data with more accurate, modern approaches that will give us the ability to make decisions on how to best manage humans systems, watersheds, and streams. More robust and sustainable approach is needed to quantify needs in specific watersheds and reliably fund large infrastructure projects.

We recommend creating an observational network of weather and water condition observational stations that allows the coupling of climate and hydrologic data or long periods of time. That will improve our understanding of the watershed response to various weather patterns. A goal should be to quantitatively understand how the watershed responds at the creekshed scale when a major precipitation event occurs in the watershed. That connection, based on quantitative, observational data collected over time, will establish the observational basis for tailoring climate and hydrologic models to the watershed. This coupled climate-hydrologic model would allow us to assess existing conditions in the watershed and project how climate change will alter hydrologic conditions in the future. That information can be used to inform decisions around infrastructure and ecological vulnerability.

Timeframe: 2027-2032

Milestones:

- 2027: Install the first weather monitoring station or successfully collect and utilize data from existing weather observing stations in the watershed.
- 2032: Expand the network across the whole Huron River Watershed, with 1 weather station per county within the watershed, and with 1 flow sensor at the mouth of every

major tributary and multiple along the main branch of the Huron River. Existing weather observing stations that collect the relevant data may be used to reduce costs or improve watershed coverage.

Cost: $2,500 for weather stations; $400 for flow devices; plus $150k for staff time to write computer code and process data. Total: $175k total for the Watershed. Costs of network implementation are high, and ongoing maintenance and staff time will be required of about $30k per year.

Potential funding sources: GLRI, Foundations, NRCS

Success Measures: # of automatic stations, continuous real-time flow data, precipitation, and temperature.

4.2.3. HRWC - **P**olicy and **E**ducation Recommendations

The MS4 communities within the Middle Huron Watersheds of Section 1, 2, and 3 have formed the Middle Huron Partnership (Appendix A), and have committed to implementing a Public Education Plan (PEP), which is referenced in Appendix J.

The following recommendations are those that take concepts from the PEP and expand upon them, combining public outreach with policy and packaged up as a set of projects that address the long-term goals and short-term objectives of this WMP and that could be implemented within the next 10 years. These projects both directly address impairments in the watershed while providing teaching opportunities to inform and engage the public.

PE1. Review and comment on all new discharge permits in TMDL area.

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: 2023-2032
Milestones: Review and comment on all discharge permit applications.
Cost: HRWC and partner staff time. Likely a negligible cost.
Potential funding sources: General staffing budgets.
Success Measures: Zero new phosphorus discharge permits; monitoring (see chapter 5).

PE2. Development of resident listening sessions and community partnerships.

Through community listening sessions, watershed managers can better understand priorities and needs of local residents and ensure buy-in on watershed implementation strategies. Listening sessions can serve as a forum for gauging existing resident knowledge on watershed issues, assessing barriers to implementation, and identifying opportunities for collaboration and community partnership. Information collected via these listening sessions will guide decision making for future implementation projects within this Watershed.

This proposed strategy would likely consist of 3-5 sessions in the community/area of focus with 6-15 participants in each session. Listening sessions would last between 90 to 120 minutes and consist of questions and activities led by a facilitator. Questions would be directly related to watershed issues and relevant project considerations. Facilitators would follow up with residents after the session to confirm findings and provide opportunities for additional input. Data may also be synthesized and shared with the broader community for additional validation and information collection.

Timeframe: 2024- 2026
Milestones:

- 2024: Identify priority communities/geographies in Lower Middle Huron for further relationship-building and social research.
- 2025: Develop strategy for data collection and listening sessions. Begin outreach to community leaders, local organizations, and potential listening session attendees.
- *2026:* Execute 3-5 listening sessions in priority communities. Analyze and synthesize data. Report out to community members.

Cost: $4000-8000

Potential funding sources: Foundations, HRWC general operations
Success Measures: Number of listening session attendees/participants, number of new community partnerships, minutes of qualitative data collected

PE3. Pass and Enforce Water Friendly Ordinances

To protect water, you need to protect the land the water drains from. This fact is a constant struggle in a world that tries and often fails to balance ecosystem needs with the demands of a human civilization. People need places to live and work, but people and animals need clean water and clean land. Fortunately, local governments have regulatory tools at hand to allow development while protecting the important natural areas that are mandatory in maintaining water quality and other important ecological functions (see 2.1.3.2). Tools include wetland, woodland, riparian buffer, and other natural feature protection ordinances, and regional planning to direct development away from natural areas.

We recommend that all local governments in the Watershed adopt the following local government policies for water quality protection:

1. Identify high priority natural areas

2. Adopt land protection funding program
3. Master planning to direct development away from sensitive areas
4. Overlay zoning of areas that need extra protection,
5. Setbacks and buffers from natural features like waterways, wetlands, woodlands.
6. Wetland protection ordinance
7. Reduce impervious surfaces through site design
8. Green Stormwater Infrastructure requirements to mimic ecosystem services of natural green infrastructure that was destroyed by development.
9. Pet waste pickup

HRWC has previously (2006) developed a Cost and Ordinance Worksheet (COW) to determine which local municipalities have which of these ordinances. HRWC will need to revise these COWs by conducting a survey of the Watershed's municipalities to see where they have these policies and where they don't.

