Burt Lake Watershed Management Plan

Protecting the Water Resources of the Burt Lake Watershed

2018

Burt Lake, Little Carp River, Hasler Creek, Unnamed Creek of West Burt Lake Road, White Goose Creek, Douglas Lake, Lancaster Lake, Lancaster Creek, Larks Lake, Munro Lake, Certon Creek, Cold Creek, Cope Creek, Bessey Creek, Beaver Tail Creek, Brush Creek, Maple River, East Branch Maple River, West Branch Maple River, Van Creek, Arnott Lake, Sherett Lake, Vincent Lake, Crooked Lake, Mud Lake (Emmet County), Pickerel Lake (Emmet County), Round Lake, Spring Lake, Iduna Creek, Weber Lake, Cedar Creek, Crooked River, McPhee Creek, Minnehaha Creek, West Branch Minnehaha Creek, Mud Creek, Oden Creek, Sanford Creek, Silver Creek, Silver Creek Pond, Berry Creek, Deer Creek, Allen Creek, Blackjack Creek, Bradley Creek, Barhite Lake, Berry Lake, Beebe Creek, Black Lake, Bows Lake, Fitzek Lake, Fleming Lake, Fulmer Lake, Heart Lake, Hoffman Lake, Kidney Lake, Clifford Lake, Lake Eighteen, Olund Lake, Reardon Lake, Standard Lake, Storey Lake, Woodin Lake, Mud Lake (Cheboygan County), Huffman Lake, Pickerel Lake (Otsego County), Silver Lake, Mossback Creek, Marl Creek, Pickerel Creek, Stewart Creek, Thumb Lake, Wildwood Lake, Club Stream, Sturgeon River, West Branch Sturgeon River

Acknowledgements

Thank you to Julia Kirkwood and Greg Goudy of the Michigan Department of Environmental Quality Nonpoint Source Program for their assistance with development of the Burt Lake Watershed Management Plan.

Thank you to the Burt Lake Watershed Advisory Committee for their dedication to protecting the Burt Lake Watershed through watershed management planning and implementation.

Financial assistance for this project was provided, in part, by a Michigan Department of Environmental Quality's Nonpoint Source Program grant under Section 319 of the Federal Water Pollution Control Act (Clean Water Act). Funding for the program is provided to the MDEQ from the United States Environmental Protection Agency for the implementation of nine-element watershed management plans.

The Burt Lake Watershed Management Plan was prepared by:

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November 2017

Approved under Section 319 of the federal Clean Water Act
September 2018

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Introduction

Northern Michigan is known for its outstanding lakes and streams. Our water resources are legendary….Douglas Lake, Burt Lake, Walloon Lake, Jordan River, Sturgeon River… to list only a few whose names are known far and wide. We depend on these waters for our livelihood, our recreation, and our traditions. In return, we must be good stewards of these resources and work collaboratively and continually to see that they are protected now and into the future.

> "Economically, inland lakes support a recreational industry valued at $15 billion per year and the value of shoreline property is estimated to be worth $200 billion, generating $3.5 billion in tax revenue. Comprehensive water quality monitoring is necessary to inform natural resource management, assess inland lake quality, and protect public health. Although the Michigan Department of Environmental Quality (MDEQ) is the lead state agency responsible for monitoring, assessing, and managing the state's surface water and groundwater, effective water resource management is best achieved through partnerships with other state and federal agencies, local governments, tribes, universities, industry, environmental groups, and citizen volunteers. Wherever possible, the MDEQ strives to organize and direct the resources and energies created by these partnerships through a "watershed approach" to protect the quality and quantity of the state's water resources."
>
> -Monitoring Strategy for Michigan's Inland Lakes (MDEQ)

The Burt Lake Watershed Management Plan is the result of this partnership among an active group of stakeholders under the unifying element of the watershed management plan process. Through this process we have inventoried aquatic resources, collected data, analyzed results, and synthesized the information into this Watershed Management Plan. It includes our shared goals and objectives, and a lengthy list of implementation steps designed to restore degraded water resources and protect the pristine lakes and streams of the Burt Lake Watershed.

The Burt Lake Watershed Advisory Committee

Dozens of Burt Lake Watershed stakeholders, including local government officials, natural resource managers, non-profits, lake association groups, were invited to attend the first Burt Lake Watershed Advisory Committee on Friday, April 1, 2016 at Tuscarora Township Hall in Indian River, MI.

The invitation read as follows:

> Hello! This email is your invitation to participate in the newly forming Burt Lake Watershed Plan Advisory Committee. We hope you can join us as a partner in the creation of a new Watershed Management Plan! Invitations are going out to local government entities, agencies, and citizen organizations, and to interested individuals, as well.
>
> Tip of the Mitt Watershed Council received a grant from the Michigan Department of Environmental Quality (DEQ) to write a new plan for the Burt Lake Watershed, including the Sturgeon, Crooked, and Maple Rivers. We spent the past two years working in the field to collect data about the region. We are now in the process of actually writing the plan. We hope you can join us for the first meeting of this group.
>
> We need your feedback to help finalize the plan and get it approved by both the DEQ and the US Environmental Protection Agency (EPA). This is our first goal – to accomplish plan approval. That is because once it is approved, all partners involved in the plan can use it to obtain grant funding for projects to implement steps of the plan. Examples of grant projects based on the new Watershed plan could include things like replacing old culverts at road/stream crossings to prevent sedimentation from tributaries; restoring shorelines to help with habitat concerns; or sponsoring education programs to teach shoreline property owners about best practices for septic maintenance.
>
> At this first meeting, we will present information about the fieldwork done to create a foundation for the new plan, and will give you a general overview. We will explain how the writing process unfolds, and how you and your group or organization can contribute. You will have the opportunity to be listed formally as a plan partner. Come and see what all the excitement is about!

Subsequent meetings were held in June, August, and October (Appendix F), with plans for the Advisory Committee to continue to meet quarterly for years to come. The Advisory Committee was asked to provide input for the development of the Watershed plan through the meetings, as well as several "homework" assignments (Appendix F).

Burt Lake Watershed Advisory Committee:

Burt Lake Preservation Association

Burt Township

Cheboygan County Planning & Zoning

Cheboygan County Planning Commission

Cheboygan County Road Commission

Conservation Resource Alliance (CRA)

Douglas Lake Improvement Association (DLIA)

Emmet County Planning & Zoning

Emmet County Road Commission

Huron Pines

Little Traverse Bay Bands of Odawa Indians

Little Traverse Conservancy

Michigan Department of Environmental Quality

Michigan Department of Natural Resources

Michigan Department of Transportation/North Region

Miller Van Winkle Chapter of Trout Unlimited

Pickerel-Crooked Lakes Association

Sturgeon for Tomorrow

Tip of the Mitt Watershed Council

Wilmot Township

Watershed Residents:

Trish Woollcott

CHAPTER 1

The Burt Lake Watershed

The Burt Lake Watershed includes some of the Michigan's greatest natural resources. Thousands of residents live and recreate on the Watershed's lakes and streams, and thousands more come as tourists to enjoy the opportunities these high-quality water resources have to offer. Northern Michigan depends on these resources and their protection is critical. Despite the Watershed's mostly rural landscape, its water resources are continually threatened by nonpoint source pollution.

The Watershed includes four major subwatersheds and their lakes and streams:

Burt Lake Direct Drainage:
Burt Lake, Little Carp River, Hasler Creek, Unnamed Creek of West Burt Lake Road, White Goose Creek

Maple River Watershed:
Douglas Lake, Lancaster Lake, Lancaster Creek, Larks Lake, Munro Lake, Certon Creek, Cold Creek, Cope Creek, Bessey Creek, Beaver Tail Creek, Brush Creek, Maple River, East Branch Maple River, West Branch Maple River, Van Creek, Arnott Lake, Sherett Lake, Vincent Lake

Crooked River Watershed:
Crooked Lake, Mud Lake (Emmet County), Pickerel Lake (Emmet County), Round Lake, Spring Lake, Iduna Creek, Weber Lake, Cedar Creek, Crooked River, McPhee Creek, Minnehaha Creek, West Branch Minnehaha Creek, Mud Creek, Oden Creek, Sanford Creek, Silver Creek, Silver Creek Pond, Berry Creek, Deer Creek

Sturgeon River Watershed:
Allen Creek, Blackjack Creek, Bradley Creek, Barhite Lake, Berry Lake, Beebe Creek, Black Lake, Bows Lake, Fitzek Lake, Fleming Lake, Fulmer Lake, Heart Lake, Hoffman Lake, Kidney Lake, Clifford Lake, Lake Eighteen, Olund Lake, Reardon Lake, Standard Lake, Storey Lake, Woodin Lake, Mud Lake (Cheboygan County), Huffman Lake, Pickerel Lake (Otsego County), Silver Lake, Mossback Creek, Marl Creek, Pickerel Creek, Stewart Creek, Thumb Lake, Wildwood Lake, Club Stream, Sturgeon River, West Branch Sturgeon River

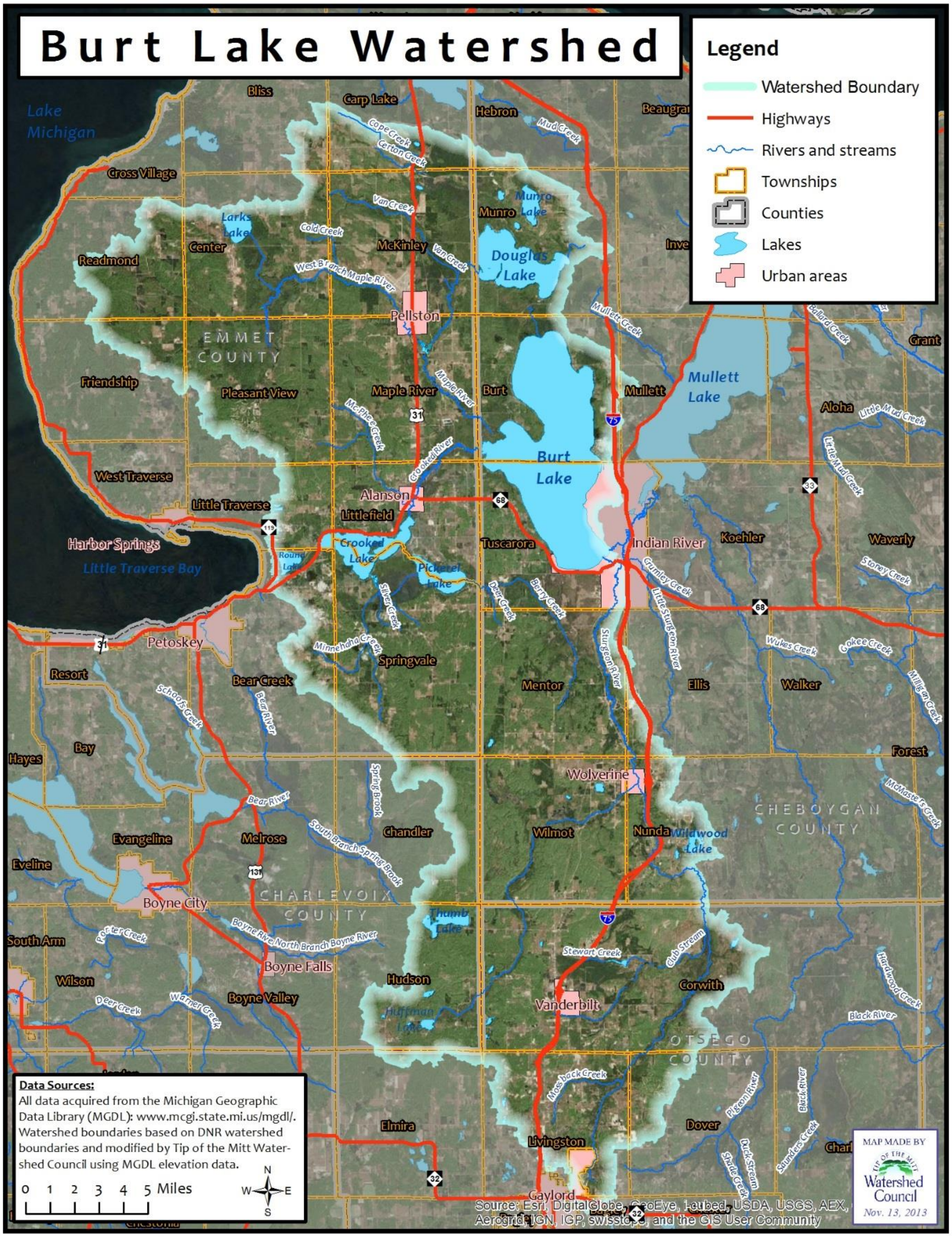


Figure 1: Burt Lake Watershed

Land Cover

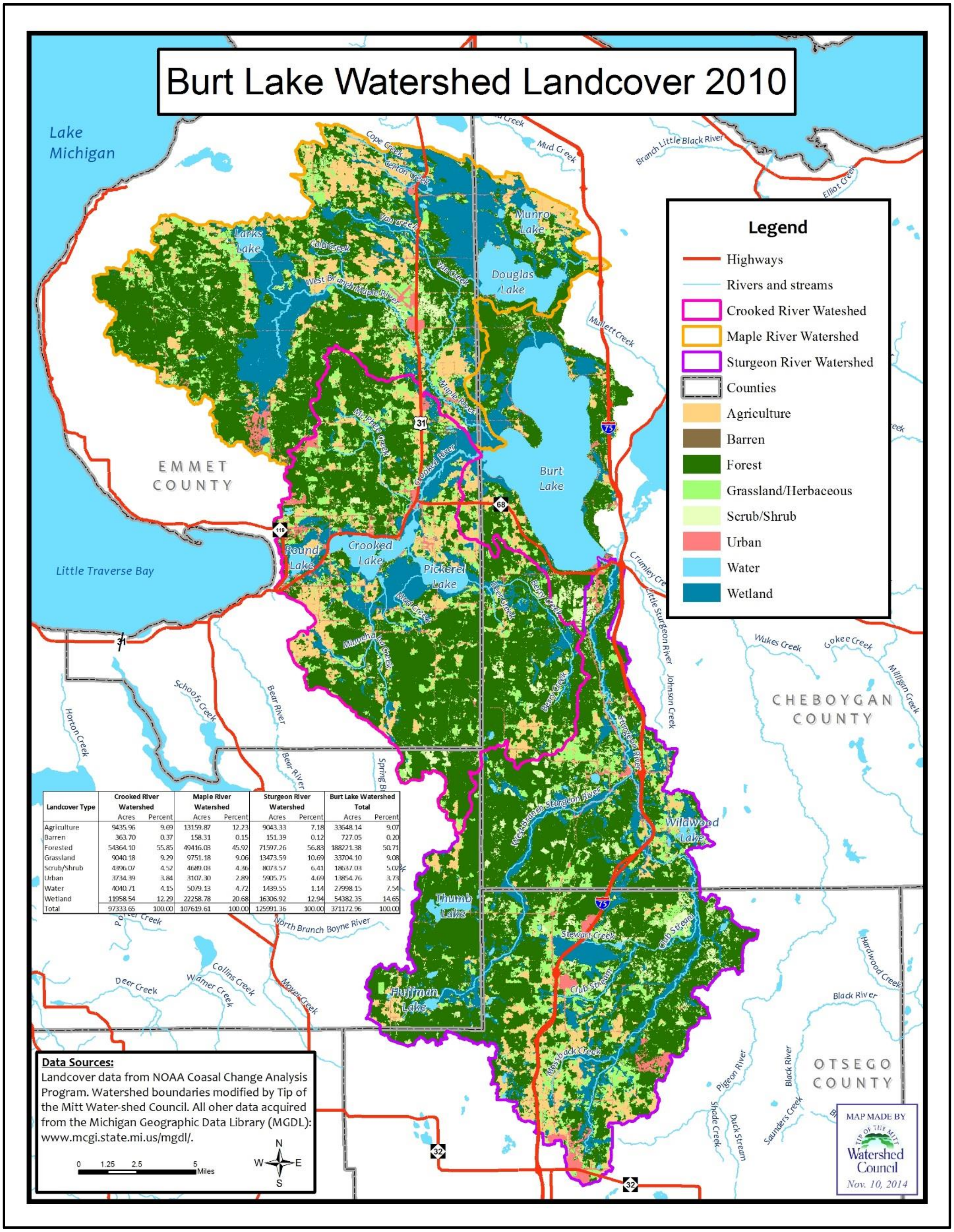
Land cover refers to the material present at the surface of the earth. Land cover may be either a biological (e.g. grassland or pine forest), physical (e.g. lake or parking lot) or chemical (e.g. concrete or asphalt) categorization of the surface. Although land use/land cover can be (and has been) categorized in great detail, there are four basic land use/covertypes: urban, agricultural, wetland, and collectively forested/grassland/scrub/shrub. The type of land and the intensity of its use will have a strong influence on the receiving water resource. Studies have determined the likely inputs of nutrients and other pollutants from different land uses/cover types.

The Burt Lake Watershed encompasses an impressive 371,173 acres. The vast majority (51%) of the Watershed is forested, followed by wetlands (15%). The undeveloped nature of the Watershed certainly contributes to its high-quality water resources. The composition of the various land covers has remained consistent, as compared to other watersheds in more developed regions, according to land cover statistics generated using data from the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program. Between 1985 and 2010, the largest change in land cover occurred in forested lands (-1.97%), grasslands (-1.24%), scrub/shrub (+1.47%) and urban (+.91%)(Table 1)(Figure 2).

Table 1: Burt Lake Watershed land cover (NOAA 2010)

Land Cover Type	Crooked River Watershed		Maple River Watershed		Sturgeon River Watershed		Burt Lake Direct Drainage		Burt Lake Watershed Total	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Agriculture	9,436	10	13,160	12	9,043	7	2,009	5	33,648	9
Barren	364	0	158	0	151	0	54	0	727	0
Forested	54,364	56	49,416	46	71,597	57	12,844	32	188,221	51
Grassland	9,040	9	9,751	9	13,474	11	1,439	4	33,704	9
Scrub/Shrub	4,396	5	4,689	4	8,074	6	1,478	4	18,637	5
Urban	3,734	4	3,107	3	5,906	5	1,107	3	13,855	4
Water	4,041	4	5,079	5	1,440	1	17,439	43	27,998	8
Wetland	11,959	12	22,259	21	16,307	13	3,858	10	54,382	15
Total	97,334	100	107,620	100	125,991	100	40,228	100	371,173	100

Of the 371,173 acres, the Burt Lake Watershed has 112,570 acres of protected lands, there are 112,570 acres of protected lands within the Burt Lake Watershed. Protected lands include state forests and parks, federal forests, township and county parks and lands, conservancy preserves, and conservation easements on private properties. Together these lands comprise 30% of the Watershed's total acreage. Excluding the privately owned conservation easements (5,472 acres), there are 107,098 acres of publicly owned protected lands, which equals slightly less than 30% of the total Watershed.



Landcover Type	Crooked River Watershed		Maple River Watershed		Sturgeon River Watershed		Burt Lake Watershed Total	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Agriculture	9435.96	9.69	13159.87	12.23	9043.33	7.18	33648.14	9.07
Barren	363.70	0.37	158.31	0.15	151.39	0.12	727.05	0.20
Forested	54364.10	55.85	49416.03	45.92	71597.26	56.83	188221.38	50.71
Grassland	9040.18	9.29	9751.18	9.06	13473.59	10.69	33704.10	9.08
Scrub/Shrub	4396.07	4.52	4689.03	4.36	8073.57	6.41	18637.03	5.02
Urban	3734.39	3.84	3107.30	2.89	5905.75	4.69	13854.76	3.73
Water	4040.71	4.15	5079.13	4.72	1439.55	1.14	27998.15	7.54
Wetland	11958.54	12.29	22258.78	20.68	16306.92	12.94	54382.35	14.65
Total	97333.65	100.00	107619.61	100.00	125991.36	100.00	371172.96	100.00

Figure 2: Burt Lake Watershed land cover (2010)

Inland Waterway

The Burt Lake Watershed includes part of the Inland Waterway, one of Michigan's longest chains of rivers and lakes. It begins with Crooked Lake and extends to Lake Huron via the Crooked River, Burt Lake, Indian River, Mullett Lake, and the Cheboygan River. The Burt Lake Watershed includes Crooked Lake, the Crooked River, and Burt Lake. Historically, the Inland Waterway was used by the Native Americans and trappers as a fast route across Northern Michigan instead of the longer, more dangerous passage through the Straits of Mackinac. Today, the Inland Waterway provides recreational boaters with over 40 miles of navigable waters, plus direct access to four of Michigan's most beautiful and popular lakes.

Figure 3: Inland Waterway steamer (www.riverboattoursmi.com)

Glacial History of the Inland Waterway

The size, depth, and configuration of the lakes and rivers of the Inland Waterway were shaped in large part by the advance and retreat of vast continental glaciers. The last advance of the glaciers, which covered most of Cheboygan and Emmet counties, was known as the Valders Advance.

The deep lakes of the Inland Waterway region were formed when huge blocks of ice were left in the area during glacial retreat. As these huge ice blocks melted they left behind the deep basins which now make up the lakes. As the glaciers receded meltwaters flooded the region. Many of the low lying wetland areas that border the Waterway, including the Crooked River Marsh, Pigeon River Spreads, and the Indian

River Spreads, were once under 129 feet of water. The entire area was part of vast lakes known as Lakes Algonquin and Nipissing, precursors to the modern Great Lakes.