HRWC will work with municipalities in getting new policies passed, by sharing model policies and advocating and educating local decision makers. To accomplish this, HRWC will recruit motivated individuals from local Watershed governments or citizenry for a series of trainings that provide intensive technical assistance including how to conduct an audit of current policies and will give recommendations on adopting necessary policies to provide clean water and natural area protections.

HRWC has run such activities in recent years for other areas of the Huron River Watershed under our "Change Makers" program. Based on our experience, we estimate it takes about $15,000 per municipality to conduct audits of their master plans, hold trainings which consist of multiple in person sessions over a one year period, and work directly with each Community in providing technical advice.

Timeframe: 2024- 2034
Milestones:

- 2024-2034: Run highly motivated government elected official, employees and/or citizens from each of the 7 Core Communities (Table 1.1) in the Watershed through HRWC's Change Maker program
- 2034: Every municipality in the Watershed has policies that cover these nine priority areas.

Cost: $105k ($15,000 per Core Community: City of Ypsilanti, City of Belleville, Superior Township, Van Buren Township, Ypsilanti Township, Washtenaw County, Wayne County)

Potential funding sources: Foundations, HRWC general operations
Success Measures: # of new ordinances or policies adopted

PE4. Develop and Implement a Green Stormwater Infrastructure (GSI) Strategy and Program

As mentioned in chapter 3.4.1.3, under the reality of climate change and the ever-growing need to attenuate stormwater, runoff, and flooding effects, built infrastructure will always be at least partially static and likely to become obsolete in the future. 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. However, natural ecosystems are inherently dynamic. The use of green infrastructure and natural areas conservation should be incentivized wherever possible to mitigate the pace and magnitude of future changes.

Ideally, all impervious surface runoff within the Watershed would be captured and treated at some level, whether it be detention ponds, underground storage or GSI. There are about 6.8 mi^2 or 4,434 acres (20%) of impervious surface in the Watershed. At a conservative 7:1 ratio of impervious surface to treatment area, an appropriate goal would be to develop at least 619 acres or 27 million square feet of GSI or other treatment in the watershed. EGLE 319 funding may have additional requirements for BMPs beyond the 7:1 ratio. Furthermore, 619 acres are a conservative estimate as this value is based on current conditions and as additional areas are developed the number should be adjusted to match.

Achieving the benchmark of 619 acres will not occur without significant effort— and it can't be done operating at a "business as usual" approach. Getting single grants to do a GSI project on one piece of property is highly time consuming. Even implementing one or two GSI builds at a time, which takes about two years, takes up HRWC's capacity for GSI projects. That rate of project completion results in very slow progress even on this smaller Watershed scale, let alone on the full Huron River Watershed scale that HRWC has the obligation to consider.

Thus, there is a need to operate differently in order to implement GSI on the scale envisioned. Three possible strategies to move toward this objective are:

1) Starting a self-funding operation to identify, fund, design, install, and maintain GSI projects
2) Make GSI training more accessible to the public through an GSI Outdoor Training Center
3) Targeting non-residential landowners through GSI Behavior Change Education

Strategy 1) Develop a self-funding program to identify, fund, design, install, and maintain GSI projects.

A relatively new collaborative organization called the Rain Catchers Collective (RCC) envision a region where distributed GSI is the norm for stormwater management in communities across all types of developed landscapes. To facilitate this, the RCC will use seed grant funding to protect critical ecosystem functions and scale-up GSI installation at the small and large scales where it will have the greatest impact on flood and pollution reduction. By the end of five years, the collaborative will be a self-sustaining operation with the demand and revenue stream to continue GSI implementation.

The RCC will achieve the above vision by implementing an integrated set of strategic activities. RCC seeks to scale-up GSI services commensurate to the challenge of climate change by formalizing a shared vision and programming based on established business and marketing plans for delivering residential GSI, deepening community engagement throughout the region, and seeding a regional GSI implementation fund. Partners would also allocate grant funds to build the collaboration's brand and set up constituent engagement systems and management (e.g. website and back-end data system). The Collaborative will focus on the development and broad installation of various types and sizes of GSI. The following activities are needed to scale-up the RCC and GSI implementation across southeast Michigan.

1. Formalize Collaborative Organization and Regional Steering Committee.

2. Engage Communities.
3. Develop a GSI Workforce.
4. Finalize and Implement a Residential GSI Program.
5. Build out a Strategic Marketing Plan
6. Establish a Regional GSI Resilience Fund
7. Develop and Execute an Adaptive Evaluation Plan.
8. Report Progress and Results.

Strategy 2) Make GSI training more accessible to the public through an GSI Outdoor Training Center

HRWC, Van Buren Township, and other interested partners could build a Green Infrastructure Outdoor Learning Center in Van Buren Park on Belleville Lake to show examples of multiple GI best management practices (BMPs). The Learning Center will serve as a place to provide hands on training and educational experiences that will remove barriers to GI implementation. Through programming administered at the Learning Center, developers and commercial property owners will be given the training, support and incentives to install GI BMPs on their properties. Additionally, K-12 students and their families will learn about GI, the benefits and how they can make changes at home to improve water quality. The Learning Center will include examples of pervious pavement, rain gardens, bioswales, other bioinfiltration and a cistern. Course materials will be developed for the developer and commercial property owner audience. Materials will be applicable outside of project geography and shared broadly.

A learning center will grow Green Infrastructure and water quality programming long after any finite grant period and will reach people throughout southeast Michigan with water quality implications for area watersheds.

Strategy 3) Targeting non-residential landowners through GSI Behavior Change Education

We recommend an outreach campaign using a behavior change marketing approach to increase the voluntary adoption of rain gardens among businesses, churches, schools, and non-profit properties. Each target group would need its own marketing strategy.

Residential GSI is already well covered in the region through efforts in the Office of the Washtenaw County Water Resources Commissioner.

At its core, behavior change marketing requires significant understanding of the target audience. This includes observation-based research, focus groups and surveys of the target demographic to understand their current knowledge levels and their barriers to implementation, which could range from costs, lack of knowledge, motivation, and access to resources among other things. With this data as a guide, the educational campaign would develop and pilot test strategies to reduce or eliminate identified barriers and increase motivation for adopting the desired behaviors.

Some possibilities include educational materials that use beautiful photography and appeals to GSI's benefits to the community and low-cost maintenance; trainings on how to plan, implement, and maintain GSI; tours of beautiful and successful GSI; increasing access to contractors that provide GSI design, installation and maintenance; identifying and supporting early adopters and influencers; establishing peer-to-peer social networks; and more. Successful strategies would then be used on a larger scale.

Timeframe: 2024-2034
Milestones:

- 2024-2025- Rain Catchers Collective gets first customers
- 2027- Fee for Service GSI is fiscally independent
- 2026-2030- Multiyear Behavior Change project conducted
- 2028- GSI Outdoor Learning Center launches
- *Cost:* $50k to form and launch Fee for Service GSI with the goal of it being self-funded in the long run. $300,000 for establishing the GI Outdoor Learning Center. $150,000 for a multiple year educational campaign with surveys, staffing and products

Potential funding sources: Section 319, local government match, local agency or private investment, Foundations
Success Measures: # square feet with new GSI treatment, Reduced runoff volume, pollutant concentrations, and bacteria concentration measured from projects compared to conventional development, and monitoring.

PE5. Stream and Lakeshore Buffer Enhancement Program

Vegetated 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, wetland, or lake. These buffer zones also are known as riparian buffer zones, referring to the zone along 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.

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.

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.

As mentioned in 3.3.2.1, Changes in Bird Nesting and Migration Patterns, climate change is shifting bird's migration patterns among other effects, and in light of these challenges, buffer zones are all the more important for providing critical oasis habitat corridors, especially in urban dominated areas like the Watershed.

We recommend starting a behavior-change based, buffer enhancement educational program. The approach would include techniques such as observation-based research, focus groups and surveys to identify the motivations for, and barriers to, creating and maintaining buffers, be it roadblocks like costs, aesthetics, lack of information, knowledge, or motivation. The educational program would then develop and pilot test strategies to best mitigate these challenges and inspire riparian landowners to build buffers and keep and restore protective riparian buffers. Successful strategies that are identified could then be implemented on a larger yet targeted scale to measure results in the targeted group. Follow up surveys would show change in knowledge and behaviors and follow up monitoring could show direct physical results.

This educational program would start small by directly targeting riparian property owners on specific properties, like those who live on streams assessed by BANCs, or Ford and Belleville Lake properties identified through lakeshore assessments, but the products and ideas from this program could eventually be scaled to cover the whole Huron River Watershed.

Property owners in agricultural, urban, and suburban areas face different challenges and the education program would have to distinguish between these. There are some resources that already exist for agricultural property owners to utilize. The Wildlife Habitat Incentive Program (WHIP) is available 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.

Timeframe: 2026-31
Cost: Multiple year educational campaign, $150,000 for surveys, staff time, and products. Funds could be provided to participants to help kickstart buffers: @ $500/ac for 80 ac: $50,000; mailing, site visits, planning, technical assistance, reporting: $25,000. Total: $225,000.
Success Measures: # landowners participating, # and % of riparian acres buffered, monitoring (chapter 5)

4.2.4. HRWC- **M**aintenance and **R**estoration Recommendations

MR1. Targeted GSI and stream channel restoration to reduce channel erosion

As noted in Chapter Two, there are stream segments that should be repaired and restored to a more natural state. A restored channel, with a more moderated delivery of stormwater to the river provided by GSI efforts, will accentuate the river's resiliency to handle climate-related impacts. 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.

As discussed in Chapter Two, most of the stream reaches that were assessed (13 of 23) had erosion rates in the highest category. Compared with other watershed areas that have been similarly assessed, all 13 reaches could be considered high priority. However, it would be impractical to restore that much stream length, so we identified the top seven targets to propose stream channel restoration. These are described in detail in the BANCS inventory (Appendix C). The seven priority restoration projects are shown in Table 4.3.

Restoration projects should proceed after upstream flow can be shown to be stable.

Some streams are likely eroding due to increased runoff from built surfaces. That should be reduced or at least stabilized first.