The geology of the region is variable due to its glacial origin. As the glaciers advanced and retreated across the landscape, they deposited the debris scraped from the land surface. In many areas of Northern Michigan, this glacial drift is hundreds of meters thick. It is composed of a mixture of sand, gravel, and rocks in a matrix of silt and clay. These deposits overlay limestone bedrock in the Burt Lake Watershed. Bedrock is found near the surface in a few areas, but is generally more than 100 meters below the surface throughout most of the Watershed.

Soils

Soils are an important watershed feature for many aspects of water resource management, including groundwater recharge, septic system performance, and erosion/sedimentation potential. Soil is the unconsolidated material within six feet of the surface that has been modified from the "parent" glacial deposits by climate, biological processes, and other environmental factors.

In the United States, soils are assigned to four hydrologic soil groups, A, B, C, and D. This describes their rate of water infiltration when the soils are not protected from vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The hydrologic soil groups in the Burt Lake Watershed include mostly A groups, followed by C and D. Group A consists of soils that have high infiltration rates even when thoroughly wet, because of sandy or gravelly, well-draining soils. Groups C and D have respectively slower infiltration rates when thoroughly wet, due to fine texture or clay-rich soils. Soil descriptions for the subwatersheds are provided in following sections.

Climate

The local climate for the Burt Lake Watershed varies slightly because of the extensive size and varying topography. In general, summers are mild and winters are snowy and cold.

Table 2: Climate data for the Pellston Regional Airport

Annual high temperature	53.3°F
Annual low temperature	30.4°F
Average temperature	41.85°F
Average annual precipitation (rainfall)	30.2 inches
Average annual snowfall	96 inches
Average warmest month	July
Average coolest month	February
Average wettest month	October
Average driest month	February

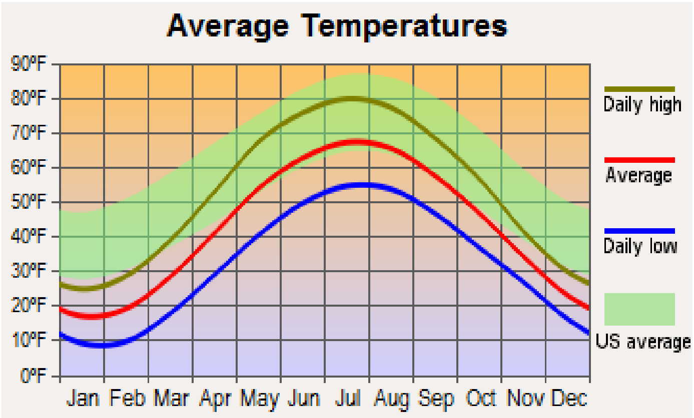


Figure 4: Average temperatures for Gaylord, MI (www.city-data.com)

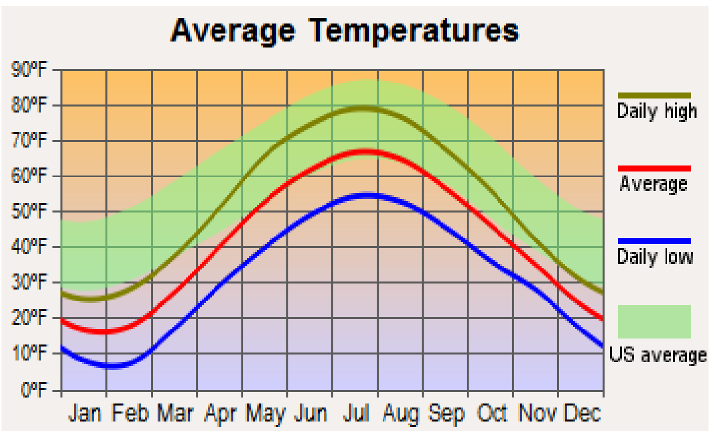


Figure 5: Average temperatures for Pellston, MI (www.city-data.com)

Groundwater

Groundwater is critically important for water quality and ecosystem integrity of lakes, streams, and wetlands. Rain, melting snow, and other forms of precipitation move quickly into and through the ground throughout much of the Watershed due to highly permeable (sandy) soils. Gravity causes vertical migration of groundwater through soils until it reaches a depth where the ground is filled, or saturated, with water. This saturated zone in the ground is called the water table and can vary greatly in depth. Figure 6 illustrates groundwater recharges areas throughout the Watershed based on their respective infiltration rates.

In watershed areas with steep slopes, hillsides intersect the water table, resulting in groundwater expulsion at the land surface. The exposed water table causes horizontal groundwater movement, which releases to create seeps and springs that then form or contribute water to streams and wetlands. The degree of groundwater contributions to surface waters in the Burt Lake Watershed is illustrated in subwatershed maps found in following sections. The data used to generate the maps are based on the Michigan Rivers Inventory subsurface flux model (MRI-DARCY), which uses digital elevation and hydraulic conductivity—inferred from mapped surficial geology—to estimate spatial patterns of hydraulic potential. The model is used to predict groundwater delivery to streams and other surface water systems because biological, chemical, and physical attributes of aquatic ecosystems are often strongly influenced by groundwater delivery.

The surface waters of the Burt Lake Watershed are dependent upon groundwater inputs. This dependency makes it is extremely important to protect and conserve groundwater resources in the Watershed. The prevailing sandy soils that facilitate groundwater recharge and expedite groundwater transport to surface waters also present a danger to the aquifers, streams, lakes, and wetlands in the Burt Lake Watershed. Although soils are a natural filtration medium, pollutants associated with agricultural activity (e.g., pesticides, herbicides, nutrients) and the urban or residential environment (e.g., metals, automotive fluids, nutrients) can be transported through the ground and contaminate either drinking water supplies or local surface waters fed by groundwater. Furthermore, expanding development, such as road and house construction, alters the hydrologic cycle by replacing natural land cover with impervious surfaces, which impedes infiltration and groundwater recharge. Therefore, protecting groundwater resources must address both the potential for pollutants to reach and contaminate groundwater and the reduction of groundwater recharge due to development.

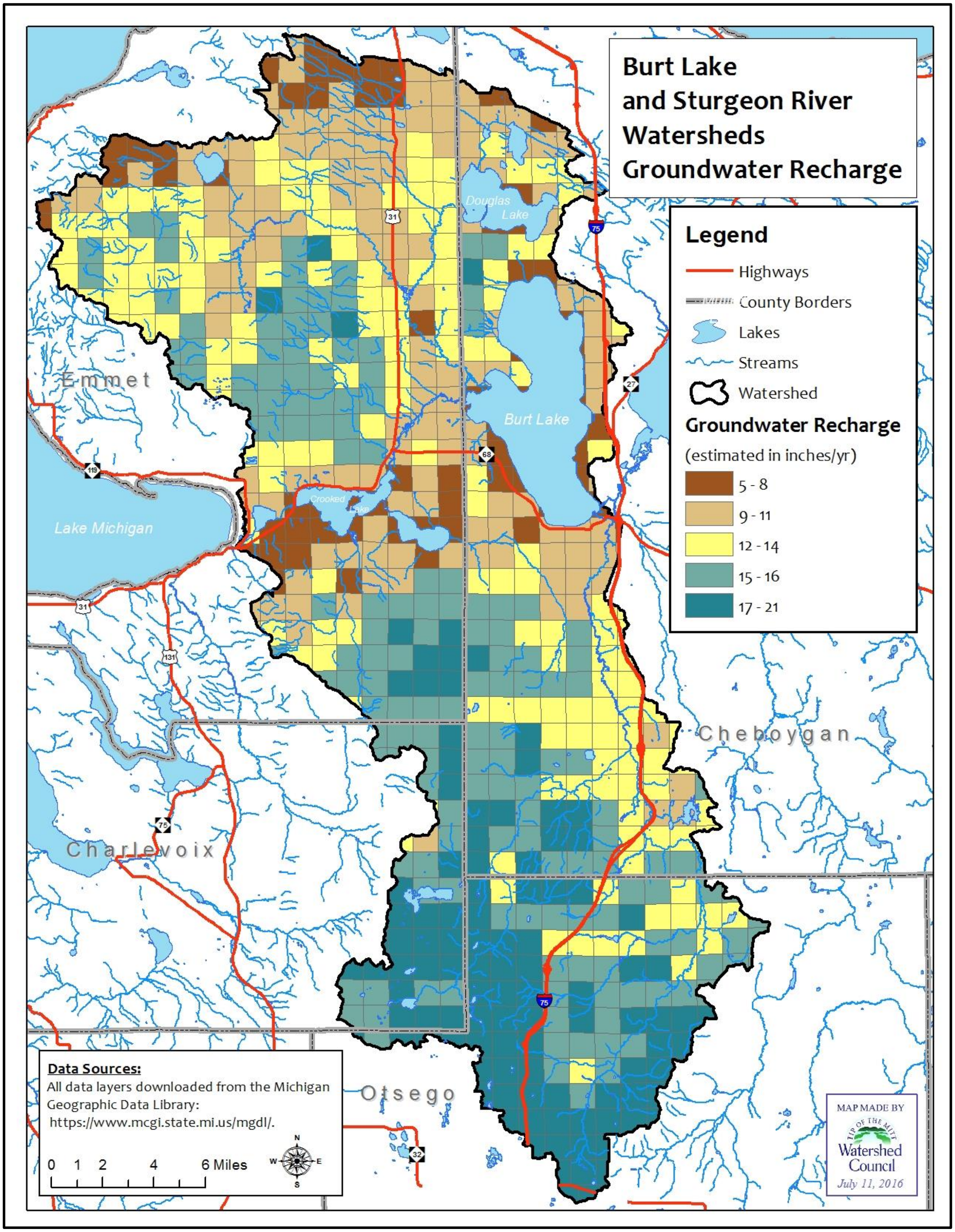


Figure 6: Burt Lake Watershed groundwater recharge

Drinking Water

Groundwater is the drinking water source for all communities within the Burt Lake Watershed. Many communities throughout Michigan, in an effort to protect their drinking water systems from many possible contamination sources, have Wellhead Protection Programs (WHPP) and Wellhead Protection Areas (WHPA). These programs are voluntary and designed to be locally initiated and implemented, with the Michigan Department of Environmental Quality (MDEQ) playing a supporting role. The Michigan Rural Water Association (MRWA) provides the expertise of their Groundwater Specialist to aid in the implementation of WHPPs. Michigan also has a Wellhead Protection Grant Program.

A Wellhead Protection Area (WHPA) is defined as the surface and subsurface areas surrounding a water well or well field, which supplies a public water system, and through which contaminants are reasonably likely to move toward and reach the water well or well field within a 10-year time-of-travel. The purpose of developing a WHPP is to identify the WHPA and take the necessary steps to safeguard the area from contaminants. The State of Michigan requires communities to identify seven elements to be included in the WHPP. These elements along with a brief description are below (MRWA 2015).

- **Roles and Responsibilities:** Identify individuals responsible for the development, implementation, and long-term maintenance of the local WHPP.
- **WHPA Delineation:** Determine area that contributes groundwater to the public water supply wells.
- **Contaminant Source Inventory:** Identify known and potential sites of contamination within the WHPA and include in a contaminant source inventory list and map.
- **Management Strategies:** Provide mechanisms that will reduce the risk of existing and potential sources of contamination from reaching the public water supply wells or well field.
- **Contingency Planning:** Develop an effective contingency plan in case of a water supply emergency.
- **Siting of New Wells:** Provide information on existing groundwater availability, the ability of the PWSS to meet present and future demands and the vulnerability of the existing wells to contamination.
- **Public Education and Outreach**: Generate community awareness in the WHPP by focusing on public education and the dissemination of WHPP information.

At this time, no community with in the Burt Lake Watershed has a WHPP.

Ecoregion

Ecoregions are regions that have relatively similar ecological systems. Ecoregions display regional patterns of environmental factors, such as climate, vegetation, soils, geology, physiography, and land use: the same factors that determine water quality within a watershed. Adjacent watersheds may or may not be within the same ecoregion.

The ecoregion concept is not new, having been described as early as the 1905. Subsequently, a number of ecoregion classification schemes have been developed. A widely utilized classification scheme identifying 120 ecoregions throughout the continental United States was developed by the U.S. EPA in the 1980s. The Cheboygan River Watershed, of which the Burt Lake Watershed is included, lies primarily within an ecoregion called "Northern Lakes and Forests" (#50), although a small area in the southwest corner of the Watershed lies within the "North Central Hardwood Forest" ecoregion (#51).

The Northern Lakes and Forests ecoregion is characterized by nutrient-poor soils, forests of conifers and northern hardwoods that cover a landscape of undulating till plains, morainal hills, broad lake basins, and extensive sandy outwash plains. Numerous lakes dot the landscape. Farming is not common. Logging and fires in the past have had great impacts on water quality, but the water quality remains high overall. Today, the effects of land use on water quality, especially in streams, are generally minimal. In fact, the portion of this ecoregion at the northern tip of Michigan's lower peninsula contains lakes that tend to have summer concentrations of total phosphorus less than five parts per million. Few other areas in the upper Midwest have lakes with such high water quality.

The North Central Hardwood Forests is transitional between the predominantly forested Northern Lakes and Forests to the north and the agricultural ecoregions to the south. Land use/land cover in this ecoregion consists of a mosaic forests, wetlands, lakes, cropland agriculture, pasture, and dairy operations.

Lake Classification

A classification scheme with three basic categories has been developed for lakes. Eutrophic is the term given to fertile waters with high levels of nutrients and high biological productivity. Oligotrophic is used to describe waters of low productivity. Mesotrophic lakes are those of medium productivity. Eutrophication is the process of nutrient enrichment (or "lake aging"). It is a natural process usually taking thousands of years for significant change to occur. However, nutrient pollution can greatly accelerate the eutrophication process, resulting in excessive amounts of plant and algae growth, among other things.

Burt Lake is a large, oligotrophic lake with extensive areas of shallow or only moderately-deep water, and a relatively small area of deep water that undergoes stratification. Although dissolved oxygen levels in the bottom waters drop, levels do not normally become totally depleted.

Crooked and Pickerel Lakes can generally be grouped as relatively deep, oligotrophic lakes that undergo summer stratification and consistently experience oxygen depletion in the deepest waters by late summer. Prior to the colonization of invasive mussels, these lakes trended more toward mesotrophic.

Douglas Lake is a multi-depression basin lake. This means that it has several deep basins separated by shallow areas. The basins are thought to have resulted when large blocks of ice became isolated from melting glaciers and were buried by outwash sediments. Upon melting of the buried ice blocks, a deep water-filled basin resulted. Each basin within the lake may have individual water quality characteristics. Douglas Lake's water is lightly brown-stained by the presence of high levels of dissolved organic compounds originating in wetlands throughout its large Watershed. Like Crooked and Pickerel Lakes, Douglas Lake is an oligotrophic lake that develops stratification and depleted oxygen levels in the deepest waters by late summer.

Larks, Munro, and Round Lakes are all shallow, mesotrophic lakes. They do not undergo summer stratification. However, Larks and Munro lakes are known to develop winterkill conditions during severe, snowy winters.

Fisheries

The Burt Lake Watershed includes some of the greatest fisheries within the state, including approximately 134 of stream miles of Blue Ribbon trout streams. Although many segments of coldwater streams are classified as designated trout streams, some are considered Blue Ribbon trout streams because they meet higher standards. These include their capacity to support stocks of wild resident trout, are large enough to permit fly casting but shallow enough to wade, produce diverse insect life and good fly hatches, have earned a reputation for providing a quality trout fishing experience, and have excellent water quality. The Blue Ribbon trout streams within the Watershed include: the Maple River from the Maple River Dam to the Cheboygan County line; the Sturgeon River from Sturgeon Valley Road to Burt Lake; and the West Branch of the Sturgeon River from Wilderness Road to the junction with the mainstream. Additional fisheries information can be found in the subwatershed sections.

Aquatic Invasive Species

Aquatic invasive species are non-native species introduced to an aquatic ecosystem that causes environmental and/or economic harm. Aquatic invasive species have come to the forefront of issues impacting our lakes, streams, and wetlands.

The Burt Lake Watershed, like many other watersheds, is infested to varying degrees with aquatic invasive species. Some species have been in the Watershed for decades while others are more recent invaders. Furthermore, some invasive species are on the verge of entering the Watershed as they expand their respective ranges. These species tend to be well established in the southern United States and are advancing northward. The Great Lakes also remain a potential source of invasives for inland lakes as many species spread via connecting waterways. The following species are all present within the Burt Lake Watershed. While there are many others that are not included here, these species are featured because of their prevalence or the threat they pose.

Zebra mussels

Zebra mussels (*Dreissena polymorpha)* are freshwater mollusks that have had a profound impact on the Great Lakes and inland lakes since their introduction in the late 1980s. The sheer number of zebra mussels in combination with their feeding habits has caused severe disruptions in aquatic ecosystems. As filter feeders, each zebra mussel is capable of filtering a liter of water per day; thus, removing almost every microscopic aquatic plant and animal (phytoplankton and zooplankton). The effect of this filtration is increased water transparency, which shows that water has become clearer in lakes infested with the mussels. Increased water clarity allows sunlight to penetrate to greater depths and results in increased growth of rooted aquatic vegetation and bottom-dwelling algae.

Zebra mussels are thought to be in all of the lakes within the Watershed. Exceptions may include smaller, isolated lakes without a connecting waterway to an infested lake.

Quagga mussels

Quagga mussels (*Dreissena rostriformis bugensis)* are freshwater mollusks similar in appearance to zebra mussels. A distinguishing characteristic between the two is when quaggas are placed on a surface they fall over as they lack a flat underside (hinged side), whereas zebra mussels remain stable on the flattened hinge side. Quagga mussels are commonly found in waters more than 90 ft. deep, while zebra mussels are usually found at depth of less than 50 ft. Unlike zebra mussels, quagga mussels can live and thrive directly on a muddy or sandy bottom. They also tolerate a wider range of extremes in temperature and water depth than zebra mussels and spawn at colder temperatures.

The known occurrences of quagga mussels within the Watershed are:

- Burt Lake
- Crooked Lake
- Crooked River

Figure 7: Quagga mussel (left) and zebra mussel (Michigan Sea Grant)

Eurasian watermilfoil
Eurasian watermilfoil (*Myriophyllum spicatum*) is a plant native to Europe and Asia that was first documented in North America in the mid 1940s. Since its introduction, it has spread to more than 40 states in the United States and to three Canadian provinces.

As Eurasian watermilfoil takes hold in a lake, it causes problems for the ecosystem and for recreation. It tolerates lower temperatures and starts growing earlier than other aquatic plants, quickly forming thick underwater stands of tangled stems and vast mats of vegetation at the water's surface. These dense weed beds at the surface can impede navigation. Eurasian watermilfoil also displaces and reduces native aquatic plant diversity, which is needed for a healthy fishery. Infestations can also impair water quality due to dissolved oxygen depletion as thick stands die and decay.

A key factor in the species' success is its ability to reproduce through both stem fragmentation and underground runners. Eurasian watermilfoil spreads to other areas of a water body by fragmentation. A single stem fragment can take root and form a new colony. Locally, it grows by spreading shoots underground.

The known occurrences of Eurasian watermilfoil within the Watershed are:

- Burt Lake
- Crooked Lake
- Crooked River
- Thumb Lake

Phragmites
Phragmites (*Phragmites australis*), also known as the common reed, is an aggressive wetland invader that grows along the shorelines of water bodies or in water several feet deep. It is characterized by its towering height of up to 14 feet and its stiff wide leaves and hollow stem. Its feathery and drooping inflorescences (clusters of tiny flowers) are *purplish* when flowering and turn whitish, grayish, or brownish in fruit. Eventually, *Phragmites* become the sole dominant plant in many of these wetlands at the expense of native plants and animals that depend on these native habitats.

There are several known occurrences of *Phragmites* within the Watershed. These stands are concentrated in the Sturgeon River Watershed (upper Watershed) and near the mouth of the Maple River. More stands elsewhere within the Watershed have not been documented.

Purple loosestrife
Purple loosestrife (*Lythrum salicaria*) is an invasive wetland plant. Imported in the 1800s for ornamental and medicinal uses, purple loosestrife poses a serious threat to wetlands because of its prolific reproduction. Native to Europe and Asia, purple loosestrife can be identified by its purple flowers which bloom from June to September. Purple loosestrife produces square woody stalks 4 to 7 feet high. Leaves are heart or lance shaped and flowers have 5 to 7 petals.

Due to the long flowering season, purple loosestrife plants have the ability to produce millions of seeds each year. In addition to seeds, purple loosestrife can also produce vegetatively by sending up shoots from the root systems. The underground stems can grow up to a foot each growing season.

Purple loosestrife is widely distributed throughout the Watershed, particularly within the Crooked River Watershed. Efforts to manage it have helped to curtail its spread. Most stands tend to be patchy and are located in roadside ditches.