In other reaches, the impacts are from alterations to isolate the streams from farm fields. The altered hydrology is not likely due to runoff from built-up or impervious areas. While the target reaches would benefit from GSI or other flow control in their contributing areas, bank restoration can be beneficial on its own.

Table 4.3. Priority Stream Restoration Reaches

Reach ID	Stream Name	Reach Length (linear ft)	Erosion Rate (tons/yr/ft)	Total Erosion (tons/yr)	Total Phosphorus (lbs/year)	Notes
771	Unnamed	4,436	0.35	1,572	1,336	Straightened ag channels. Channel shape and floodplain restoration needed, or natural bank protection.
365	Unnamed	1,598	0.32	519	441	Straightened channel between new developments. Wetland restoration upstream with natural bank protection.
372	Willow Run	2,331	0.29	672	571	Sequential w 531. Need to address airport runoff first. Some grade control would help. Room in floodplain for riparian restoration and channel complexity.
531	Willow Run	2,037	0.26	530	451	Sequential w 372. Need to address airport runoff first.
543	Unnamed	1,917	0.25	486	413	Straightened ag channels. Channel shape and floodplain restoration needed, or natural bank protection.
600	Unnamed	1,700	0.24	410	349	Sequential w 464. Straightened ag channels. Channel shape and floodplain restoration needed, or natural bank protection. Possible wetland restoration.
464	Unnamed	1,030	0.21	216	184	Sequential w 600. Straightened ag channels. Channel shape and floodplain restoration needed, or natural bank

						protection. Possible wetland restoration.

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.

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.

All stream restoration projects require EGLE Non-Point Source Unit review and approval. 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.
- *Wetland restoration* can be included where the water table is high by restoring the natural hydrology, breaking drain tiles and removing dikes. Connecting streams to wetlands can slow and cool flows, settle out sediments and filter pollutants and nutrients.

Timeframe: 2024-2034
Milestones:

- 2024-25: Identify capital improvement and grant opportunities and schedule projects.
- 2024-2034: recommend restoration improvements to development projects.
- 2024-2034: Implement and construct public and private restoration 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.

Potential funding sources: Stream restoration grants, local government match; local agency or private investment; mitigation funding; 319 funding.
Success Measures: Increased DO levels; improved channel morphology dimensional measures and substrate characterization; biota monitoring (see chapter 5)

MR2. Ford and Belleville Shoreline Erosion Control and Habitat Restoration

As described at length throughout this document, Ford and Belleville Lakes are impoundments of the Huron River with longstanding phosphorus and algae bloom issues. The data show that the phosphorus and sediment input comes from the upstream system, and also from internal phosphorus cycling. However, there are also many erosive locations on the shoreline itself. Furthermore the lake has particularly poor shoreline habitat for fish and other wildlife, per habitat surveys done by the DNR about 10 years ago (Section 2.4.2.3, Shoreline Habitat).

Following the shoreline assessment in Recommendation S2, HRWC and stakeholder should resolve top priority shoreline erosion and habitat concerns. Best practices should be used for stabilization and erosion control as well as using natural materials, native plantings, and anchored large woody debris to provide for shoreline habitat and wave protection. Education materials and signage should be developed so the sites can serve as demonstration projects to encourage future investment.

All projects should be coordinated with the Michigan Natural Shorelines Partnership to ensure that they are done with the most effective techniques and to further their public education reach.

Timeframe: 2025-2034
Milestones:

- 2025-2034: Identify capital improvement and grant opportunities and schedule projects.
- 2025-2034: recommend restoration improvements to development projects.
- 2025-2034: Implement and construct public and private restoration projects

Cost: Highly variable, depending on project. Low grade lakeshore restorations can be done as low as $100 per linear foot on a private lakeshore residence with total project costs less than $1000. Larger projects with more earth movement required can cost multiple millions of dollars.

Potential funding sources: Stream and lake restoration grants, local government match; local agency or private investment; mitigation funding.

Success Measures: Decrease in lake phosphorus; increased lake DO levels; improved biota; increased Secchi; removal of shoreline invasive species

MR3. Dam Removal

The Huron River is a dammed system, and nearly all of the 100 dams in the Watershed no longer serve their original purpose and now are historical artifacts of a different age. Throughout the Huron, they block fish passage, disrupt the flow of sediment and woody habitat, change stream flow, and warm river temperature. From a biological and ecological systems perspective, there is nothing more disruptive to a high-quality river and fishery system than a dam, given its complete alteration of the system's biological, chemical, and physical processes resulting in degraded habitat, fish, and mussels.

Peninsular Dam ("Pen Dam") in Ypsilanti has long been a possible target for removal due to its advanced age, high insurance costs, looming expensive repairs, and a "high" hazard rating. In addition, in 2022 EGLE downgraded the condition of the dam to "poor". Furthermore, there is a low amount of interest in keeping the system as an impoundment as there are few uses for it beyond the use of a small amount of immediate riparian landowners. This dam removal is a priority because the habitat in this stretch of the Huron is rare in the watershed and very valuable to a range of fish species and macroinvertebrates. EGLE and DNR surveys have indicated fish and macroinvertebrate community health in this stretch of river is excellent and organisms would greatly benefit from an extension of this stretch of open river. Pen Dam sits on one of the highest gradient areas on the mainstem of the Huron. River gradient has a strong influence on channel habitat. Higher gradient stretches support various life stages and functions of many species. Fish and other aquatic life are most diverse and productive in stretches of river with gradients at, or greater than, 10 feet/mile, but due to Michigan's relatively flat topography, these gradients are rare and are the most likely to have been dammed.

Superior Dam, located in very close proximity to Pen Dam, would also be a wise target for removal for all of these same reasons. Superior Dam has not been a focus as Pen Dam, given its poor condition, needs to be a dealt with first. However, as Pen Dam gets removed in the near future, Superior Dam should be considered shortly thereafter.
Willow Run Creek also has two dams that should be removed within the next decade. Willow Run Creek has a history of contamination, flashiness, and erosion as it has drained the runoff from the Willow Run airport. The dams are old and in poor repair; the impoundment at Tyler Dam has already been drawn down and is inoperational though the structure remains. Dam removals and the associated floodplain restoration work are needed to restore the creek and riparian habitat and reduce sediment input from the stream banks.

Timeframe: 2024-2034
Milestones:

- 2025-2026: Peninsular Dam is removed.
- 2027-2030: Tyler and Beyer Dams are removed
- 2032-2034: Superior Dam is removed

Cost: $1M - $10M per dam removal; highly variable based on individual dam requirements and complications like contaminated soils.

Potential funding sources: A wide variety of state and federal grants can address the planning and construction costs, and the biological/chemical/sediment monitoring & testing, with different grants paying for different parts of the process.

Success Measures: Dams removed, feet of channel restored, acres of floodplains restored

4.2.5. Stakeholder Recommendations

A. Continue Rawsonville Dam's bottom draws to oxygenate Ford Lake

As discussed in 2.4.2.5 Phosphorus, University of Michigan professor John Lehman conducted a large EPA-funded study on Ford Lake from 2008 through 2012. The purpose of this study was to examine the effectiveness of discharging hypolimnetic waters in causing vertical mixing in the water column, to prevent hypolimnetic anoxia, lower phosphorus recharge from the bottom sediments, and ultimately reducing incidences of nuisance cyanobacterial blooms. It is possible to discharge the hypolimnetic waters of Ford Lake because the Ford Lake dam at the downstream end has the mechanical capacity to conduct bottom withdrawals. What Lehman found was that the vertical mixing caused by the bottom withdrawals of the dam did indeed lower phosphorus cycling and resulted in a lack of nuisance blooms for three years. Since Lehman's work, Ypsilanti Township dam operators have continued these bottom draws whenever possible.

The dam operators rely on buoy-based temperature and dissolved oxygen water monitoring equipment for informing them if the water conditions are acceptable to conduct bottom withdraws to lessen the frequency of anoxic conditions and still maintain the electrical generation purposes of the dam. In recent years this equipment failed and staff were unable to use Dr. Lehman's procedures efficiently and Ford Lake had nuisance algae blooms, particularly in late summer of 2020-2022.

That particular problem was fixed with an EGLE Watershed grant, but regular maintenance of the monitoring equipment must still remain a priority for keeping the bottom draws operational with the result of lessened anoxia and internal cycling. Lehman's sensors lasted about 10 years.

Timeframe: Maintenance yearly; replacement of sensors as needed but potentially every ten years based on past experience.

Costs: $20k to replace the sensors plus township staff time

Potential funding sources: EGLE Watershed Council grants; relevant 319 grants (as a part of the grant if it deals with Ford Lake phosphorus; not the full grant)

Success Measures: # of algae blooms on Ford Lake; improved lake DO.

B. Fix French Landing Dam Portage

As of 2023, the operators of French Landing Dam are working with Van Buren Township officials to relicense the dam for hydropower generation through the Federal Energy Regulatory Commission (FERC). The relicensing procedure is comprehensive and has revealed several opportunities to improve safety for recreation and flow management near French Landing Dam.

In particular, the portage around this dam is considered the most dangerous along the entire Huron River Water Trail. The entire portage trail is subject to routine vandalism, and the downstream portage launch is a narrow set of wooden steps anchored to a concrete retaining wall. Given the position and dimension of the portage, along with flow management of the dam, it's common for the wooden steps to be suspended several feet from sure footing for launching small watercraft. All options should be considered for improving, fortifying, or relocating the portage access points, as climate change will likely make flows even less predictable and more dangerous to people accessing the portage.

Timeframe: 2024-2027

Milestones:

- 2024-25: Plans finalized for a portage fix
- 2026-2027: Plans are implemented and a high functioning portage is constructed.

*Cost: $*25k- 50k

Potential funding sources: Private investment; Township infrastructure funding, and/or family foundations.
Success Measures: Increased recreational usage

C. Maintain and Implement Stormwater Management Plans

As mentioned in 3.3.5.1 and 3.3.6, the recent 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. Continued efforts to reduce stormwater leakage into the sanitary sewers are effective for lessening the chances for untreated sewage run off. These actions are described more fully in community Stormwater Management Plans (SWMPs).

All MS4s in the Watershed submit completed Stormwater Management Plans (SWMPs) along with permit applications to EGLE every five years. 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. The reference to the SWMPs in this WMP are meant to indicate that these MS4 communities do prioritize proper stormwater management for the betterment of the Watershed's water quality.