Curly-leaf pondweed
Curly-leaf pondweed (*Potamogeton crispus)* is a perennial, submerged aquatic plant that is native to Eurasia. It tolerates fresh or slightly brackish water and can grow in shallow, deep, still, or flowing water. It generally grows in 3-10 feet of water. Curly-leaf pondweed tolerates low water clarity and will readily invade disturbed areas.

The known occurrences of curly-leaf pondweed within the Watershed are:

- Crooked River
- Crooked Lake

Sea lamprey
Sea Lamprey (*Petromyzon marinus)* are primitive, jawless fish native to the Atlantic Ocean. In 1921, lampreys appeared in Lake Erie for the first time, arriving via the Welland Canal, which was constructed for ships to avoid Niagara Falls on their way up the St. Lawrence Seaway. Shortly thereafter, sea lamprey quickly populated all of the upper Great Lakes. The sea lamprey is an aggressive parasite with a toothed, funnel-like sucking mouth and rasping tongue that is used to bore into the flesh of other fish to feed on their blood and body fluids.

The known occurrences of sea lamprey within the Watershed are:

- Burt Lake
- Crooked River
- Crooked Lake
- Pickerel Lake

The following information is sourced from Northern Inland Lakes Citizens Fishery Advisory Committee Minutes (October 12, 2015).

Update on recent sea lamprey control efforts and studies in the waterway (Nick Johnson, Research Ecologist, and Hammond Bay Biological Station).

> Sea lamprey have a similar life cycle to salmon in that they migrate up rivers to spawn and then die. The hatched larvae burrow into the sediment, eat plankton for 3 years or more, undergo a metamorphosis acquiring their sucker-like mouth, leave the stream bottom, and drift to the lake to feed on fish. While growing to a mature adult, a sea lamprey can consume up to 40 lbs. of fish. The first attempt to control sea lampreys was to block spawning grounds with dams and electrical barriers, which are still used today on many streams. Another method that was developed via research was to use a lampricide to kill the larvae in the stream bottom; treatment of a given stream had to be repeated every 3-4 years. The US Fish and Wildlife Service conducts the lamprey assessments and applies the lampricide while the USGS Hammond Bay Biological Station conducts research relevant to these treatments.
>
> Anecdotal reports during the last decade indicated that sea lampreys were preying on fish in the Inland Waterway. An effort was then begun in Mullett and Burt Lakes to determine how abundant sea lamprey feeding scars were present on fish caught by anglers. An observation program was initiated in 2013 and in that year 22 reports of fish with lamprey scars were received, which provided evidence that a population of sea lampreys

existed in the Inland Waterway. The question was raised as to the source of these lampreys.

It was originally thought that the adult lampreys were traveling up from the Cheboygan River from Lake Huron and passing through the Cheboygan lock. However, in 2011 as part of a telemetry study, 148 lampreys were tagged and released below the Cheboygan lock. None of the tagged lampreys were detected in the river above the lock, indicating that few if any lampreys are passing through the lock to gain entrance to the upstream Inland Waterway. This result supported the view that a self-sustaining population of sea lamprey exists in the Inland Waterway.

The overall goal currently of the USFWS is to delay or eliminate the need to apply lampricide to the streams above the Cheboygan Lock in the Inland Waterway where the sea lamprey spawn. Applying lampricide is difficult and costs about $400,000 per treatment. The rivers needing treatment include the Maple, Sturgeon, and Pigeon and the lower Cheboygan. Significant challenges for treatment are the 48 dams in the Watershed and the possible presence of an endangered species, the Hungerford's Crawling Water Beetle. Working around these challenges will require time and effort.

The next step was to follow-up and confirm the existence of a sea lamprey population in the Inland Waterway above the Cheboygan Lock. Survey netting began in 2013 before the Cheboygan lock opened in the spring. Adult sea lampreys were captured upstream in the Waterway which showed that indeed a population of adult sea lamprey was living in the Inland Lake system. In addition, land locked sea lamprey have a different bone microchemistry and are smaller than Great Lakes sea lampreys. Netting will continue during 2016 to obtain additional information. The survey results to date suggest that the abundance of adult sea lamprey above the Cheboygan lock in the Inland Waterway is very low with an estimate of less than 200 adult lampreys. However, a low number of adults can produce large numbers of progeny.

Control options for sea lamprey include continued costly lampricide treatments, removing adult lamprey with nets (nets only catch about 10%), refurbish the Cheboygan Lock, or use of the sterile male release technique which potentially reduces the spawning success of the adult lamprey. The sterile male release technique may be a viable alternative to lampricide. Modifying the lock would prevent lamprey from moving upstream but it would ignore the land locked population. Sterile male release technique has the advantage of controlling both the land locked adult lamprey and those that migrate through the lock.

Since the projected adult sea lamprey population is estimated to be relatively low at less than 200 adults, the sterile male release technique has the potential of being an effective control method. Previous research on other rivers has shown that for this technique to be successful a low number of adult lamprey must be present. This allows the fertile females to be overwhelmed with sterile spawning males resulting in few fertile eggs. If the program is successful, it is estimated that only two females would be successfully fertilized each year. Obtaining a desirable ratio of 40 sterile spawning males to each spawning female is possible since it is estimated that only about 100 adult females spawn in the upper river. Sterile males are obtained by trapping the returning males below the Cheboygan Dam and treating them. The sterile males would then be released in the upper river and would spawn with the fertile females.

If the sterile male release technique is successful, regular expensive lampricide treatments would no longer be needed, and if the Cheboygan Lock is upgraded it might be possible to exterminate all the sea lamprey above the Cheboygan Dam. The information obtained with this project could be applied to other similar watersheds around the Great Lakes to reduce the cost of sea lamprey control treatments.

Proposed timeline for the sterile male release technique project if it proceeds:

- Lampricide treatment expected 2016
- Continued adult sea lamprey assessment 2016
- Sterile male release technique would occur 2017-2019
- Next expected lampricide treatment 2020
- Post sterile male release technique assessment 2020-2023

Threatened and Endangered Species

Several notable threatened and endangered species inhabit the Burt Lake Watershed. The species listed represent only a small portion of the total that are considered threatened, endangered, or species of concern. More information on these and other species can be found in Appendix B. It is also important to note that the following information oftentimes applies to the entire Cheboygan River Watershed, of which the Burt Lake Watershed is included.

Lake Sturgeon

The lake sturgeon is a state threatened species in Michigan. According to Baker (1980), lake sturgeon were considered historically abundant throughout the Great Lakes region, particularly before the appearance of Europeans in the region. Lake Sturgeon would have been common throughout the lower reaches of the Cheboygan River Watershed and probably common in Black, Burt, and Mullett lakes. The species still exists today in each lake, with the largest population found in Black Lake. Hay-Chmielewski and Whelan (1997) consider the Cheboygan River Watershed as highly suitable for future lake sturgeon rehabilitation and enhancement.

Over-harvest by European Settlers, destruction of food sources, sea lampreys and dam construction on spawning rivers have all had a significant impact on the lake sturgeon population. They are currently listed as a state threatened species. As lake sturgeon require diverse benthic zones for feeding and clean riffles and rapids in streams to spawn it is important that steps are taken to preserve habitat. The biggest threats that lake sturgeon face are sedimentation of river and lake bottoms and restrictions to spawning due to dams in the migration corridor (MDNR www.michigan.gov/dnr/0,4570,7-153-10370_12145_12203-33009--,00.html)

The following section was provided by the Little Traverse Bay Bands of Odawa Indians (LTBB). It details the fall 2015 Burt Lake juvenile lake sturgeon netting efforts undertaken along with the Michigan Department of Natural Resources (MDNR).

LTBB has stocked fall fingerling sturgeon in Burt Lake since 2013. The goal of the survey is to gather data on the survival, growth rates and other information for these stocked fish. The Burt Lake sturgeon assessment was conducted September 14 through October 5 and targeted both juvenile and adult sturgeon. Gill nets were used and checked every 2 to 3 hours so the fish would not be harmed. They were handled very carefully when being removed from the nets and examined in the boat. The fish were checked for tags which showed if the sturgeon were wild (no tags) or stocked. The tags provide a history of when the fish were stocked and when they might have been caught in previous surveys. The wild fish were also tagged so that they can be followed in new surveys or when they are possibly harvested in the future.

Sampling locations were randomly chosen throughout the entire lake in appropriate depths greater than 20 feet. Three boats were used, including two tribal boats, and one DNR boat and crew. There were 63 unique sturgeon captured and three of these sturgeon were recaptured during this survey. In addition, seven of the captured sturgeon were tagged during the 2011 survey. Despite the smaller mesh size, the 2015 survey did not produce many small sturgeon and provided little evidence of strong natural or stocked juvenile recruitment. Very preliminary population projections estimate the sturgeon population of Burt Lake to be between 644 and 1535 sturgeon. Expanded numbers should be interpreted with caution due to the low numbers captured during the survey.

Table 3: LTBB lake sturgeon stocking in Burt Lake

Stocking Event	Year	LOT code	Date	Total Fish Stocked	Size (inches)	PIT Fish
Fall	2013	LAS-BLR-2013	9/23/2013	202	5.50	74
Fall	2014	LAS-BLR-2014	8/28/2014	677	6.14	60
Fall	2015	LAS-BLR-2015	9/10/2015	497	6.38	150
Fall	2016	LAS-BLR-2016	9/8/2016	223	7.78	223

Figure 8: Little Traverse Bay Bands of Odawa Indians/Lake Sturgeon/Burt Lake (www.nibiishnaagdowen.com)

In addition to lake sturgeon, several other species of threatened, endangered, or species of concern have been documented within the Watershed, including the pugnose shiner, channel darter and cisco. The pugnose shiner is classified as endangered in Michigan. It inhabits clear vegetated lakes and vegetated pools and runs of low gradient streams and rivers. They appear to be extremely intolerant to turbidity. The channel darter is classified as endangered within the state. It inhabits rivers and large creeks in areas of moderate current over sand and gravel substrates. Cisco, also known as Lake Herring, is a threatened species in Michigan. Cisco often live in deep, oligotrophic lakes that possess good amounts of cold and highly oxygenated waters. This species has recently been found in Douglas and Burt lakes, and is probably common in many other small inland lakes that possess these characteristics.

Reptiles
The eastern massassauga rattlesnake has special concern status in Michigan. The state's only venomous snake species, they inhabit damp lowlands, including river bottom woodlands, shrub swamps, bogs and fens, marsh borders, sedge meadows, and moist prairie, but may be found in upland meadows and woodlands in summer. They are considered uncommon and local, but are widely distributed across Michigan's Lower Peninsula.

The Cheboygan River Watershed is home to five species of turtles. Two of these (wood and Blanding's) are species of special concern in Michigan. Blanding's turtles inhabit clean, shallow waters with abundant aquatic vegetation and soft muddy bottoms over firm substrates. This species is found in ponds, marshes, swamps, bogs, wet prairies, river backwaters, embayments, sloughs, slow-moving rivers, and lake shallows and inlets. Habitat loss and road crossing mortality are the major causes of mortality for the Blanding's turtle. Wood Turtles are found primarily in or near moving water and associated riparian habitats. Their populations have been reduced primarily through mortality from crossing roads and from pet collection.

Birds
The state-threatened common loon breeds on the lakes, while stream edges are popular habitat types for several species of shorebirds and wading birds, such as great blue herons. Great blue heron rookeries are also listed as a natural feature of concern in the Burt Lake Watershed. These rookeries contain groups of nests and are located in wooded wetlands with large trees.

Invertebrates
The Burt Lake Watershed is also home to two endangered invertebrates, the Hungerford's crawling water beetle (*Brychius hungerfordi*) and the aquatic snail *Planorbella smithi*. The Hungerford's crawling water beetle has been found in recent years in the East Branch of the Maple River (USFWS 2006). This species prefers cool water, and well-aerated streams with a sand, gravel, and cobble bottom. The status of the aquatic snail *Planorbella smithi* was elevated to endangered by the State of Michigan in 2009, and is known to occur only in Douglas and Burt lakes (MNFI 2011).


Figure 9: Hungerford's crawling water beetle (Roger M. Strand)

Plants

Michigan monkey-flower (*Mimulus michiganensis*) is a federal and state-listed endangered species. Nearly all known populations of the monkey-flower occur near present or past shorelines of the Great Lakes. Recreational and residential development is the main threat to this aquatic and semi-aquatic species. Increased construction along lakes and streams has destroyed monkey-flower habitat, including three known populations of the flower. Because the monkey-flower needs flowing spring water, road construction and other activities that affect water drainage also affect the species. Michigan monkey-flowers now survive at only 12 sites in Michigan. Two-thirds of the plants are on private property.
(www.fws.gov/midwest/endangered/plants/monkeyfl.html)

Occurrences of Michigan monkey-flower are often very localized, sometimes consisting of small but dense patches restricted to small seeps, springs, and depressions, whereas others are comprised of numerous patches of plants widely dispersed along small streams and spring-fed seeps within northern white cedar swamps. Large to moderately sized populations occur in the Burt Lake Watershed.
(http://mnfi.anr.msu.edu/abstracts/botany/Mimulus_michiganensis.pdf)

Wetlands

It is important to include wetlands in watershed plans because of the important role they play in ecosystem function and watershed dynamics. Wetlands are a product of and have an influence on watershed hydrology and water quality. Wetlands contribute to healthy watersheds by influencing important ecological processes.

> *Wetlands are the link between land and water. They are transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils, and vegetation, making these areas very important features of a watershed.*
>
> *-US EPA 2004*

The Burt Lake Watershed includes a variety of wetland types. In general, wetlands provide many ecological services including water quality protection through recycling of nutrients and filtration of pollutants. They help to mitigate flooding, while recharging groundwater. The provide habitat for countless wetland-dependent species. Lastly they play a critical role in reducing the impacts from climate change sequestration of carbon.

In a 1990 report to Congress, the Michigan Department of Natural Resources (MDNR) and the U.S. Department of the Interior estimated that Michigan had lost approximately 50% of its original wetland resource base. According to the DEQ, the Burt Lake Watershed pre-settlement conditions included an estimate **49,947 acres of wetlands, as compared to 45,599 acres remaining as of 2005 (a loss of 4,348 acres, or 9%, of wetlands).** In addition, the average size of wetlands has decreased during this time from 35 acres to 24 acres. (The Burt Lake Sturgeon River Watershed Landscape Level Wetland Functional Assessment, MDEQ, November 2015).

Given the extensive functions and values associated with wetlands, it is no longer adequate to simply quantify wetland loss in terms of acreage. As a result, there have been recent, statewide efforts to interpret loss of wetland function on a landscape level and incorporate that information into watershed management plans.

In 2007, the Michigan Department of Environmental Quality (MDEQ) received a Wetland Program Development Grant from the EPA to aid in their development of a tool to evaluate wetland functions on a watershed scale. MDEQ identified the need to develop such a tool to support watershed planning efforts, guide zoning decisions and help define wetland restoration priorities for resource managers. The tool would be used to assess wetland quantity and wetland functions to evaluate the impact that wetlands have on the watershed in its entirety. For more information, refer to (www.epa.gov/wetlands/michigan-integrates-wetland-assessment-watershed-protection).

In Michigan, wetlands are just beginning to be considered in the context of watershed management planning and the creation of municipal master plans. Wetland restoration and enhancement are increasingly becoming popular tools, in lieu of traditional best management practices, to enhance the overall ecological health and surface water quality of a watershed. Understanding the overall historic impact of wetland loss and degradation can assist local planners and resource managers in sighting future development as it lends new importance to the wetlands that remain.

Watershed groups and local governments should consider using landscape assessments to identify priority areas, probable stressors, and wetland restoration and conservation opportunities

-(Apfelbeck, 2006)

Landscape Level Wetland Functional Assessment

The landscape level wetland functional assessment (LLWFA) tool was developed by staff of the Michigan Department of Environmental Quality (MDEQ) in conjunction with cooperating state and local agencies, universities, and nongovernmental organizations. It enables users to identify existing wetlands and the functions those wetlands currently perform. The LLWFA tool also enables the user to identify historical or former wetlands (i.e., areas of hydric soils that are not currently wetlands) and the functions they would likely perform if restored. Restoring lost wetland functionality shows great promise in addressing the systemic cause of much of the nonpoint source pollution occurring in the state.

Application of the LLWFA indicates that this study found that wetland resources in the Burt Lake Watershed have changed drastically since pre-settlement, with both wetland acreage and function decreasing significantly.

The LLWFA is, in essence, a screening tool for identifying wetland types and their functions, including:

Flood Water Storage:
This function is important for reducing the downstream flooding and lowering flood heights, both of which aid in minimizing property damage and personal injury from such events.

Streamflow Maintenance:
Wetlands that are sources of groundwater discharge that sustain streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams. All wetlands classified as headwater wetlands are important for streamflow.

Nutrient Transformation:
Wetlands that have a fluctuating water table are best able to recycle nutrients. Natural wetlands performing this function help improve local water quality of streams and other watercourses.

Sediment and Other Particulate Retention:
This function supports water quality maintenance by capturing sediments with bonded nutrients or heavy metals. Vegetated wetlands will perform this function at higher levels than those of non-vegetated wetlands.

Shoreline Stabilization:
Vegetated wetland along all waterbodies (e.g. estuaries, lakes, rivers, and streams) provide this function. Vegetation stabilizes the soil or substrate and diminished wave action, thereby reducing shoreline erosion potential.

Stream Shading:
Wetlands that perform water temperature control due to the proximity to streams and waterways. These wetlands generally are Palustrine Forested or Scrub-Shrub.

Conservation of Rare and Imperiled Wetlands:
Wetlands that are considered rare either globally or at the state level. They are likely to contain a wide variety of flora and fauna, or contain threatened or endangered species.

Ground Water Influence:
Wetlands categorized as High or Moderate for Groundwater Influence are areas that receive some or all of their hydrologic input from groundwater reflected at the surface. The Darcy model was the data source utilized to determine this wetland/groundwater connection, which is based upon soil transmissivity and

topography. Wetlands rated for this function are important for maintaining streamflow and temperature control in waterbodies.

Fish Habitat:
Wetlands that are considered essential to one or more parts of fish life cycles. Wetlands designated as important for fish are generally those used for reproduction, or feeding.

Waterfowl/Waterbird Habitat:
Wetlands designated as important for waterfowl and waterbirds are generally those used for nesting, reproduction, or feeding. The emphasis is on the wetter wetlands and ones that are frequently flooded for long periods.

Shorebird Habitat:
Shorebirds generally inhabit open areas of beaches, grasslands, wetlands, and tundra and undertake some of the longest migrations known. Along their migration pathway, many shorebirds feed in coastal and inland wetlands where they accumulate fat reserves needed to continue their flight. Common species include plovers, oystercatchers, avocets, stilts, and sandpipers. This function attempts to capture wetland types most likely to provide habitat for these species.

Interior Forest Bird Habitat:
Interior Forest Birds require large forested areas to breed successfully and maintain viable populations. This diverse group includes colorful songbirds such as; tanagers, warblers, vireos that breed in North America and winter in the Caribbean, Central and South America, as well as residents and short-distance migrants such as; woodpeckers, hawks, and owls. They depend on large forested tracts, including streamside and floodplain forests. It is important to note that adjacent upland forest to these riparian areas are critical habitat for these species as well. This function attempts to capture wetland types most likely to provide habitat for these species.

Amphibian Habitat:
Amphibians share several characteristics in common including wet skin that functions in respiration and gelatinous eggs that require water or moist soil for development. Most amphibians have an aquatic stage and a terrestrial stage and thus live in both aquatic and terrestrial habitats. Aquatic stages of these organisms are often eaten by fish and so for certain species, successful reproduction may occur only in fish-free ponds. Common sub-groups of amphibians are salamanders, frogs, and toads. This function attempts to capture wetland types most likely to provide habitat for these species.

Carbon Sequestration:
Wetlands are different from other biomes in their ability to sequester large amounts of carbon, as a consequence of high primary production and then deposition of decaying matter in the anaerobic areas of their inundated soils.

Pathogen Retention:
Wetlands can improve water quality through natural processes of filtration for sedimentation, nutrients, and *Escherichia coli (E. coli)*. *E. coli* is a sub-set of fecal coli forms whose presence in water indicates fecal contamination from warm-blooded animals. The presence of *E. coli* indicates that contamination has occurred and other harmful pathogens may also be present.

Wetland restoration activities could possibly lead to water quality improvements in the Watershed. It is important to remember that the LLWFA is intended as a first-level or coarse-scale assessment of wetland location, condition, and function. A subsequent step in the watershed planning process is to ground-truth the data from the LLWFA. The LLWFA provides a general picture of wetland extent and function within a watershed that can be used to identify trends in wetland condition and function, identify initial restoration locations, and form the basis of a wetland inventory.

Based on the results of the LLWFA for the Burt Lake Watershed, thousands of acres of wetland complexes have been identified as performing valuable ecological functions currently or at some point in the future upon restoration. Table 4 summarizes the results from the LLWFA and includes a comparison of original function-acres and current function-acres. It is important to note, however, that in many cases it appears the acreage has increased since pre-settlement. The discrepancy can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

According to the LLWFA, 10,720 acres within the Burt Lake Watershed are categorized as having high potential for wetland restoration, regardless of wetland function. The Sturgeon River Watershed includes the greatest number of high-potential restoration wetlands (4,936 acres)(Figure 13), followed by the Maple River Watershed (2,573 acres)(Figure 11), the Crooked River Watershed (1,861 acres)(Figure 12), and the Burt Lake Direct Drainage (1,350 acres)(Figure 10).