Section 319 dollars cannot be used to implement activities required by a permit, if 319 dollars are used in these areas, they must be above and beyond what is called for in the permit.

Readers should refer to SWMPs from individual municipal and county agencies to find activities beyond those specified within this WMP.

Timeframe: 2024-2034
Milestones:

- 2026: Revise plans and resubmit for permits.
- Ongoing: Implement recommendations of each individual SWMP, including:
  - Upgrading aging parts and maintaining system components
  - Implementing GSI projects

Cost: Permitting: Development of SWMPs and permit applications: $25k. $50k total.
Costs of Repairs to SW systems: 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, county budgets, stormwater utility funds, and agency budgets. Larger system upgrades should take advantage of 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: Monitoring results, % of systems meeting satisfactory or equivalent ratings, # problems corrected, lbs of sediment cleared, wildlife accesses blocked (bacteria source)

D. Enforce rules, standards and ordinances for stormwater management

The Washtenaw County Water Resource Commissioner developed rules and engineering standards for new and re-development to help reduce 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. WCWRC'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. All municipalities in Washtenaw county have adopted stormwater ordinances which refer to these stormwater standards. WRC staff review development proposals to ensure they meet WRC 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 WCWRC.
Success Measures: Reduced runoff compared to previous standards, monitoring (see chapter 5)

E. Natural Areas Protection.

Stakeholder partners, including municipalities and land conservancies throughout the Watershed, should pursue acquisition, conservation easements or otherwise preserve natural areas.

Through the use of HRWC's existing prioritization and the accomplishment of Recommendation S3 (field assessments and enhanced ranking system), high ranking natural areas should be permanently protected through acquisition and conservation easements.

Current land protection programs include the City of Ann Arbor's Greenbelt program and Washtenaw County's Natural Areas Protection Program. These programs are funded through a land protection millage levied on property taxes. These kinds of protection programs should be implemented by all municipalities in the Watershed.

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 foundations.

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.

Timeframe: 2022-2032
Milestones:
- By 2032: One municipality in the Watershed starts a land conservation program based on a millage levied on property taxes.
- By 2032: 500 new acres of the highest priority natural areas in the Watershed is purchased or put into a conservation easement.

Cost: $5000- $15,000 an acre for easements; approximately $10M for 1000 acres.
Potential funding sources: see text above
Success Measures: # of acres protected

F. Pet waste ordinance education and enforcement
Pet waste ordinance development was suggested as a River Friendly policy in recommendation PE3.

After such ordinances are passed, and in areas where the ordinance already exists, we recommend an educational campaign to educate 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 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.

Timeframe: 2022-2032
Milestones:
- 2022-23. Draft ordinance developed, revised and passed in Scio Township
- 2024. Education Materials distribution.
- 2025-2032. Ordinances in other municipalities enacted.
- 2026-2032. Follow-up education and surveys.

Cost: Elected official time in review and enactment: $15,000.
Potential funding sources: Section 319, local government match
Success Measures: Ordinance enactment, volume of calls about ordinance, ordinance enforcement rate, monitoring (see section 5).

G. Place doggie bag stations at target locations

Local municipalities and park systems, including the County, Townships, and HCMA should install pet waste stations at local parks, frequently recreated public areas, and other likely high-concentration areas to reduce bacteria contamination of stormwater. This should reduce pet waste in high traffic areas, subsequently reducing the amount of E. coli entering the watershed via pet waste. 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, the property owners should modify the placement of the stations or expand the network. This activity should be done in conjunction with activity F.

Timeframe: 2022-2032
Cost: 50 dog waste stations @ $150 ea.: $7,500; technical assistance, installation, maintenance labor: $20,000. Total: $27,500
Success measures: Number of stations installed, bag volume utilized, pounds of feces removed

H. Climate Action Planning

Chapter 3 describes the changes in climate already occurring and those to come, and the impact on all the sources of impairments addressed in this watershed management plan. Each municipality and resident in the Watershed must take action to reduce greenhouse gas emissions to the greatest extent possible and as quickly as possible, to avoid the most catastrophic impacts. Municipalities must act now to build resilience against the inevitable increased flooding, extreme temperatures, habitat degradation, and other impacts the Watershed is already suffering.

The City of Ann Arbor has created an ambitious plan, A2Zero, for city operations and the entire community to reach carbon neutrality by 2030. Washtenaw County has pledged for its municipal operations to reach neutrality by 2030 and for community-wide neutrality by 2035. The county is creating its carbon neutrality plan currently. Other municipalities, businesses, institutions, and residents throughout the Watershed should engage with the county planning process and use the resulting climate action plan as a guide and resource to enact climate action policies.

Timeframe: 2022-2032
Cost: Highly variable depending on actions, $1M-$1B
Success Measures: municipalities creating climate action plans, enacting policies that will reduce community greenhouse gas emissions, enacting policies to increase climate resilience.

4.3. Impairment Loading Implications

4.3.1. 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 within the more proximate Middle Huron River, Section 2[2] plan 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. The further activities recommended in this upstream, Section 3 plan will provide a sufficient margin of safety, and the plan is thus quite conservative for addressing the phosphorus nutrient impairment. 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.

[1] Community-Based Study on PFAS in Fish. The Ecology Center. 2023.
https://www.ecocenter.org/sites/default/files/2023-02/Fish%20Report%202023%20V2.pdf

[2] Huron River Watershed Council. 2020. Middle Huron River Watershed Management Plan, Section 2.
https://www.hrwc.org/what-we-do/programs/watershed-management-planning/middle-huron-WMP-section-2/

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 10-Year Watershed Improvement Strategy 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. Measurable goals can be developed to evaluate BMP effectiveness, for example, by evaluating a structural BMP's effectiveness at reducing pollutant loadings. A public education campaign's effectiveness can be measured with social indicators as from a Social Indicators Data Management and Analysis (SIDMA) survey which quantifiably addresses how the campaign reached the target audience. 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 (Hydromorphology)
	8	Erosion Rates (BANCs), Bank Erosion Hazard Index (BEHI)
	9	Instream habitat monitoring
	10	Impacted dry weather flows (Flashiness Index)
	11	Increased flooding frequency
	12	Percent impervious surface of watershed area
	13	Stream temperature monitoring
Biological Indicators	14	Fish assemblage

This group of indicators uses biological communities to measure changes to or impacts on biological parameters.	15	Macroinvertebrate assemblage
	16	Single species indicator
	17	Composite indicator
	18	Other biological indicators
Social Indicators This group of indicators uses responses to surveys, questionnaires, and the like to assess various parameters.	19	Public attitude surveys
	20	Public involvement and monitoring
	21	User perception
Programmatic Indicators This group of indicators quantifies various non-aquatic parameters for measuring program activities.	22	Number of illicit connections identified/corrected
	23	Number of BMPs installed, inspected and maintained
	24	Permitting and compliance
	25	Growth and development
Site Indicators This group of indicators assesses specific conditions at the site level.	26	BMP performance monitoring
	27	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, water quantity, social, hydromorphology, and biological monitoring programs to determine where to focus resources as they progress toward meeting collective goals. These 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, 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 3. Finding creative ways to measure the effectiveness of each of these individual programs is a challenge.

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, online, 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. Con: No measure of change in behavior or retention of knowledge	Post-event participants complete brief evaluations that ask what was learned, what was missing, what could be done better. Evaluations completed on-site.
Stream and Lake Surveys	Identify riparian and aquatic improvements.	Habitat; Flow; Erosion; Recreation potential; Impacts	Pro: Current and first-hand information. Con: Time-consuming. Expertise and some cost involved.	Identify parameters to evaluate. Use form, such as Stream Crossing Inventory or MiCorps Score the Shore, 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 and expertise to do well.	Select random sample of population as participants. 6-8 people per group. Plan questions, facilitate. Record and transcribe discussion. Analyze results.

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 3, 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. The BANCs assessment was conducted in 2021-2022 and could be repeated when this plan needs to be updated.

- 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 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. The data can be summarized as biological indicators like fish assemblages, macroinvertebrate assemblages, single species indicators, and composite indicators like the Hilsenhoff Index of Biotic Integrity.

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

- HRWC could better promote and facilitate lake monitoring on Ford and Belleville through the Cooperative Lakes Monitoring Program (CLMP) of the MiCorps program.[2] The CLMP provides training and equipment for volunteers to measure transparency, chlorophyll, dissolved oxygen, total phosphorus, shoreline habitat and erosion, and aquatic plants.

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

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.

Total Body Contact (May1 thru October 31)

Daily Maximum Geometric Mean: 300 E.coli per 100 ml

30-Day Geometric Mean: 130 E.coli per 100 ml

Partial Body Contact (all year)

Daily Maximum Geometric Mean: 1,000 E.coli per 100 ml

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 D).

Table 5.3 Ford Lake Loading Capacity (From the Total Maximum Daily Load for Total Phosphorus in Ford and Belleville Lake, Table 3, Appendix D).

	Permit Number	Current Load lbs/yr	TMDL Goal lbs/yr	TMDL Goal lbs/day
LA				
Huron River upstream of Bell Road/TMDL watershed		19000	15000	41.1
Urban		3000	800	2.2
Agriculture		19000	7000	19.2
Other		500	500	1.4
Internal Load		2000	480	1.3
Precipitation/Deposition		130	130	0.4
LA Total		43630	23910	65.5
TMDL WLA				
WWTP				
Ann Arbor WWTP	MI0022217	22000	8980	24.6
Chelsea WWTP	MI0020737	600	560	1.5
Dexter WWTP	MI0022829	270	180	0.5
Loch Alpine SA-Scio-WEB WWTP	MI0024066	510	95	0.3
Thornton Farms WWTP	MI0056405	200	45	0.1
Other				
Chrysler-Chelsea Proving Grds	MI0046540	40	40	0.1
Sweepster Harley Attachments	MI0045934	100	100	0.3
Thetford/Norcold-Dexter	MI0036951	40	40	0.1
UM Power Plant	MIG250333	20	20	0.1
Ann Arbor WFP	MIG640207	30	30	0.1
Aggregate MS4	(See Table 1)	9180	2500	7
WLA Total		32990	12590	34
Margin of Safety			Implicit (0)	
Total Load		76620	36500	100

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.”[3] 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 HRWC 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.”