Three wetland functions are highlighted in Table 4 as well as in Figure 14, Figure 15, Figure 16.

Wetlands capturing flood water at significant levels would include wetlands along streams and rivers.

Wetlands are sources of groundwater discharge that sustain streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams.

Vegetated wetlands along all water bodies (e.g. estuaries, lakes, rivers, and streams) provide this function. Vegetation stabilizes the soil or substrate and diminishes wave action, thereby reducing shoreline erosion potential (Tiner, 2002). Vegetated wetlands along lakes, streams, or rivers provide a buffer to shorelines that would otherwise be more vulnerable to erosion. Wetlands that are along rivers, streams, and lakes that are vegetated perform this function at highly significant level. Wetlands in a headwater position within a watershed, that are outflowing to other surface water, perform this function at a more moderate rate.

Table 4: Burt Lake Watershed wetland functional acres comparison (Source: LLWFA/DEQ)

Function	Potential Significance	Pre-settlement Acreage	Current Acreage	% Change in Acreage
Flood Water Storage	High	21247	27549	29.66
	Moderate	27926	15247	-45.40
	TOTAL	49173	42797	-12.97
Streamflow Maintenance	High	33216	31123	-6.30
	Moderate	11911	9977	-16.24
	TOTAL	45127	41100	-8.92
Nutrient Transformation	High	45824	42499	-7.26
	Moderate	4092	3100	-24.24
	TOTAL	49917	45600	-8.65
Sediment and Retention of Other Particulates	High	22584	27212	20.49
	Moderate	24194	15371	-36.47
	TOTAL	46778	42583	-8.97
Shoreline Stabilization	High	19617	24615	25.48
	Moderate	23167	15090	-34.86
	TOTAL	42784	39706	-7.19
Fish Habitat	High	42792	36906	-13.75
	Moderate	3276	3923	19.73
	TOTAL	46069	40829	-11.37
Stream Shading	High	9412	15561	65.33
	Moderate	1698	3277	93.01
	TOTAL	11109	18837	69.56
Waterfowl/Waterbird Habitat	High	444	4522	919.41
	Moderate	41398	13883	-66.47
	TOTAL	41842	18405	-56.01
Shorebird Habitat	High	0	5	N/A
	Moderate	49917	45571	-8.71
	TOTAL	49917	45576	-8.70
Interior Forest Bird Habitat	High	6888	7156	3.90
	Moderate	43010	36876	-14.26
	TOTAL	49898	44033	-11.75
Amphibian Habitat	High	29537	18156	-38.53
	Moderate	2800	3225	15.17
	TOTAL	32337	21381	-33.88
Carbon Sequestration	High	3144	3587	14.11
	Moderate	41967	35345	-15.78
	TOTAL	45111	38932	-13.70
Ground Water Influence	High	5413	3469	-35.92
	Moderate	38344	37546	-2.08
	TOTAL	43756	41014	-6.27
Conservation of Rare and Imperiled Wetlands & Species	High	ND	26319	N/A
	Moderate	ND	5521	N/A
	TOTAL	0	31840	N/A

**Increases in the predicted percent change functional capacity in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.*

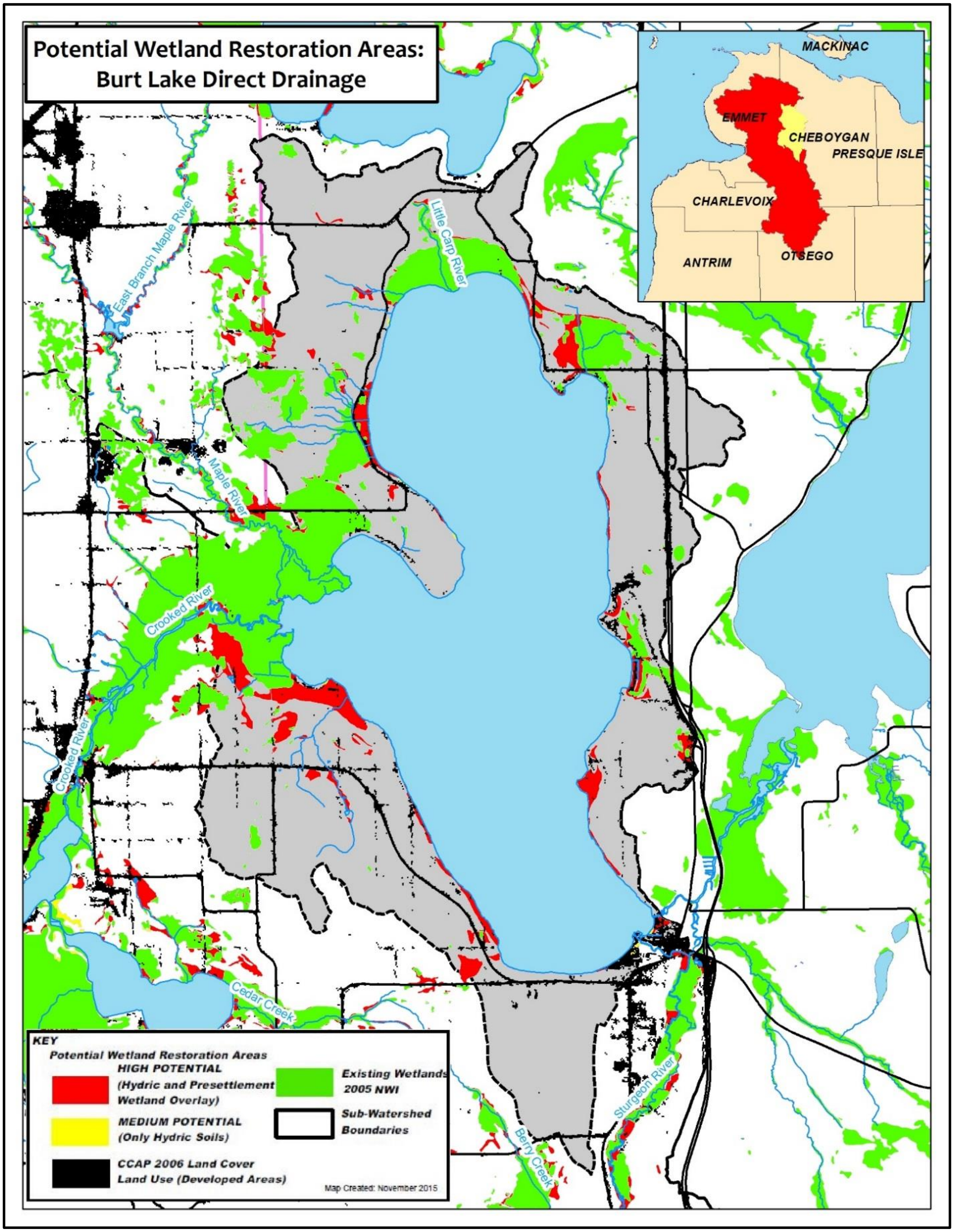


Figure 10: Potential Wetland Restoration Areas: Burt Lake Direct Drainage (LLWFA)

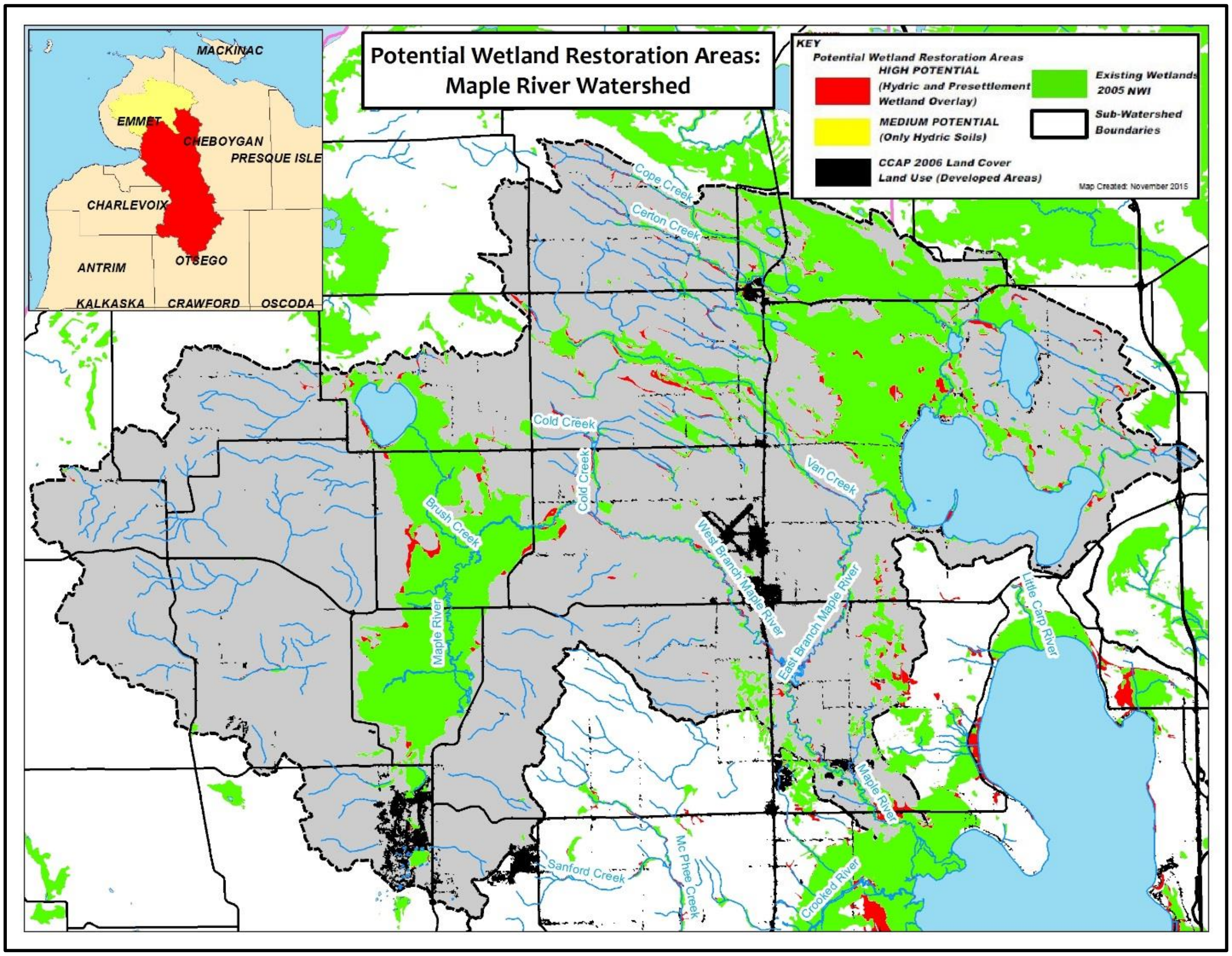


Figure 11: Potential Wetland Restoration Areas: Maple River Watershed (LLWFA)

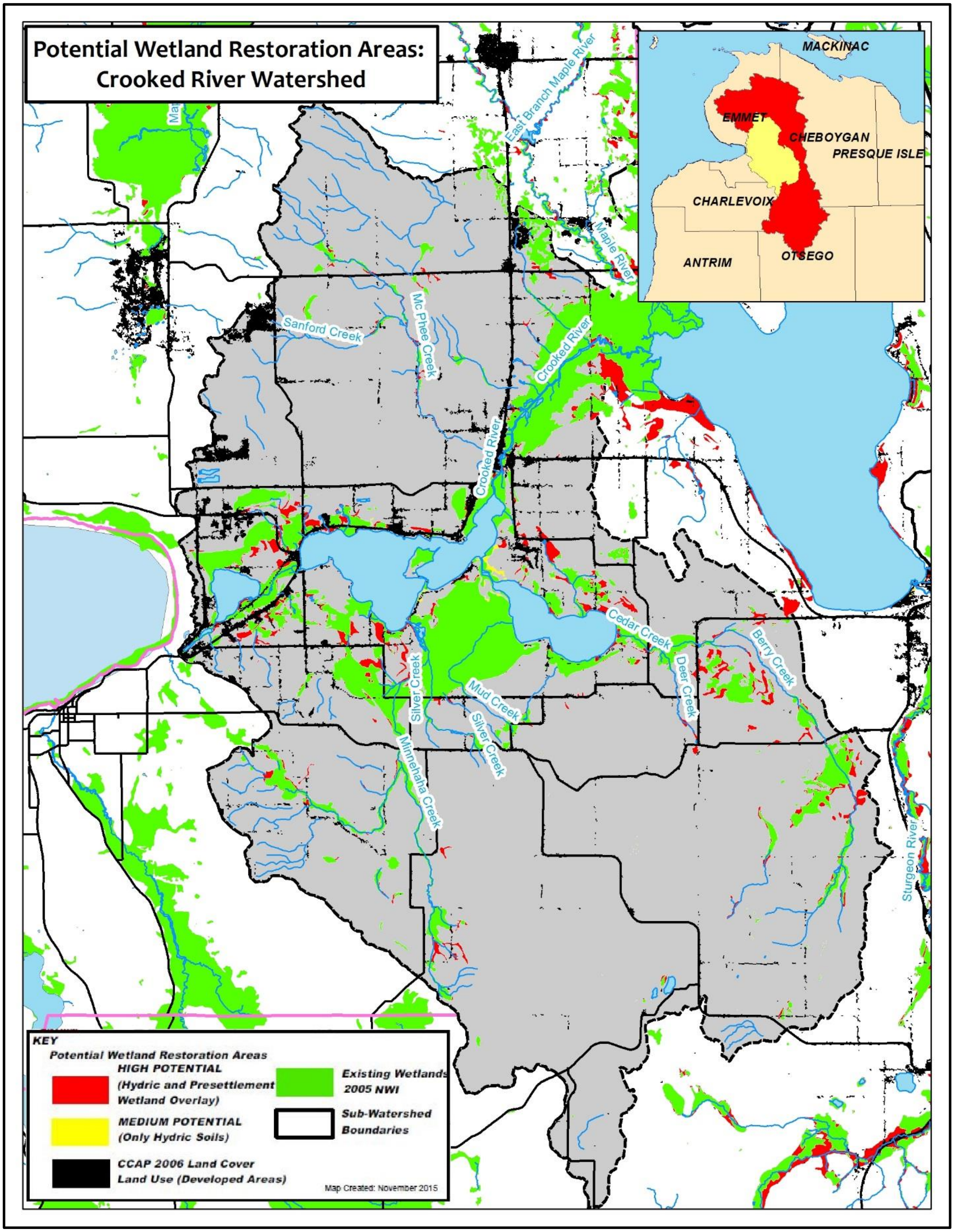


Figure 12: Potential Wetland Restoration Areas: Crooked River Watershed (LLWFA)

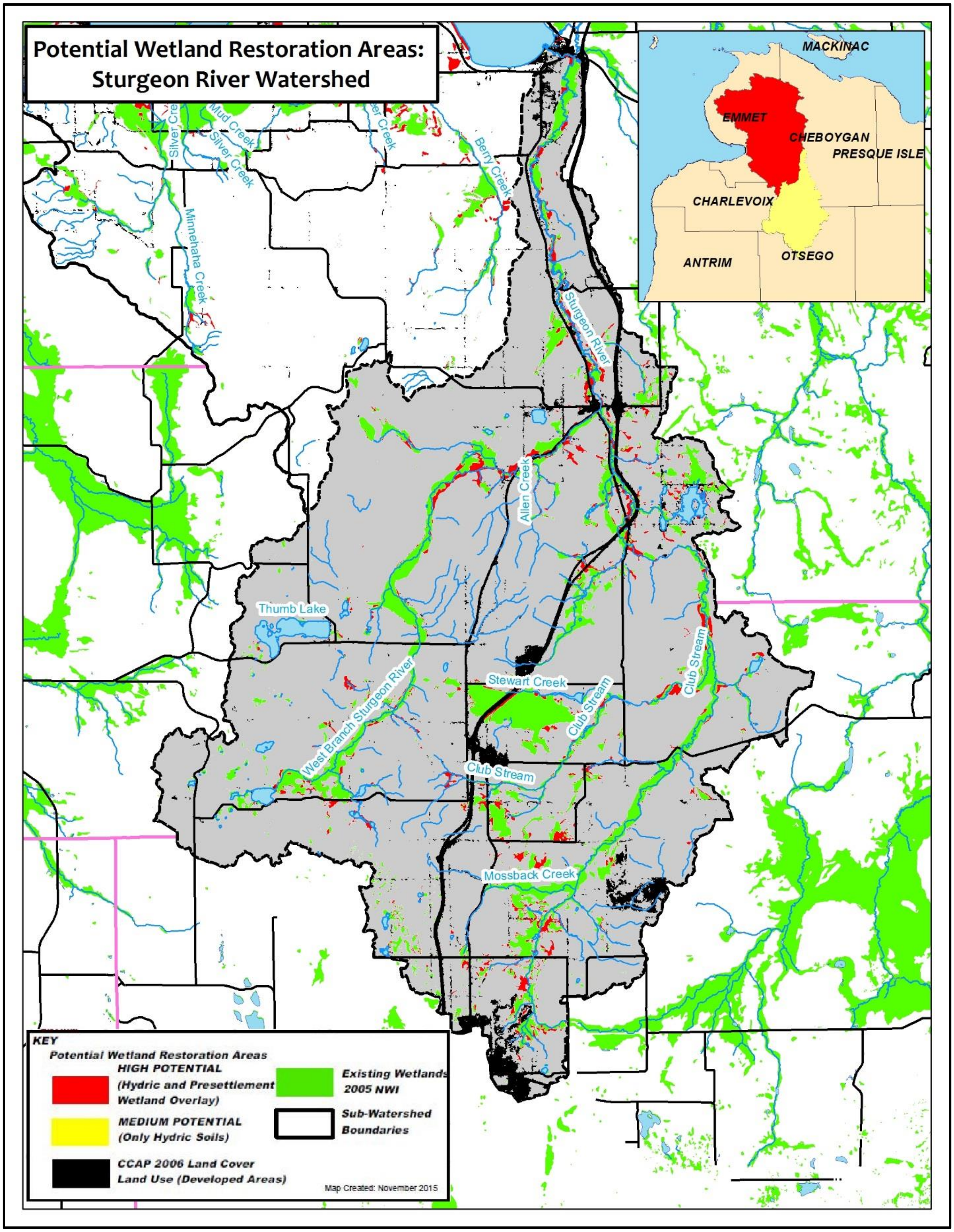


Figure 13: Potential Wetland Restoration Areas: Sturgeon River Watershed (LLWFA)

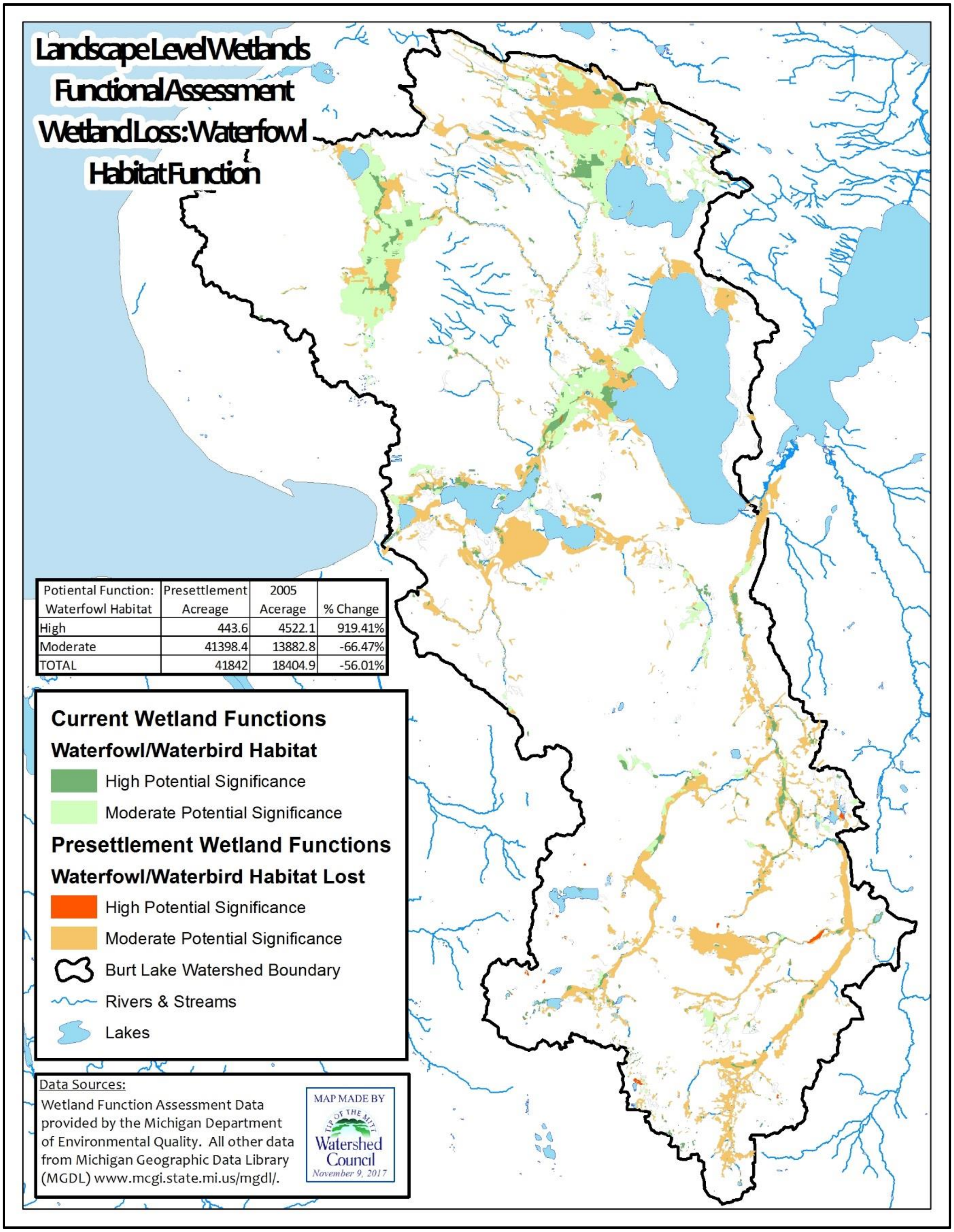


Figure 14: Landscape Level Wetlands Functional Assessment: Waterfowl Habitat Function Loss

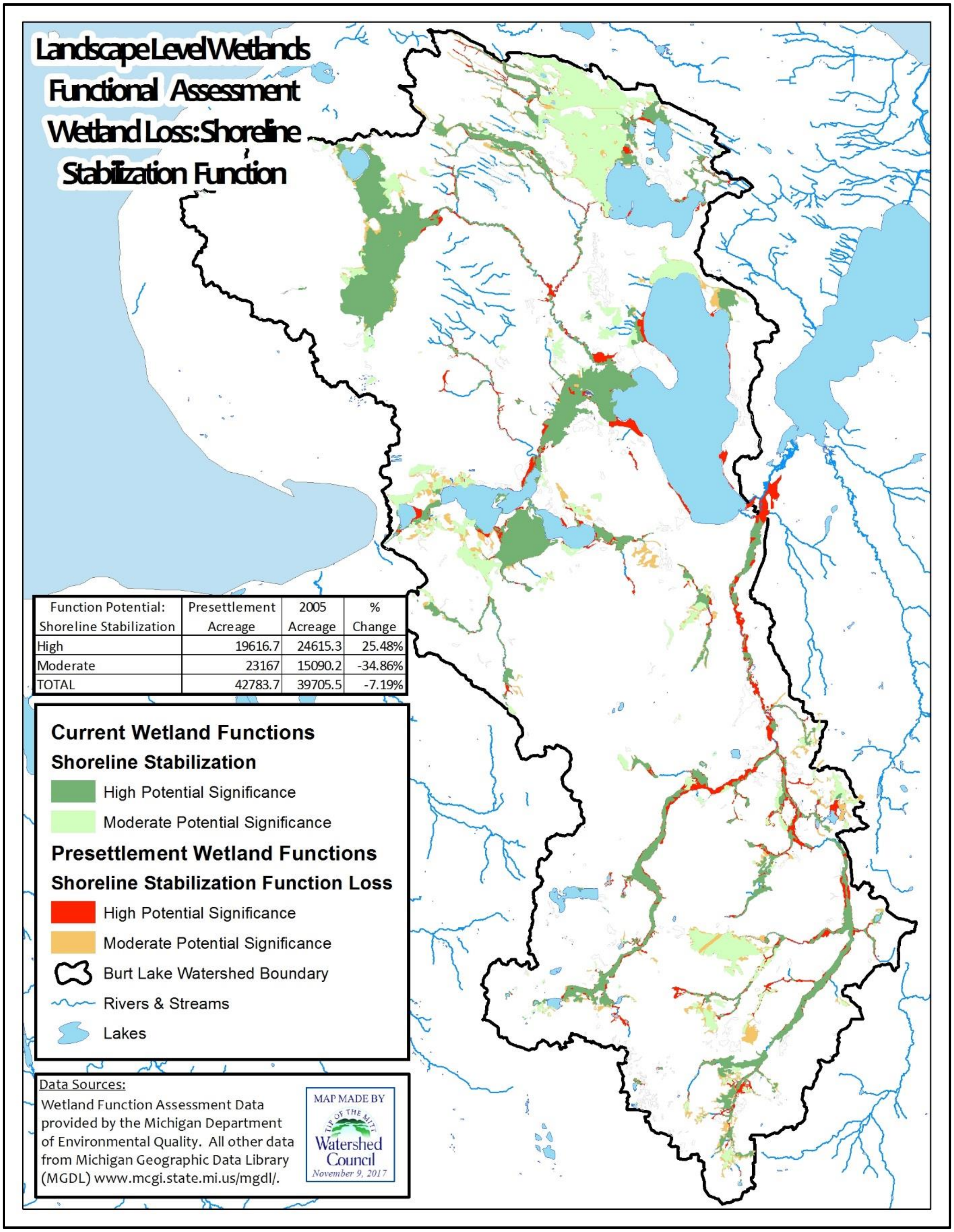


Figure 15: Landscape Level Wetlands Functional Assessment: Shoreline Stabilization Function Loss

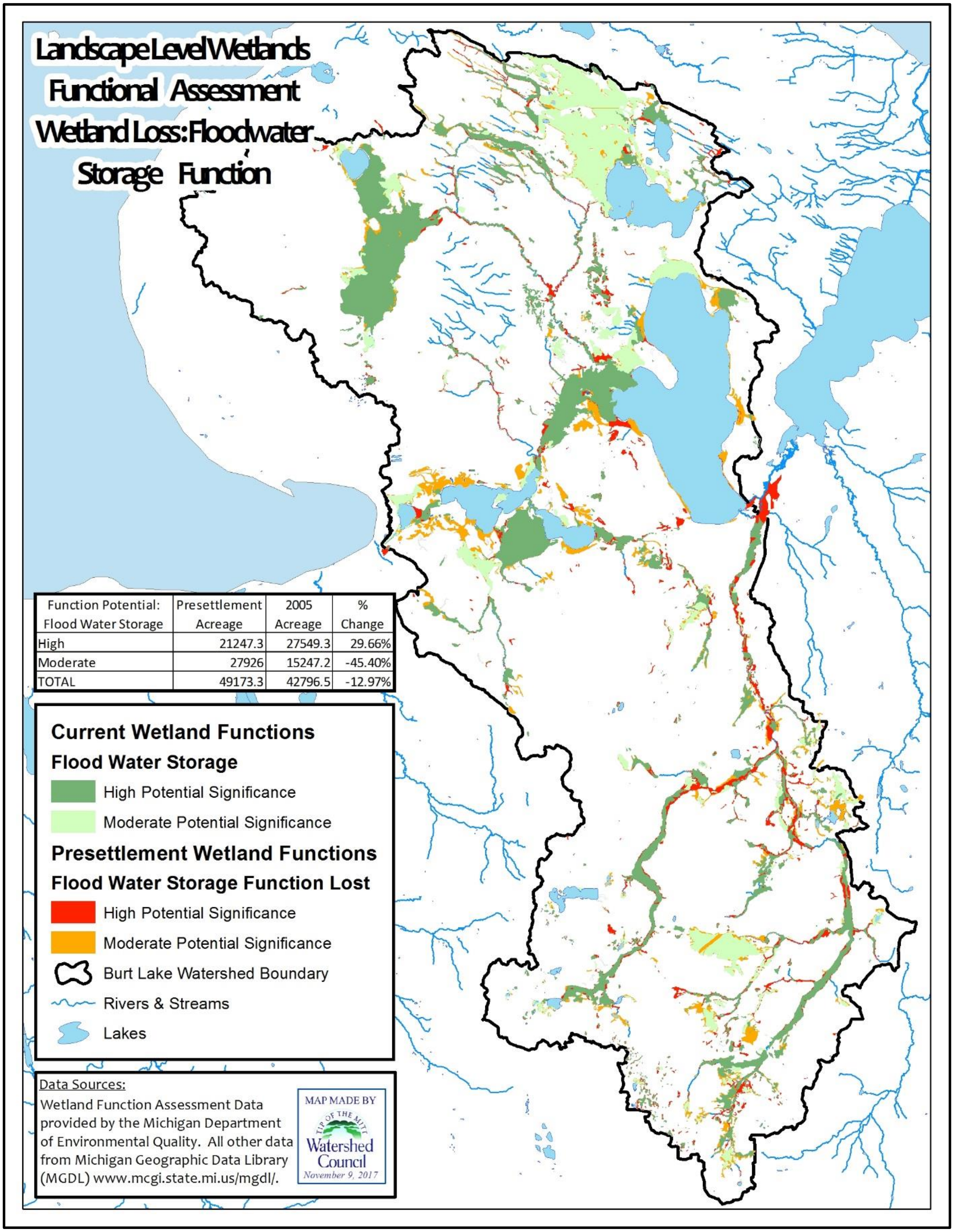


Figure 16: Landscape Level Wetlands Functional Assessment: Flood Storage Function Loss

Cultural History

Long before the arrival of Europeans, the northern portion of Michigan's Lower Peninsula was most recently home to the Ottawa (Odawa) Nation. The total population of the Odawa in this region at that time is not known, although the summer population has been estimated to range somewhere between 30,000 and 100,000.

The Odawa made their home here for hundreds of years, maintaining villages along the Lake Michigan shoreline, and along the Inland Waterway. These northern villages were primarily occupied with the tribes traveling to rivers along the southern coast of Lake Michigan during winter. After the spring maple syrup season was completed, the tribes returned north to the Little Traverse Bay, Cross Village, and the Inland Waterway. These villages were connected by a series of footpaths which allowed natives to travel overland (many of today's roads and highways roughly follow these paths). More important than footpaths for travel were the waterways, because large distances could be covered quickly. Native Americans utilized the Inland Waterway, in part, as a means of traveling from Lake Huron to Little Traverse Bay, avoiding the perilous journey through the Straits of Mackinac and around Waugoshance Point. Not surprisingly, the name Cheboygan is Algonquin meaning "place for going through". Using birch bark canoes well adapted for rough waters and light enough to carry on portages, Native Americans could quickly travel from Little Traverse Bay to hunting grounds, seasonal fishing spots, and neighboring villages along the Crooked River, Burt Lake, Indian River, Mullett Lake, and the Cheboygan River.

The marshes, bogs, and swamps along the Inland Waterway are rich in plants that were utilized by the Odawa for fiber, medicines, and foodstuffs. Bulrushes, grasses, cattails, and sedges found in today's marshes were extensively harvested for baskets, shelter, fish nets, and clothing. Sphagnum moss, a common plant of many wetland environments, was stuffed into boots and clothing for insulation and wetland shrubs such as red-osier dogwood and some common mosses were used for dyes. Numerous wetland plant species were used for their medicinal properties: Labrador tea for the treatment of ulcers, willow for indigestion, balsam fir for headaches, and tamarack for burns.

Waterfowl, which were attracted to the vast wetlands in the area, gathered in great numbers during both the spring and fall migratory seasons and were a primary source of food. Freshwater mussels and clams were harvested from shallow waters and numerous types of fish, from whitefish to lake sturgeon were netted or speared throughout the warm months.

Demographics

The Watershed today includes several small towns and villages (Table 5), but overall the Watershed is mostly rural and lightly populated. Riparian areas tend to be more developed with both permanent and seasonal residences.

Table 5: Burt Lake Watershed population of municipalities

Municipality	2000	2010	Change	Percentage Change
Alanson	785	738	-47	-5.99
Gaylord	3,707	3,645	-62	-1.67
Indian River	2,008	1,959	-49	-2.44
Pellston	771	822	51	6.61
Vanderbilt	587	562	-25	-4.26
Wolverine	359	244	-155	-32.03

Figure 17 depicts population densities by township throughout the Burt Lake Watershed.

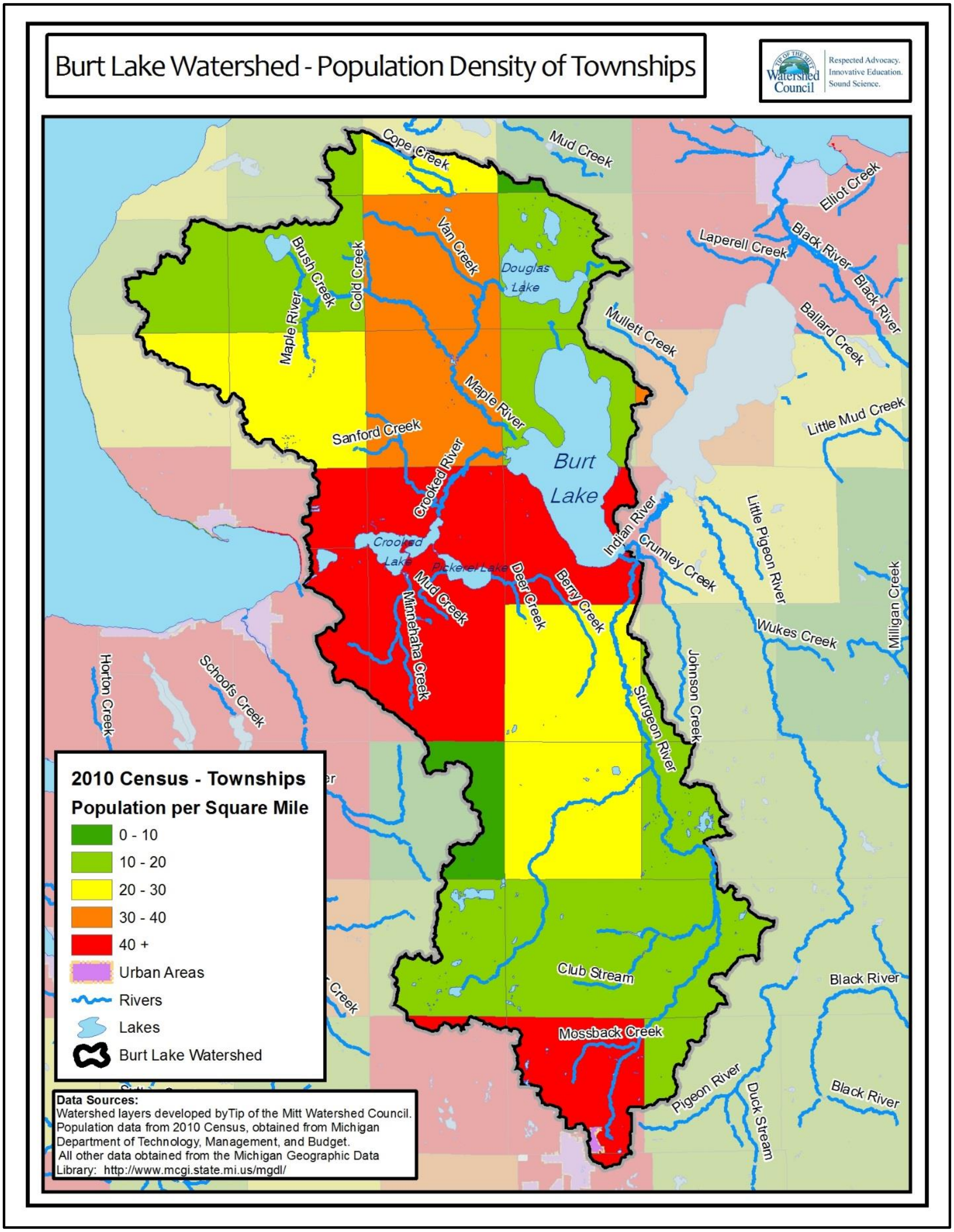


Figure 17: Burt Lake Watershed population density by townships

Focus Groups
As part of a Michigan Department of Environmental Quality's (MDEQ) Nonpoint Source Program grant under Section 319 of the Clean Water Act (Tracking code 2013-0035), Michigan State University Extension (MSUE) conducted focus groups within the Burt Lake Watershed. The results of this effort are detailed below, as provided by MSUE.

The goal of this effort was to determine overall values and perceptions about water quality awareness and risks, governmental challenges, and ways to engage local leaders and residents in water quality protection efforts in the Burt Lake Watershed. To that end, MSU Extension conducted two focus groups sessions during late 2014, and subsequently interviewed 30 individual leaders and landowners residing within the Watershed.

The original project plan, developed in 2013, was to conduct seven focus group sessions to gauge perceptions of key target audiences (shoreline property owners on large and small lakes, Sturgeon River riparian property owners, Maple River Watershed residents, Crooked River Watershed residents, local officials from jurisdictions with the Watershed, and businesses within the Emmet and Cheboygan portions of the Watershed). As participant recruitment began, it became evident that it would be very difficult to gain commitment from a sufficient number of individuals to successfully conduct all seven focus group sessions. As a result two, 90-minute focus group sessions were conducted in September and December 2014, one with local elected and appointed officials (7 participants), the other with residents of large lakes (Burt, Pickerel, Crooked and Douglas Lake - 11 participants). Project staff members followed up during 2015 with phone interviews of 30 individuals, recruited to ensure representation from four of the five remaining target audiences. We were unable to successfully recruit any participation from business representatives.

The list of potential local officials' participants was randomly generated from a spreadsheet of all local elected and appointed officials in watershed jurisdictions within Emmet and Cheboygan Counties. In the case of large lakes and phone interviewees, we were especially interested in talking to individuals with the greatest interest in water quality issues and most likelihood to participate in water resource protection actions. With this goal in mind, invitees were identified primarily from Tip of the Mitt Watershed Council member database, along with referrals from invitees themselves.

Moderator/interviewers asked a structured set of questions to gain unique perspectives. The questions were purposefully general, and interviewers said little, allowing the discussions and comments flow on their own. During our analysis, we looked for common themes within and across questions.

Questions were designed to gather perceptions about:

- Overall perceptions about best attributes of the Watershed.
- Connection to and use of Burt Lake and Sturgeon River Watersheds.
- Perspectives on water sources and risks to the Watershed.
- Ideas for applying information from the Emmet County Gaps Analysis report (local officials).
- Ideas for effective messages to gain interest from local residents in nonpoint source pollution prevention.

Findings

Best attributes of the Burt Lake Watershed

The Burt Lake Watershed is quite large, over 371,000 acres, so perceptions of the Watershed reflected areas near where they live, work or recreate, and not a generalized view of the whole Watershed. Even though focus group participants viewed Watershed maps (phone interviewees did not), comments tended to be locally based. That said, participants described best attributes of the Burt Lake Watershed using similar terms. Clear and clean water, serenity, scenic beauty, and outdoor recreational opportunities were common themes. As one interviewee said, "…It's god's country. My blood pressure goes down as I'm pullin' out of my driveway to get up there. Beautiful area." Some participants highlighted the combination of solitude with access to small town amenities in areas like Petoskey, Cheboygan, Gaylord, and Boyne City.

Recreational activities, especially hiking, boating, fishing and wildlife observation were, by far, the most commonly mentioned uses of natural resources in the Watershed. (Local officials were not asked this question.) As might be expected, given the interview/focus group topic, participants identified water-related recreation more frequently than land-based recreation. Very few identified themselves with forestry and agriculture uses.

Water quality threats

For the most part, interviewees and focus group participants had very few concerns about water quality threats that impacted activities on the water or within the Watershed. Swimmer's itch came up most frequently (but still not a lot), and comments concerning "mucky" lake bottoms unsuitable for swimming. In addition, of course, weather came up as a limiting factor in accessing and using water resources.

Water quality concerns most frequently noted included:

1. Invasive species - Eurasian watermilfoil and zebra mussels were highlighted most frequently. Most commented on the negative effects of invasive species, although the positive benefit of zebra/quagga mussels to water clarity was also

noted by a few participants. *Phragmites* and a few terrestrial invasives were also mentioned, but less often.

2. Septic systems – Phone interviewees, large lake property owners, and local officials identified failing septic systems as a major water quality threat. Several participant told stories about their own experience with old or failing septic systems and the need for proper maintenance around their lake or in their area.
3. Erosion – Participants identified erosions issues in the context shoreline erosion and road crossings over rivers.
4. Pollution - Stormwater runoff was the most frequently mentioned pollution source. Participants in the large lakes focus group also highlighted excessive fertilizer application in shoreline areas.
5. Enbridge pipeline – The Enbridge pipeline issue was very much in the news during the timeframe when these focus group sessions were held and interviews conducted. Although not as frequently mentioned as the above issues, those who did spoke with considerable passion about their perceptions of water quality risks posed by the pipeline. As one large lake shoreline owner commented "I think there's no question that the single biggest threat to our lake is the [Enbridge] oil pipeline."

Local government leaders identified additional issues that have a greater relationship to the policy issues they deal with, including access issues and road ends, equity concerns between shoreline owners' access rights vs. those of non-shoreline residents and visitors, development issues associated with small shoreline lots, cottage-to-large-home conversions, and balancing private property and public rights. Interestingly, association leaders participating in the large lakes focus group commented on similar issues, recognizing the split between lake residents and others in the community, and the need to bridge that gap. They also commented that it is sometimes difficult to communicate with and impact local and county leaders.