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. That being said, EGLE recommends using the Richard-Baker Flashiness Index as a way of understanding flow and interpreting other data, such as watershed development trends, stream bank erosion rates, or biological survey data.[4]

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.[5] 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. In addition to EGLE, The DNR Fisheries Division also does fisheries assessments on both lakes and streams.

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. HRWC 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 scores of EGLE and HRWC monitoring to improve “poor” and “fair” communities to “good” while maintaining the “good” and “excellent” conditions at the remaining sites.

Temperature:

Rule 75 of the EGLE Waters Quality Standards[6] states that Rivers, streams, and impoundments naturally capable of supporting warmwater fish shall not receive a heat load which would warm the receiving water at the edge of the mixing zone more than 5 degrees Fahrenheit above the existing natural water temperature.

and

Rivers, streams, and impoundments naturally capable of supporting warmwater fish shall not receive a heat load which would warm the receiving water at the edge of the mixing zone to temperatures greater than the following monthly maximum temperatures:

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
41	40	50	63	76	84	85	85	79	68	55	43

Although some temperature data have been collected in the Middle Huron system by the HRWC program and as part of the monitoring for the Middle Huron Partnership Initiative, additional studies are needed to establish natural temperatures regimes 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 Landscape Level Wetland Functional Assessment (LLWFA) should assist with tracking. 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 Natural Areas Program evaluates small, non-regulated wetlands. Once identified, these should also be tracked as above.

Reporting: 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 periodic reports (approximately every 2 years) as part of Phase II stormwater compliance. HRWC produces a summary of results on the Adopt-a-Stream and Chemistry/Flow 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 programs administered by HRWC and EGLE.

First, through its Adopt-a-Stream/BioMonitoring program, HRWC collects data on benthic macroinvertebrates three times a year, including a special collection of winter stoneflies. HRWC also samples for water conductivity at each macroinvertebrate event. HRWC 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. Summer temperatures are also documented every 5 years. HRWC uses volunteers to collect the vast majority of the data. Results from this program are included in section 2.4. The wadable portion of the Huron River in Section 3 is rather short and there is only 1 evaluated site along this stretch (Huron River at Riverside Park in Ypsilanti).

HRWC also administers the Chemistry/Flow 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 and the YCUA Wastewater Treatment Plant for analysis. Analytes include total phosphorus, nitrates, nitrites, total suspended solids and *E. coli*. Volunteers also collect stream discharge data from all 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.

EGLE conducts rotational watershed assessments 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. EGLE most recently sampled in 2022 with the next rotation set for 2027. Specific locations and data can be found online: https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-32369--,00.html

EGLE welcomes suggestions for monitoring sites outside of the basin year through the targeted monitoring process if there is a specific need identified.

Table 5.3 HRWC Middle Huron River (Section 3) Watershed Monitoring and Evaluation

Locations can be seen at: https://www.hrwc.org/our-watershed/maps/ and then pick the "Macroinvertebrate" card.

Adopt-a-Stream Monitoring Site	Parameter Target[2]	Type of Analysis	Protocol	Frequency	Test Agent
Huron River A24	T, I, Bio, S	Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC
		Temperature	Multi-Meter	3-5 yr interval	HRWC
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC
		Conductivity	Multi-Meter	2-3x/year	HRWC

Locations can be seen at: https://www.hrwc.org/our-watershed/maps/ and then pick the "Chemistry of Local Water" card.

MHP Monitoring Site	Parameter Target[2]	Type of Analysis	Protocol	Frequency	Test Agent
Huron River MH11, HR11, HR13 *Snidecar Drain* SD01 *Superior Drain #1* SD01 *Willow Run* WR01	S,N,DO,T,I, B	Total Suspended Solids	SM20 2540 D[3]	2x/Mo Apr-Sept	HRWC
		Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo Apr-Sept	HRWC
		Temp, DO, pH, Conductivity	Multi-Meter	2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	2x/Mo Apr-Sept	HRWC

[2] S= Sediment; N= Nutrients; DO= Dissolved Oxygen; T= Temperature; I= Ions; B= Bacteria; Bio= Biota
[3] 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 3 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.

Yet our concerted efforts can't slack or wane. This 2024 Watershed Management Plan provides plenty more possibilities to continue efforts toward water quality, reduced erosion, and better habitat. Each community in the watershed continues to have 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] Cooperative Lakes Monitoring Program. https://micorps.net/lake-monitoring/. Accessed September 2023.

[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.

[4] EGLE. 2012. Application of the Richards-Baker Flashiness Index to Gaged Michigan Rivers and Streams. https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/NPS/Tech/hsdsu-flashiness.pdf?rev=813d4ad07fd24d29b2757b7dc5a75845. Accessed June 2022.

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

[6] Dept. of Environmental Quality Water Bureau Water Resources Protection. Part 4 Water Quality Standards. https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Programs/WRD/NPDES/part-4-water-quality-standards.pdf?rev=4af3d104bbef4e13b4bfd780b2c0ef19&hash=E04D173C3BE9456EAD1FAB3F42DE7230