Communication about Watershed Issues

Traditional communications methods – newsletters, newspaper, meetings/workshops, and TV – were recommended by participants as the most effective ways to communicate water quality information and messages. Often, those comments were framed in their own experience – a workshop they attended, newsletter they receive, TV news interview they saw, or an article they read. E-mail was also mentioned by many of the participants as an effective way to receive information and updates. Some discussed social media, but qualified by comments like "that's the way things are going" rather than their own desire to receive information in that way.

During the large lake residents' focus group meeting, the moderator prompted responses about communication methods by circulating a notebook with a variety of printed media examples including long publications, fact sheets, web sites, social media, postcards, and others. The group identified and discussed a broader range of media than did phone interviewees, but we are not sure if that was because of the prompts, or a result of their previous experiences as leaders within their lake association.

It was notable the extent to which lake associations are engaging and educating their members through their websites, newsletters and social media. As a group, they tended to prefer longer and more technical publications as a source of water quality information.

Engagement

Phone interviewee and large lake focus group participant responses were quite a bit more general when asked for their recommendations for ways to engage Watershed residents in water quality issues. Many spoke of "education" in a broad sense, reflecting on the need to build awareness of water quality issues, especially among youth.

The value of personal interaction emerged as an important theme in some of the interviews and focus group sessions. One lake association leader commented on the success of their lake "zone representatives" approach for one-to-one interaction with shoreline property owners.

Others commented on the importance of activity as a way to engage individuals, especially through monitoring and clean-up activities.

Notably, a lot of information was exchanged between participants during the large lakes focus group discussion. In fact, the moderator had a challenging time keeping participants on task - they continued to question each other to learn about activities or ideas. One participant brought up a "little summit" that their lake association had with another and the value of that dialog. It could be that this particular group of participants had a lot to share with each other, but may speak to the broader value of providing forums for lake association interaction within the Watershed.

Local governments and the gaps analysis guidebook

The composition of the local officials' focus group was skewed to elected officials, not appointed planning commission or zoning board of appeals members. Their responses tended to be more general, even when prompted for more specific information. This result makes sense - local officials make policy, but are not frequently involved in details planning and education activities.

Those that had awareness of their water quality-related regulations – setbacks, impermeable surface maximums, shoreline greenbelts – were satisfied with them. The group agreed that governmental cooperation in the area is pretty good, although they haven't seen much need to cooperate on water quality issues, since there are few to deal with – most tend to be localized. In both counties, most townships participate in county planning and zoning, which serves, in their opinion, as an effective intergovernmental cooperation method.

The lack of awareness of specific water quality zoning standards by the local elected officials in this focus group session speaks to the need for interactions with the planning commissions and zoning boards of appeals in Emmet and Cheboygan counties, especially at the county level, when seeking feedback on watershed plan policy recommendations. While it is true that County Board of Commissioners and Township Boards enact land use policies, the Michigan Planning Enabling Act dictates that the process of developing master plans and zoning regulations begins with the planning commission.

The focus group moderator distributed excerpts from the Emmet County Gaps Analysis Guidebook prior to the session, and circulated copies of the entire publication during the discussion. Overall, the participants had just received their copies and did not have time to fully digest the content, although some reflected that they had attended a presentation about the book during one of their township board meetings. Overall, participants commented that the publication was thorough, potentially very useful as another source of information for local decision-making, and a way to see what other townships are doing. They were less sure about specific applications in their communities, although a couple of participants commented on the opportunity to use the guidebook when they review their master plan and as a tool for making their voices heard on the county level. Interestingly, participants did note the some townships had considerably longer sections than others, and were unsure whether that meant that they had few issues, or that it was because they participated in county zoning.

Finally, the local officials commented that they appreciate Watershed Council presentations during their meetings. Local Michigan Townships Association chapter meetings were also noted as a forum for education on water quality issues, although attendance at those events varies.

Additional comments

Clearly, Watershed residents, shoreline property owners, and local officials share the same values about what is special and important about the Burt Lake Watershed, and identified many of the same water quality threats and concerns.

At the conclusion of focus group sessions and individual interviews, many participants commented that they appreciate the work of Tip of the Mitt Watershed Council, and in some cases told stories of their participation in water quality monitoring or an educational effort. Even though non-governmental participants were recruited from the Watershed Council's membership list, these unprompted comments speak to the recognition and appreciation for Watershed Council activities. It is notable that, in contrast to focus group sessions conducted in the Duncan and Grass Bay project, we heard no apprehension about watershed planning or Tip of the Mitt Watershed Council roles. Although we do not have any direct evidence from these focus groups or interviews, we speculate the Watershed Council's visibility and long history in these Watersheds, especially the Emmet County portions, is largely responsible for this response.

As noted in the methods section, we were unsuccessful in recruiting enough business representative for either a focus group session or individual interviews, even those with a more direct stake in water resources issues. Other approaches are needed to develop a relationship with the business community and open lines of communication.

Given the large size and variability within the Watershed, it is difficult to identify place-specific water quality issues or needs in particular areas through this focus group and interview process. Interaction with existing organizations, sportsman's groups, and advisory committees may be a more effective way to gather this information.

Watershed Organizations

The below information includes both general descriptions about these organizations as well as highlights of their recent efforts toward watershed protection.

Burt Lake Preservation Association (BLPA)

The Burt Lake Preservation Association works to preserve and improve Burt Lake and its Watershed for quality use by future generations. To contact visit their website at www.blpa.org or call (231) 238-2177.

The following highlights provided by a BLPA representative.

- Encourages all Burt Lake Watershed residents to be involved in their local governments and volunteer to serve on local boards committees.
- Encourages a solid two-way relationship with the Department of Natural Resources and local units of government.
- Remains vigilant on statewide legislative actions that affect inland lakes and their watersheds.
- Collaborates with Little Traverse Conservancy, the Cheboygan County Road Commission, and Tip of the Mitt Watershed Council.
- Supports the Cheboygan County Sheriff's Marine Patrol with a yearly contribution for extra marine patrols of Burt Lake.
- Established a Trust fund in 2016 for the long-term care and protection of Burt Lake and its Watershed.
- Supports the existing Burt Township Zoning and works with the Township to improve and strengthen local zoning.
- Works and communicates with other area lake associations about mutual concerns and issues.
- Looks for ways to protect Burt Lake and its Watershed by using the resources that are available without dividing our community.
- Publishes newsletters at least three times per year; began in 1999.
- Supports efforts to complete shoreline surveys of Burt Lake and share results with all riparians. Recent surveys were completed in 2001 and 2009.
- Supported a Burt Lake tributary water quality-monitoring project in 2011.
- Implements the Restore the Shore program, which promotes greenbelts through outreach and education.
- Promotes septic maintenance through outreach and education.
- Enbridge pipeline initiative 2014
- Erected invasive species signs at various boat launches 2012.
- Constructed a rain garden at the Tuscarora Township's Greendocks 2011 in collaboration with Tip of the Mitt Watershed Council.
- Collaborated with University of Michigan Biological Station research students in 2016 to produce the Burt Lake Management Plan.

- Began septic system and greenbelt billboard initiative in 2015. Billboards posted in various locations in Northern Michigan.
- Supported the Burt Lake aquatic plant survey with Tip of the Mitt Watershed Council in 2016.
- Implemented POD (Prescription and Over-the-Counter Drop) Box program in 2012 in collaboration with Tip of the Mitt Watershed Council.
- Began participating in Tip of the Mitt Watershed Council's Volunteer Lake Monitoring program, which monitors water quality throughout the summer, since 2001.
- Began working to manage Eurasian watermilfoil in 2004 with biological control (weevils) and traditional methods (herbicides).
- Remain actively engaged with various agencies such as Michigan Department of Natural Resources and US Fish and Wildlife Service when they are implementing nuisance and invasive species controls.

Burt Lake Township

The Burt Township Zoning Ordinance includes many sections that specifically seek to protect water quality of Burt Lake and its tributaries within the township, including the following:

- (2006) Ordinance amended to require a natural vegetation strip be established or maintained within 25' of the shoreline on at least 70% of frontage for any new construction/ renovation that increases structure footprint by 500 ft2 or greater.
- 2. Pesticides, herbicides and fertilizers are prohibited within 25' of the ordinary high water mark on Burt Lake except for spot treatment of herbicides to eradicate poison ivy. Only zero phosphorus fertilizer may be used within the 75' waterfront setback.
- 3. Within 75' waterfront setbacks, the use of asphalt, concrete, stone, aggregate, paving of any sort, wood or other similar surfaces shall be limited to a single walkway no more than 4' in width or stairs necessary for water access.
- 4. (2008) Commercial Timber Cut amendment added. Requires a 50-foot minimum from all water bodies including streams and intermittent streams.
- Burt Township Board agreed to participate in regional recycling with placement of bins at East and West side transfer stations. This continues to be a very successful and popular program with township residents. Solids like plastics, metal, and paper are kept out of landfills. Most importantly for the Burt Lake Watershed, these materials and others, especially spent batteries, are kept out of the woods, where they would leach into groundwater.

In addition to the above, the Township sponsors an annual 'Big Dump Day' when residents bring large items such as appliances, mattresses, etc. plus hundreds of tires that might otherwise end up in the woods. The tire drop off is funded by a grant from the State of Michigan.

By agreement with the University of Michigan Biological Station the Township Board approved abandonment of Lathers Road, closing it to vehicular traffic into the Colonial Point Preserve.

Currently, the Planning and Zoning subcommittee on Septic & Water Quality is currently working with Tip of the Mitt Watershed Council on proposed septic inspection regulations.

Conservation Resource Alliance

Conservation Resource Alliance (CRA) is a private, not-for-profit corporation committed to "sensible stewardship of the land." Their service area encompasses counties in Northeast Michigan, including Emmet County. To contact, visit their website at www.rivercare.org or call (231) 946-6817.

In recent years, CRA has focused on free spanning the Maple River with the goal of achieving 100% connectivity. This initiative provides a unique chance for fish and wildlife to access over 40 miles of aquatic habitat, including the main stem and its tributaries, completely unrestricted. To date, four of the nine major road/stream crossing projects have been completed, including the recent installations of timber bridges on Robinson Road (2015) and Brutus Road (2016). Plans to tackle the largest obstacle on the river, the Lake Kathleen Dam and the contiguous Woodland Road crossing, are also underway. Partners completed a feasibility study addressing options for the dam, impoundment, and associated stream crossings.

Douglas Lake Improvement Association

The Douglas Lake Improvement Association (DLIA) is committed to promoting the maintenance and improvement of the environmental quality of Douglas Lake, its Watershed, fishing and the quality of life of its residential community. To contact visit their website at www.douglaslake.org.

- Established Aquatic Invasive Species committee
- Conducted Aquatic Plant survey by TOMWC 2012
- Placed Sign and brochure box at Douglas Lake Road end launch site
- Conducted training and Clean Boats, Clean Waters boat and trailer inspection events at Douglas Lake road launch
- Additional brochure/information placed at Maple Bay Marine and Cooks Hardware
- Random exam of boat trailers at Douglas Lake Road launch
- Report annually at DLIA annual meeting
- Douglas Lake e- News regularly features Invasives, shoreline quality
- Conducted Shoreline survey by TOMWC 2015, results reported 2016

Huffman Lake Property Owners Association

Huron Pines

Huron Pines is a nonprofit conservation organization whose mission is to conserve the forests, lakes, and streams of Northeast Michigan. To contact, visit their website at https://huronpines.org or call (989) 448-2293.

Lake Louise Christian Community

Larks Lake Association

Larks Lake Association is a group of lake property owners who work to protect and improve Larks Lake in Emmet County.

https://www.facebook.com/Larks-Lake-Association-565140210211059/home

Little Traverse Bay Bands of Odawa Indians

The Little Traverse Bay Bands of Odawa Indians' Surface Water Protection Program has completed numerous activities to protect the Burt Lake Watershed. The program participated in a Natureology Kids Winter Celebration on Round Lake in 2012, Tip of the Mitt Watershed Council's Watershed Academy on the Maple River in 2015 and 2016, and the University of Michigan's Camp Kinoomage in 2016 on the Maple River. The program has monitored Crooked Lake, Brush Creek, the West Branch of the Maple River, Mud Lake, Spring Lake, Round Lake, and Van Creek since 2000 and recently completed eDNA testing for aquatic invasive species on Round Lake and Crooked Lake. A new project occurring for the SWPP in the Burt Lake Watershed is the monitoring of historical wild rice (manoomin) areas in the Inland Waterway.

The Little Traverse Bay Bands of Odawa Indians Natural Resource Department (LTBB NRD) Inland Fisheries & Wildlife Program has been involved with fisheries monitoring and research within the Burt Lake Watershed over the last ten years. From 2011 to 2013, the program helped coordinate the Inland Waterway Walleye Movement Study with the Michigan Department of Natural Resources and Michigan State University. The main research question for this study was, does the entire Inland Waterway act as one walleye lake system, or should it be treated and managed as separate walleye lake systems? This effort involved jaw-tagging every adult walleye during the 2011 Spring Adult Walleye Abundance Estimates on Crooked-Pickerel, Burt, and Mullett Lakes. During both 2012 and 2013, LTBB and MDNR continued jaw-tagging and monitoring walleye within the Inland Waterway while Michigan State University conducted a diet study by analyzing stomach contents of walleye. The study resulted in almost 15,000 jaw-tagged walleye and over 1,000 stomachs collected for the diet analysis between 2011 and 2013.

During fall 2015, the LTBB NRD Inland Fisheries & Wildlife Program coordinated the Juvenile Lake Sturgeon Assessment on Burt Lake with MDNR and Bay Mills Indian Community. This effort utilized short-term (1 to 2 hours) gill-net sets to get an idea on the characteristics of the juvenile lake sturgeon population within Burt Lake because LTBB has been stocking lake sturgeon there since 2013. Overall, almost 70 unique lake sturgeon were handled. Along with basic biological measurements, fish were scanned for Coded Wire Tags (CWT) and Passive Integrator Transponder tags (PIT) to determine if a fish was of hatchery origin. A report for this effort is forthcoming.

Little Traverse Conservancy

The mission of the Little Traverse Conservancy is to protect the natural diversity and beauty of northern Michigan by preserving significant land and scenic areas, and fostering appreciation and understanding of the environment. Their service area includes Chippewa, Mackinac, Emmet, Cheboygan, and Charlevoix counties.

Over the past 10 years, LTC has protected over 5,350 acres of land through direct acquisition, conservation easements on private lands, and assist projects with local units of government throughout the Burt Lake Watershed. They are actively working with landowners within the Watershed who are in the process of donating conservation easements on their lands.

Northeast Michigan Council of Governments

The Northeast Michigan Council of Governments (NEMCOG) was established in 1968 as a multi-county organization to pool resources for the assistance of local governments in the region. NEMCOG Region (8-county): Alcona County, Alpena County, Cheboygan County, Crawford County, Montmorency County, Oscoda County, Otsego County, and Presque Isle County (Emmet County is in the NW region but is also a member of NEMCOG).

The Northern Inland Lakes Citizens Fishery Advisory Committee

The Northern Inland Lakes Citizens Fishery Advisory Committee, established in 2009, provides an excellent opportunity for citizens to become involved with natural resource management within the Cheboygan River Watershed through a multi-agency, multi-organization partnership. Public involvement through the advisory committee, one of its member organizations, or other citizen groups provides the opportunity to open a dialogue on natural resources issues and promotes the exchange of experiences, ideas, and proposals among individuals, communities, interest groups, and government agencies. Numerous opportunities exist for concerned citizens to become involved in issues affecting the Watershed; citizens are encouraged to take advantage of these opportunities for participation.

Pickerel-Crooked Lake Association

The Pickerel-Crooked Lakes Association is a non-profit organization that supports measures which contribute to the healthy environment of Crooked and Pickerel Lakes. Their mission statement is: " Working, Educating and Advocating for Quality Lake Living since 1963".To contact visit their website at www.pickerel-crookedlakes.org or call (231) 439-0169.

- PCLA publishes a Bi-annual newsletter to its members with articles on shoreline management, invasive species, and current water monitoring results, government and development activities, and pertinent articles about our watershed.
- PCLA maintains an active website with current articles concerning our activities and watershed resources. www.pickerel-crookedlakes.org
- PCLA monitors for invasive species and shoreline activates, year around, for ten shoreline zones and 12-14 active boat launches on our two lakes.
- PCLA Invasive Species Committee in 2016 has treated two sites for Curly Leaf Pondweed and one site for Eurasian Milfoil; and continues to monitor regularly for Purple Loosestrife on the Lakes, creeks, and streams entering our Lakes.
- PCLA has contributed to the efforts of the Little Traverse Conservancy towards acquiring and protecting fragile wetlands and shorelines on Crooked and Pickerel Lakes; and the streams, channels and creeks entering our Lakes.
- PCLA volunteered person-hours to the Tip Of the Mitt Watershed Council for a native clam and mussel study of our two lakes for a potential test treatment site for Quagga and Zebra Mussels control in our watershed.
- In the spring of 2016, PCLA volunteers participated in an invasive species signage study with the Watershed Council and the Little Traverse Bands of Odawa Indians Natural Resource Department with the purpose of creating a Clean Boating Campaign.
- In 2012 the PCLA commissioned the Watershed Council for a shoreline study of Crooked and Pickerel Lakes with results for each shoreline owner. In 2012, a permanent Shoreline Committee was established for our organization.
- In 2014-15 an Aquatic plant study was commissioned by the PCLA with Tip Of the Mitt Watershed Council as a collaborative effort with the four adjoining townships, Emmet County and the Village of Alanson. In 2016 the report was presented to the six government entities with a verbal question and answer period with recommendations.
- In 2016, and for the 25 or more preceding years, the PCLA has assisted the Watershed Council with volunteers in active monitoring for water quality tests on our two lakes.

Tip of the Mitt Watershed Council

Tip of the Mitt Watershed Council is a not-for-profit organization that is dedicated to protecting the lakes, streams, wetlands and groundwater of Northern Michigan through respected advocacy, innovative education, thorough research, water quality monitoring and restoration actions. To contact visit their website at www.watershedcouncil.org or call (231) 347-1181.

Tip of the Mitt Watershed Council has worked extensively throughout the Watershed since 1979. A list of projects undertaken over the last 15 years can be found in Table 6.

In addition, the Watershed Council has performed dozens of shoreline assessments, and designed and coordinated numerous bioengineering and greenbelt projects for shoreline properties. Tip of the Mitt Watershed Council has developed and distributed many educational and outreach materials that pertain to invasive species, shoreline management, water quality, and other topics that relate to watershed protection.

Table 6: Tip of the Mitt Watershed Council Burt Lake Watershed projects (2002-2016)

Project Title	Waterbody
Burt Lake Tributary Monitoring	Various
Burt Lake Shoreline Survey	Burt Lake
Burt Lake Shoreline Survey Follow-up	Burt Lake
Burt Lake Shoreline Survey	Burt Lake
Burt Lake Shoreline Survey Follow-up	Burt Lake
Burt Lake Aquatic Plant Survey	Burt Lake
Aquatic Plant Survey	Burt Lake
Burt Lake Eurasian Watermilfoil Control Project	Burt Lake
Crooked Lake Aquatic Plant Survey	Crooked Lake
Pickerel Lake Aquatic Plant Survey	Pickerel Lake
Crooked Lake Aquatic Plant Survey	Crooked Lake
Pickerel Lake Aquatic Plant Survey	Pickerel Lake
Round Lake Aquatic Plant Survey	Round Lake
Crooked River Aquatic Plant Survey	Crooked River
Crooked Lake Shoreline Survey	Crooked Lake
Crooked Lake Shoreline Survey Follow-up	Crooked Lake
Pickerel Lake Shoreline Survey	Pickerel Lake
Pickerel Lake Shoreline Survey Follow-up	Pickerel Lake
Pickerel Lake Water Quality Report	Crooked Lake
Pickerel Lake Water Quality Report	Crooked Lake
Crooked Lake Loosestrife Control Project	Crooked Lake
Pickerel Lake Loosestrife Control Project	Pickerel Lake
Douglas Lake Aquatic Plant Survey	Douglas Lake
Douglas Lake Shoreline Survey	Douglas Lake
Douglas Lake Shoreline Survey	Douglas Lake
Douglas Lake Shoreline Survey Follow-up	Douglas Lake
Huffman Lake Shoreline Survey	Huffman Lake
Larks Lake Aquatic Plant Survey	Larks Lake
Larks Lake Shoreline Survey	Larks Lake
Larks Lake Winter Monitoring	Larks Lake
Thumb Lake Aquatic Plant Survey	Thumb Lake
Thumb Lake Shoreline Survey	Thumb Lake
Thumb Lake Shoreline Survey	Thumb Lake
Volunteer Stream Monitoring	Various
Volunteer Lake Monitoring	Various
Burt Lake Watershed Purple Loosestrife Control Project	Burt, Crooked
Maple River Habitat Structure Survey	Maple River

Wildwood Lake Property Owners Association

The Wildwood Lake Property Owners works to protect the natural resources of the Wolverine area, and ensure the health of Wildwood Lake and is ecosystems. To contact visit their website at www.wildwoodlake.info or call (231) 333-6121.

Previous Watershed Management Efforts

Burt Lake Watershed Planning Project

In 1988, a nonpoint source pollution inventory and Watershed Management Plan was developed for the Burt Lake Watershed by the Northeast Michigan Council of Governments and Tip of the Mitt Watershed Council. Many of the recommendations were implemented as part of a follow-up project funded by the Michigan Department of Natural Resources in 1989 and 1990. In the spring of 2001, a series of meetings were held with local government officials, conservation groups, environmental organizations, regional planning agencies, and other stakeholders within the Burt Lake Watershed to discuss concerns about water quality. The group identified many different issues and committed to working together in a partnership to develop a Watershed Management Plan.

Sediment, nutrients, and toxics such as oils, grease, and heavy metals were identified as the main pollutants of concern that threaten the designated uses in the Burt Lake Watershed.

As a result, the stakeholders identified the following project goal:

The mission of the Burt Lake Watershed Planning Project is to protect and enhance the water quality of Burt Lake and its tributaries by reducing current and future polluted runoff.

Specific goals were also identified as follows:

- Maintain navigation in the rivers and lake by reducing any sediment inputs.
- Protect the diversity of aquatic habitats within the Burt Lake Watershed by reducing the contribution of sediment, nutrient, and toxic pollutants (warm water fishery and other aquatic species and wildlife).
- Maintain the excellent recreational partial and total body contact opportunities in the rivers and lake by reducing sediment and nutrient contributions.
- Reduce sediment and nutrient loads which threaten to harm habitat conditions for the cold-water fishery in Burt Lake and its tributaries.

In addition, the stakeholders determined the priority areas for the Watershed as:

1. Areas within 1000 feet of the following features:
   - Burt Lake
   - Other inland lakes in the Watershed
   - Tributary streams (including intermittent drainages)
   - Contiguous wetlands (for the Burt Lake Watershed, a contiguous wetland is defined as a wetland within 500 feet of streams or other lakes within the Watershed)
   - Urban areas that drain to surface waters via storm sewers and/or drainage ditches
2. Areas of steep slopes contiguous with any priority perimeter described above. Regarding water resources, the definition of a steep slope seems to range widely in the literature (from 8 to 25%). For this priority area determination, a 10% slope (or 1:10 ratio, or 6 degrees) or greater is recommended.

University of Michigan Biological Station: Burt Lake Watershed Planning Project: Biological Management Plan

Students from the University of Michigan Biological Station completed the Burt Lake Watershed Planning Project: Biological Management Plan in August 2016. The students cooperated with the Burt Lake Preservation Association, Tip of the Mitt Watershed Council, University of Michigan Biological Station, Michigan Department of Natural Resources, the Little Traverse Bay Bands of Odawa Indians, and Sturgeon for Tomorrow. The Plan focuses on four key aspects: lake sturgeon, crayfish, plants, and algae. The Plan sought to answer the following questions:

1. Lake Sturgeon: Is there suitable spawning habitat to host a sustainable Lake Sturgeon population?
2. Crayfish: Has there been a serious decline in the population of crayfish?
3. Plants: What invasive aquatic plants are present?
4. Algae: Are there any invasive species of algae present in the Watershed?

In response to the abovementioned questions, the Plan offers management recommendations that apply to the four focus areas. Components of the Plan have been incorporated into this Watershed Management Plan. The Plan can be accessed on the Burt Lake Preservation Association's website: www.blpa.org/projects

Figure 18: Devoe Beach, Burt Lake (TOMWC)

Figure 19: Colonial Point, Burt Lake (www.fishweb.com)

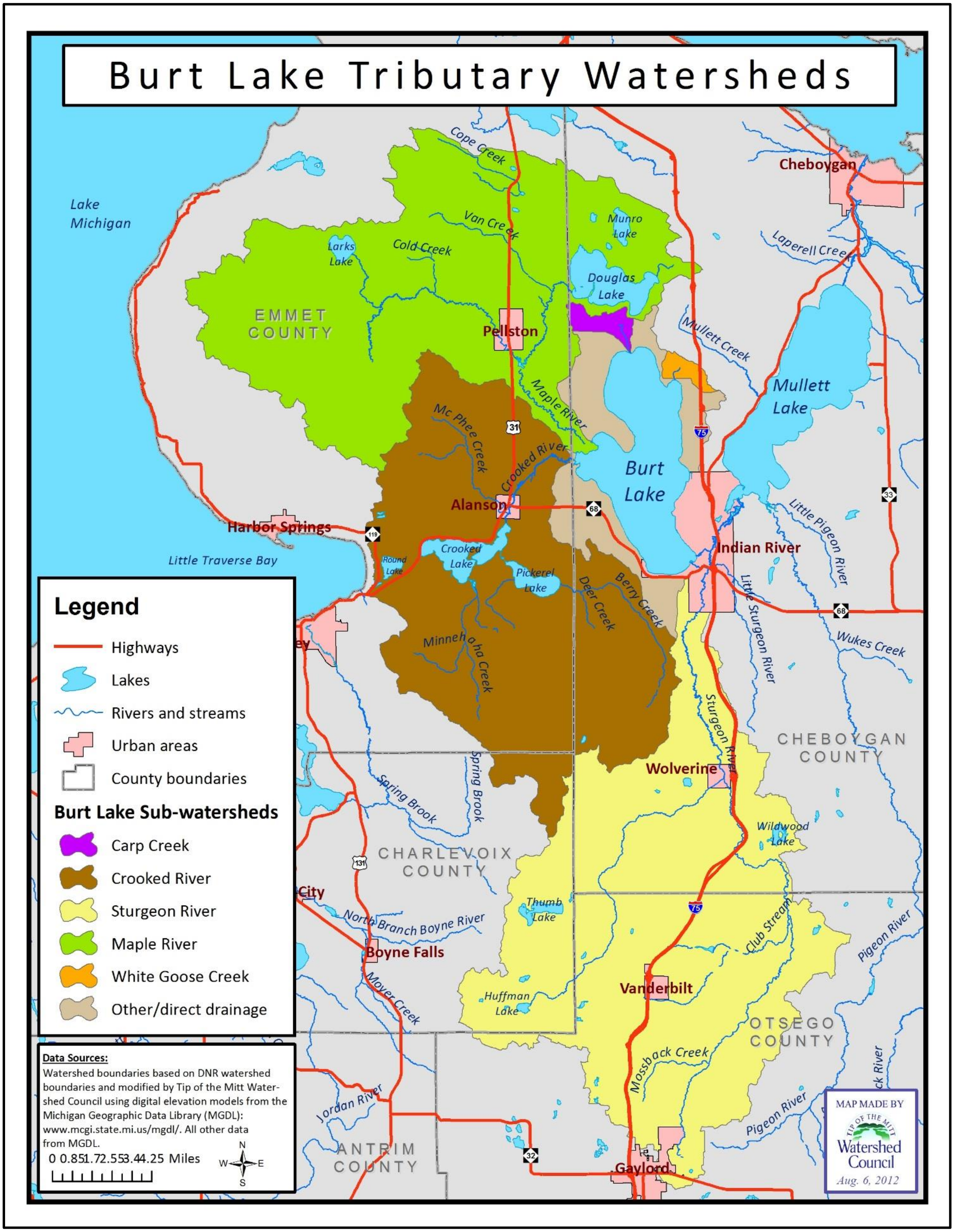


Figure 20: Burt Lake Watershed's subwatersheds

Burt Lake Direct Drainage

The Burt Lake Direct Drainage is the Watershed area that drains directly into Burt Lake. The area includes three smaller tributaries, Little Carp River, White Goose Creek, and Hasler Creek, which discharge along the north, northeastern, and western shorelines, respectively.

Figure 21: Burt Lake

Burt Lake

Primary Inflows: Maple River, Sturgeon River, Crooked River, Little Carp River
Primary Outflows: Indian River
Surface Area: 17,436 acres
Shoreline: 35 miles
Maximum Depth: 73 feet

Burt Lake has been a popular vacationing destination for over a hundred years. Part of the reason for the Lake's popularity is its clear blue water and its sandy bottom. Numerous resorts, the Burt Lake State Park, and a state forest campground help to serve the recreational demands on the lake. Burt Lake's location in the middle of the Inland Waterway makes it an ideal point from which to explore the rest of the Waterway. Loons are often seen on the lake, and some of the shoreline cedar swamps are known to be winter whitetail deeryards. The lake's high water quality supports brown and rainbow trout, as well as healthy populations of walleye and smallmouth bass. Muskellunge are also occasionally taken from the lake.

Burt Lake is Michigan's fourth largest inland lake and the largest lake in the Watershed. Approximately 18 miles (57%) of its shoreline is developed. Of the developed shoreline, 13.6 miles (45%) includes shorelines with wetland characteristics. Of the approximately 14 miles of undeveloped shoreline, 43% include shorelines with wetlands characteristics.

Landscape, Soils, and Groundwater

The shoreline topography ranges from low, flat, wetlands to extremely steep (45%+) banks that rise more than 100 feet above the lake. However, most of the shoreline is fairly level to rolling. The soils of the Burt Lake shoreline are extremely variable. They range from very poorly drained to excessively drained; from muck to sand. All of the soil series contiguous to the shoreline have severe limitations for on-site septic systems.

A large forested wetland known as Reese's Swamp exists at the north end of Burt Lake. This property, owned by the University of Michigan Biological Station, has over one and a half miles of undeveloped shoreline and is the southern edge of an extensive cedar and hardwood swamp over six hundred acres in size. The Little Carp River flows from the north through the middle of the swamp discharging into Burt Lake. The soils are of the Tawas and Roscommon series (Hydrologic Soil Group D). They are characteristically very poorly drained with a high water table. This swamp and its associated stream is habitat to river otter, beaver, bobcat, as well a number of endangered plant species.

Burt Lake's eastern and southeastern shorelines have soils of the AuGres, Lupton, Roscommon, Angelica, and Brevort series (Hydrologic Soil Groups D and B). These soils generally are poorly to very poorly drained with high water tables. Some well-drained soils such as the Cheboygan and Eastport series (Hydrologic Soils Group B and A) are scattered along the shoreline. At the south end of Burt Lake, the shoreline is extremely steep and rises in some places to 80-100 feet above the lake. Development at this end of the lake occurs at the top of this steep bank on the excessively drained soils of the Rubicon series (Hydrologic Soil Group A). Along the southwest shoreline, the bank is somewhat lower. In this area, the Rubicon series are separated from the lake by a zone of the very poorly-drained soils of the Tawas soils series (Hydrologic Soil Group D), extending from the bottom of the steep bank to the lakeshore. Further north along the southwestern lakeshore, the steep bank disappears and the soils are dominated by the Rudyard series (Hydrologic Soil Group D) that is somewhat poorly drained, with a high water table and poor percolation. North of this area lies an extensive wetland at the mouths of the Crooked and Maple Rivers. The soils here are very poorly drained Tawas, Lupton, and Roscommon series (Hydrologic Soil Groups D and B).

Figure 22: Little Carp River (TOMWC)

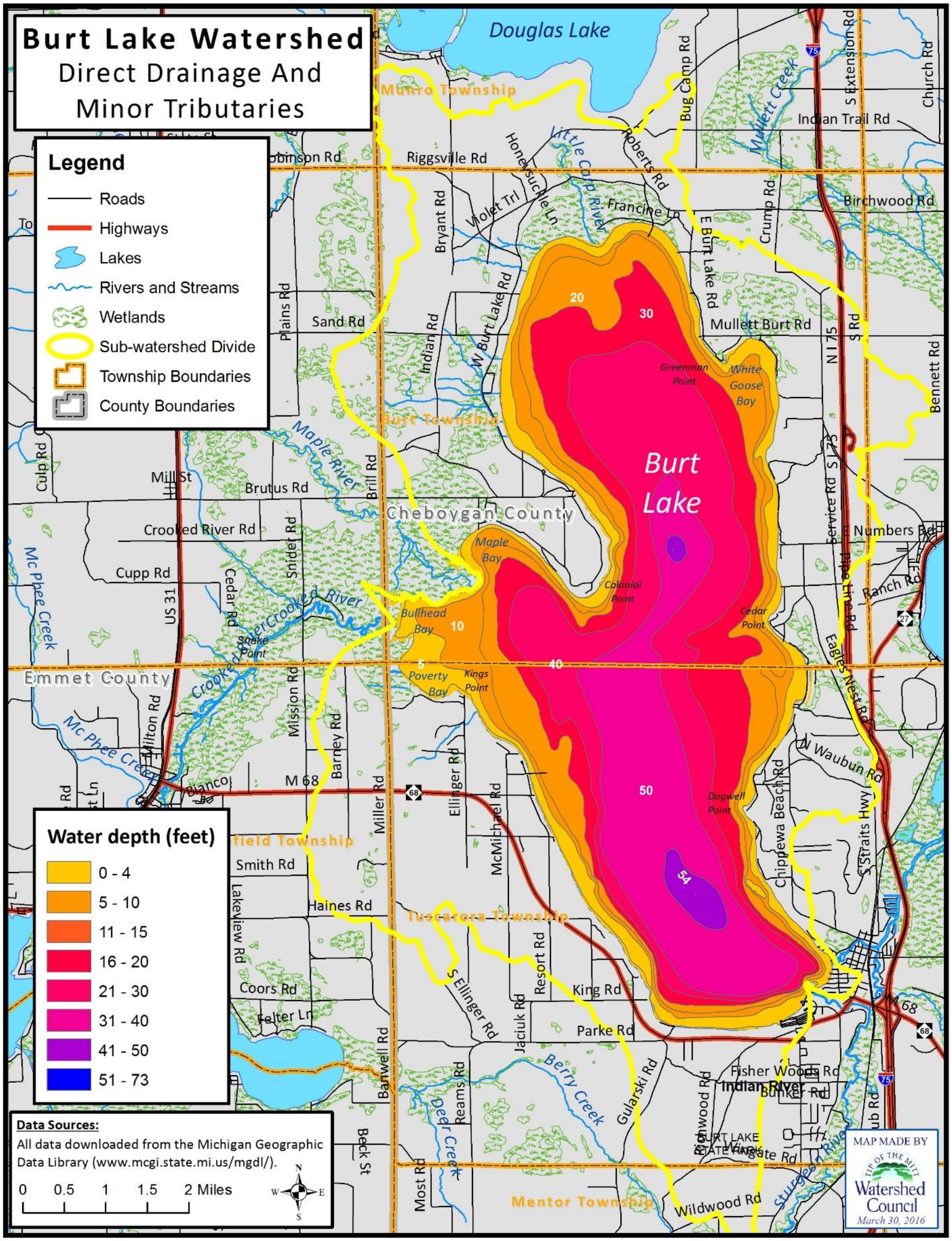


Figure 23: Burt Lake Direct Drainage

Colonial Point, on the western side of Burt Lake, is a unique environment that benefits from the protection of the Little Traverse Conservancy and the University of Michigan Biological Station. The uniqueness of Colonial Point comes from the types of trees that are found growing there. Colonial Point is home to a stand of old growth red oak and red pine. This area was extensively farmed by Native Americans prior to the turn of the century by using fire to suppress the undergrowth of beech and maple seedlings. The peninsula includes approximately 800 acres, projects into Burt Lake from its western shore just north of the Crooked and Maple River wetlands. The shoreline of the south side of the point is characterized by the well-drained soils of the Cheboygan series (Hydrologic Soil Group B). However, fine textured subsurface horizons cause this soil to have poor percolation. The well-drained Blue Lake series (Hydrologic Soil Group A) is prevalent along the end of the point. This soil is well drained but is considered too permeable to be a good septic system filter. The north shore of the point has soils of the AuGres-Roscommon Complex (Hydrologic Soil Group D), which is somewhat poorly drained to very poorly drained with a high water table. As the shoreline continues north from Colonial Point, the soil grades from the somewhat poorly drained, high water table, Brimely series (Hydrologic Soil Group D) into the very poorly drained Roscommon and Pinconning mucks. The northwest shoreline is composed of the somewhat poorly drained to very poorly drained, high water table soils of the AuGres and Roscommon series (Hydrologic Soil Group D). These soils grade into the Tawas series (Hydrologic Group D)-dominated soils of the wetland at the north end of the lake.

In watershed areas with steep slopes, hillsides intersect the water table, resulting in groundwater expelling at the land surface. The exposed water table causes horizontal groundwater movement, which releases to create seeps and springs that then form or contribute water to streams and wetlands. The degree of groundwater contributions to surface waters in the Burt Lake Direct Drainage is illustrated in Figure 25. The data used to generate the maps are based on the Michigan Rivers Inventory subsurface flux model (MRI-DARCY), which uses digital elevation and hydraulic conductivity inferred from mapped surficial geology to estimate spatial patterns of hydraulic potential. The model is used to predict groundwater delivery to streams and other surface water systems because biological, chemical, and physical attributes of aquatic ecosystems are often strongly influenced by groundwater delivery.

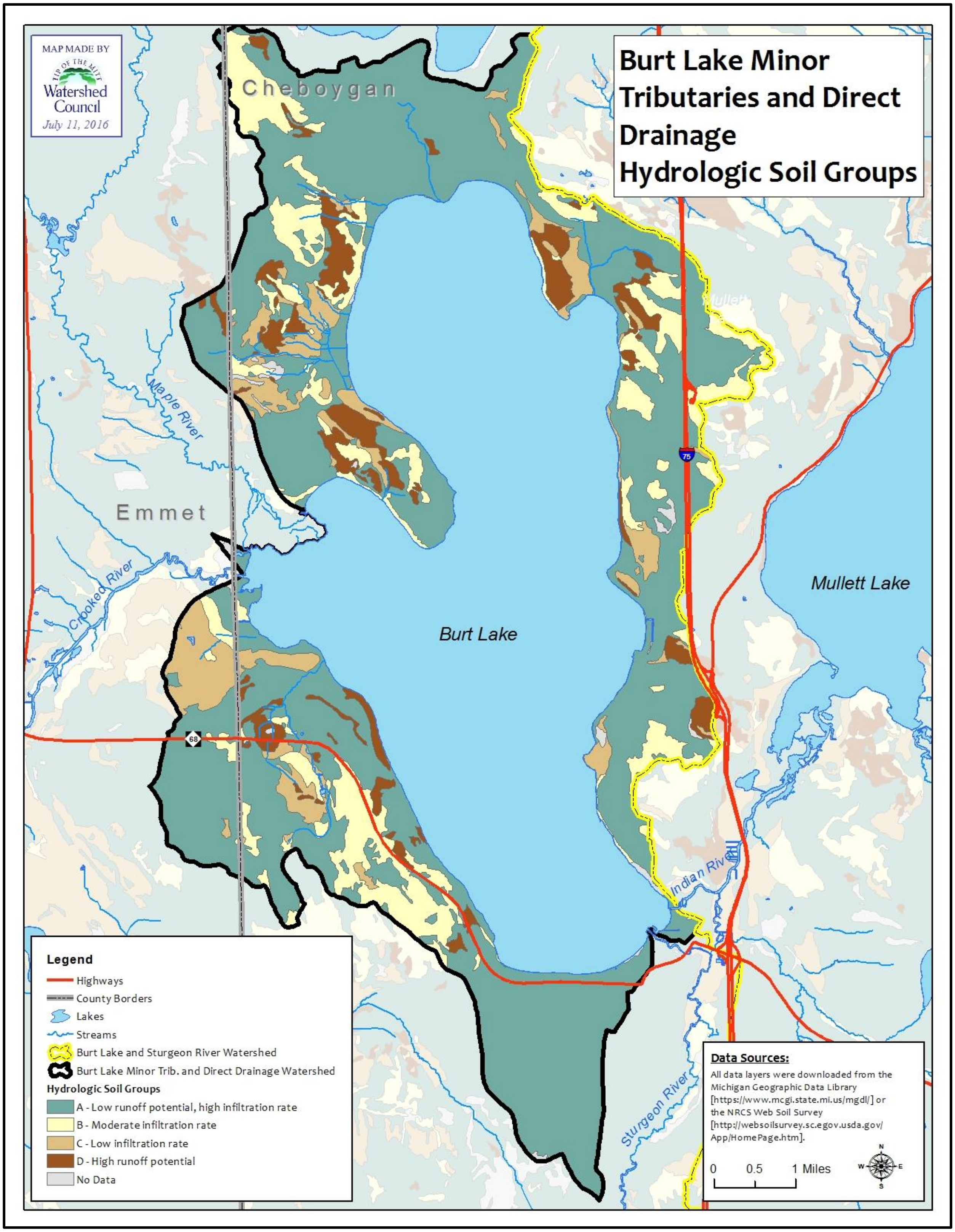


Figure 24: Burt Lake Direct Drainage hydrologic soil groups

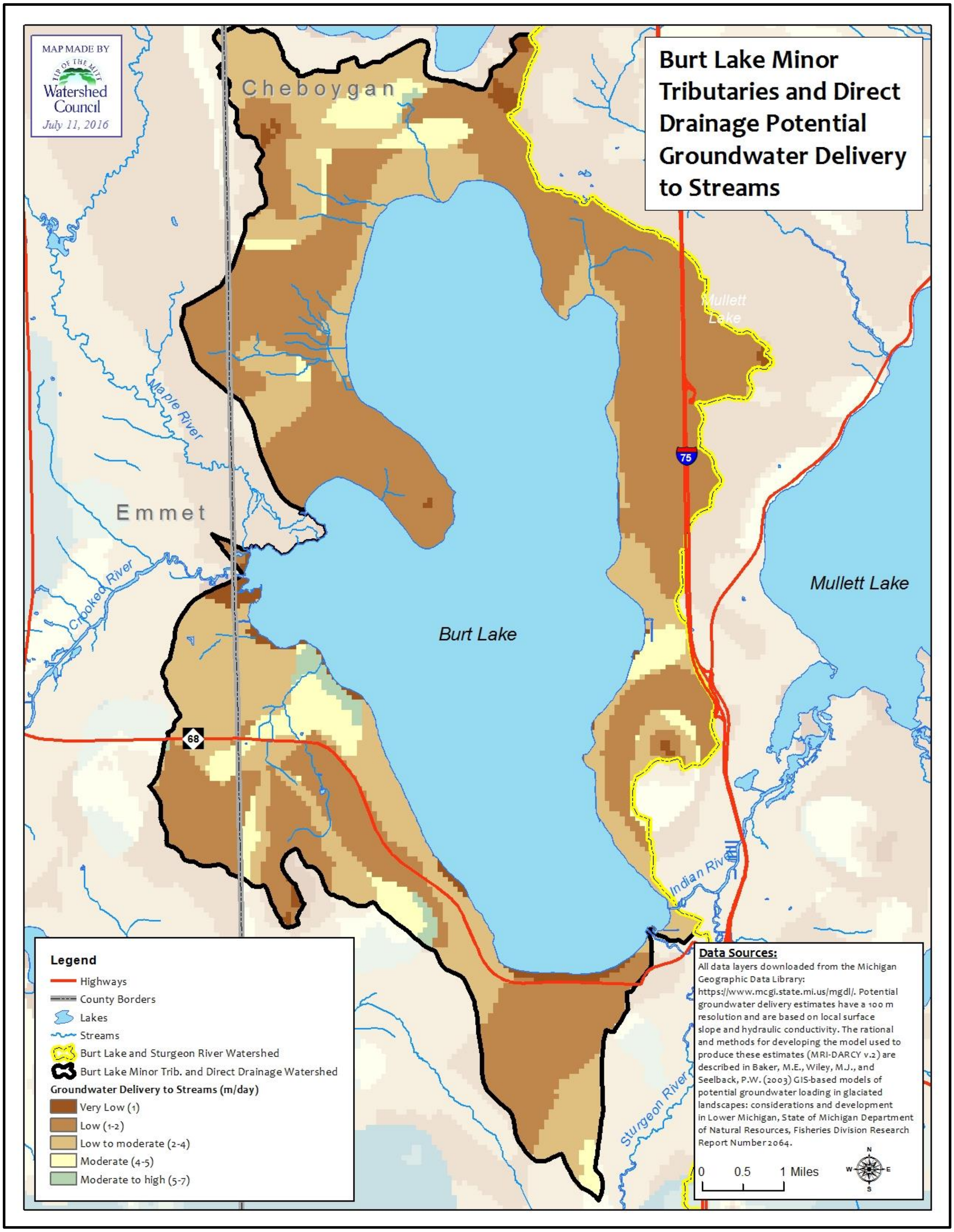


Figure 25: Burt Lake direct drainage potential groundwater delivery to streams

Maple River Watershed

The Maple River Watershed constitutes the main inland drainage basin between Little Traverse Bay and the Straits of Mackinaw. It includes:

Douglas Lake, Lancaster Lake, Lancaster Creek, Larks Lake, Munro Lake, Certon Creek, Cold Creek, Cope Creek, Bessey Creek, Beaver Tail Creek, Brush Creek, Maple River, East Branch Maple River, West Branch Maple River, Van Creek, Arnott Lake, Sherett Lake, Vincent Lake

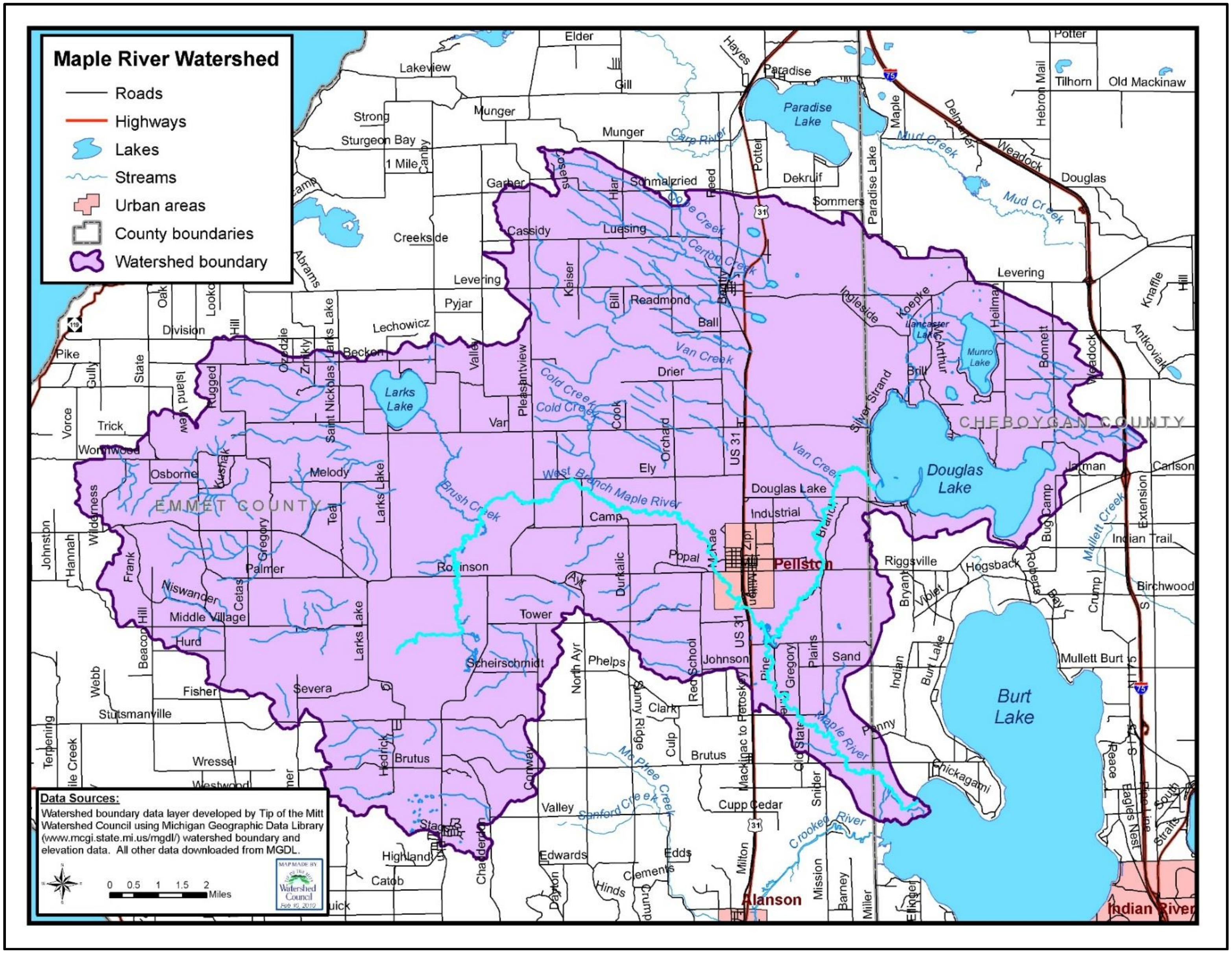


Figure 26: Maple River Watershed

Maple River

The Maple River has two branches (east and west), which converge near Pellston, MI, then flow in a southeasterly direction for six more miles to the river's mouth at Burt Lake. The headwaters of the West Branch of the Maple arise from the Pleasantview Swamp and Larks Lake, and the East Branch flows out of Douglas Lake. The river's large sand bedload causes it to spread out delta-like, so that it flows into Burt Lake via a number of small non-navigable tributaries. The Maple is a high quality river that is known for its excellent trout fishery. It has an average annual discharge of 3.7 cms (95 CFS) below the confluence of the two branches. Lake Kathleen, a 139-acre impoundment, has been created by a dam at the confluence of the two branches.

Landscape, Soils, and Groundwater

The topography is steeply rolling to nearly level. Elevation ranges from roughly 1300 feet above sea level at the Watershed's highest point, to the mouth at 594 feet above sea level. Hardwoods dominate the upland portions of the Watershed, while pines and pine-hardwood associations are common on more level, sandy areas. Cedar, balsam fir, and alders frequently occur adjacent to the river channel.

The upper-most watershed of the East Branch consists of the Munro Lake and Lancaster Lake Basins, which discharge to Douglas Lake via Lancaster Creek. From the Village of Levering to the west, small streams terminate at Arnott and Sherett Lakes, whose outflow is limited to shallow groundwater, feeding wetlands to the east. Agricultural and extractive land uses occur more predominantly in these upper reaches than in other areas of the Watershed. A considerable portion of the land surrounding Douglas Lake is owned by the University of Michigan and is used as a forest research area for the University of Michigan Biological Station (UMBS). Beavertail Creek, largely on University of Michigan property, also feeds Douglas Lake. The East Branch discharges from Douglas Lake and flows southwesterly to its confluence with the west branch. This portion of the Watershed is gently rolling to nearly level, and is largely forested.

The West Branch has a 32% larger Watershed than the East Branch. However, much of its western-most area does not form actual stream channel. Here, sandy soils have high infiltration rates, preventing runoff and channel formation. Small and isolated farm fields, many of which are fallow, form a subtle patchwork through the dominant land cover type- hardwood forest. This area is identified as a groundwater recharge zone that likely supplies water to the vast wetlands to the east, known as the Pleasantview Swamp. Roughly six miles long and two miles across, in north-south orientation, the Pleasantview Swamp hosts the Maple River's West Branch in its infancy. The early channel meanders north through the swamp, blanketed with thick vegetation. The wetland is largely intact, with limited light agricultural development on its upland borders. After roughly 1.5 miles, the river meets its first road crossing, Robinson Road. At this point, the river channel has only dropped three feet from the elevation of Four Lakes at 722 feet above sea level. As one would expect, the channel is highly sinuous and slow moving. After another 1.5 miles, the river meets its first tributary, Brush Creek. Brush Creek drains from Larks Lake 2.5 miles to the north, at the opposite end of Pleasantview Swamp. After flowing under Ely Bridge road, the river encounters its second tributary from the north, Cold Creek. Cold Creek's Watershed could be considered moderately impacted, with lower natural land cover, an impoundment at Van Road, and a compromised riparian corridor at Ely Road.

The main stem of the river, downstream of Lake Kathleen, hosts both agricultural fields and a golf course in its immediate drainage area. Riparian residential developments are found more commonly here, but are still sparse. Downstream of Brutus Road, the Watershed is completely forested, and largely owned by the State of Michigan.

The Maple River is one of northwest Michigan's most highly rated trout streams. Trout fishing is popular on both branches and the main stem of the river. Trout Unlimited has been active in protecting and enhancing trout habitat on the Maple River. River use by shallow draft boats such as canoes and kayaks has increased in the past years between Woodland Road and Brutus Road. Other sections of the river are rarely used due to downed trees that block navigation. Near the mouth of the river, the channel braids into the Maple River Spreads. This wetland area hosts a rich array aquatic and terrestrial life, and is largely protected through its inclusion in the Mackinaw State Forest. The Maple River, a tributary to Burt Lake, is almost entirely in Emmet County and flows through the townships of Friendship, Readmond, Pleasantview, Carp Lake, Center, and Maple River. The topography is steeply rolling to nearly level. Hardwoods dominate the upland portions of the Watershed while pines and pine-hardwood associations are common on more level, sandy areas. Cedar, balsam firm, and alders frequently occur adjacent to the river channel.

The soils of the Maple River Watershed are variable with topography. The upland regions of the Watershed are dominated by the Emmet Association and the Blue Lake-Leelanau Association (Hydrologic Soil Groups A and C). Both associations are deep and well-drained, but the Blue Lake-Leelanau Association is sandy while the Emmet Association tends to be more loamy. Most of the river channel occurs on soils of the Carbondale-Tawas-Roscommon Association (Hydrologic Soil Group D). These soils are deep, poorly to very poorly drained, and range from organic to sandy. Near the village of Pellston, the river flows through an area of well-drained sandy soils of the Rubicon Association (Hydrologic Soil Group A).

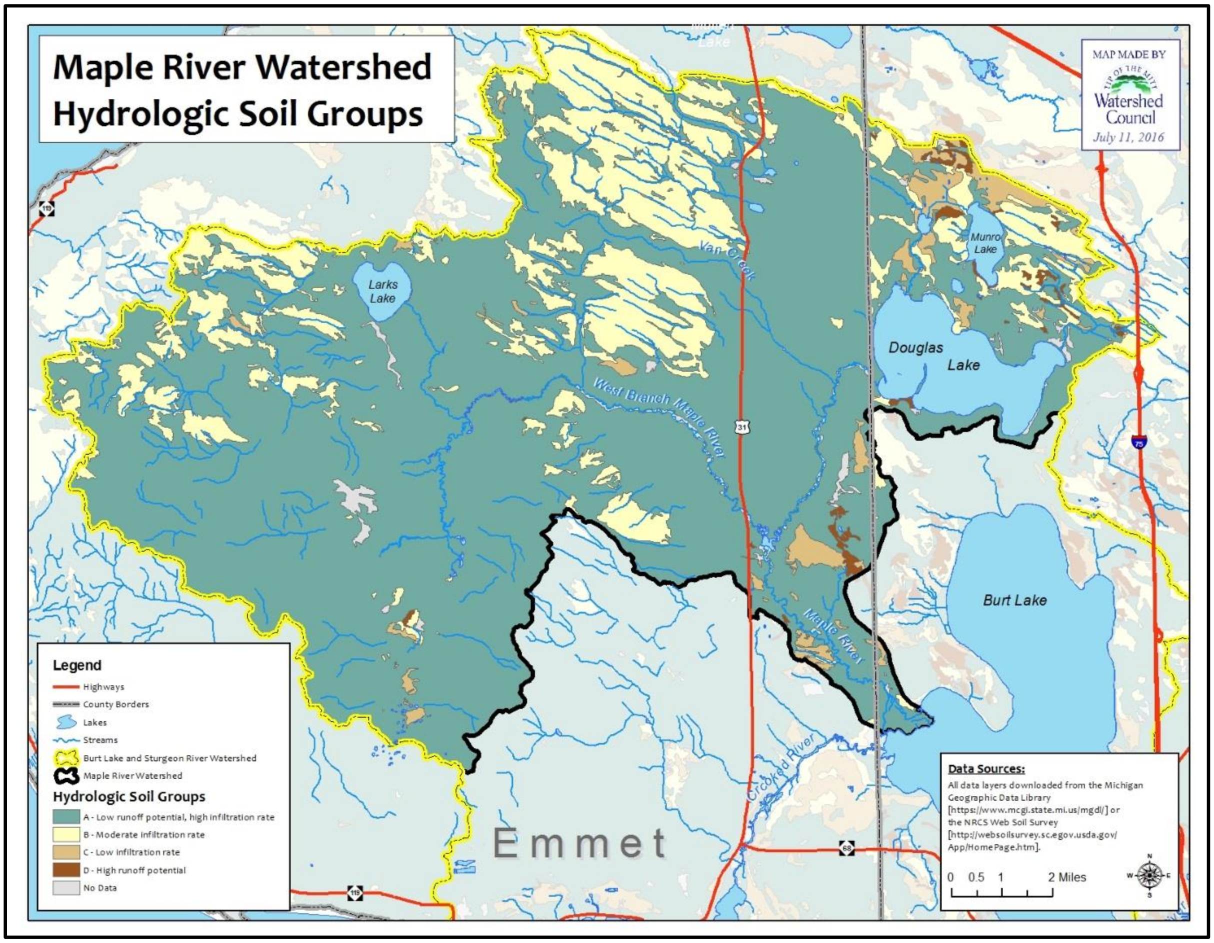


Figure 27: Maple River Watershed hydrologic soil groups

In watershed areas with steep slopes, hillsides intersect the water table, resulting in groundwater expelling at the land surface. The exposed water table causes horizontal groundwater movement, which releases to create seeps and springs that then form or contribute water to streams and wetlands. The degree of groundwater contributions to surface waters in the Maple River Watershed is illustrated in Figure 28. The data used to generate the maps are based on the Michigan Rivers Inventory subsurface flux model (MRI-DARCY), which uses digital elevation and hydraulic conductivity inferred from mapped surficial geology to estimate spatial patterns of hydraulic potential. The model is used to predict groundwater delivery to streams and other surface water systems because biological, chemical, and physical attributes of aquatic ecosystems are often strongly influenced by groundwater delivery.

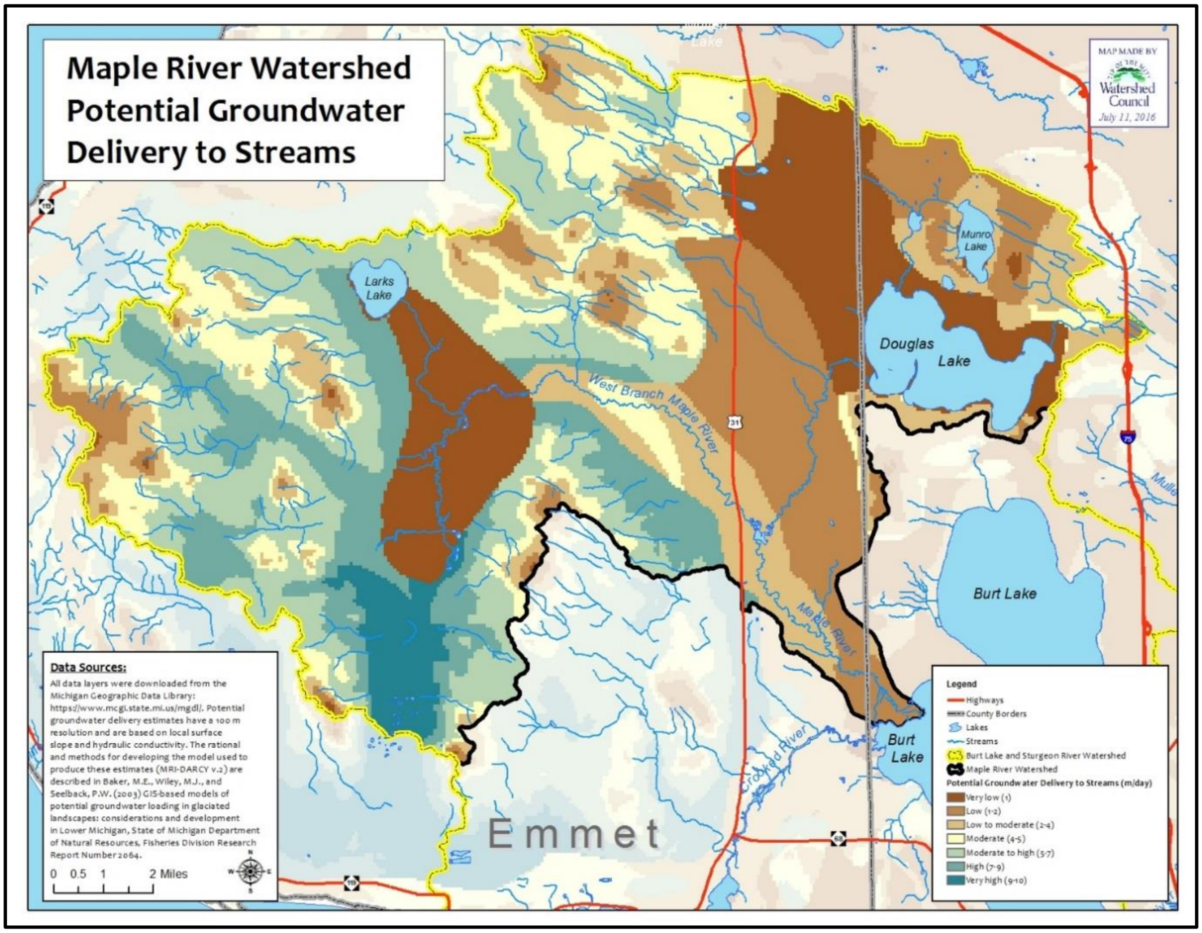


Figure 28: Maple River Watershed Potential Groundwater Delivery to Streams

Figure 29: Mouth of the Maple River (Neal Godby, MDNR)

Figure 30: Dam at Lake Kathleen on Maple River (Neal Godby, MDNR)

Figure 31: Lake Kathleen (Neal Godby, MDNR)

Munro Lake

Primary Inflows: Groundwater
Primary Outflows:
Surface Area: 515 acres
Shoreline: 5.4 miles
Maximum Depth: 15 feet

Munro Lake is located in Cheboygan County, just north of Douglas Lake. Formed by glaciers, it is relatively small and shallow compared to other Northern Michigan inland lakes. Water from the lake flows via a small stream into Lancaster Lake followed by Douglas Lake where it outlets near Marl Bay. From there, the water enters the East Branch of the Maple River and continues through the Inland Waterway and into Lake Huron via the Cheboygan River.

Fish of Munro Lake include bluegill, bluntnose minnow, bowfin, brown bullhead, white sucker, Iowa darter, johnny darter, killifishes, largemouth bass, northern pike, pumpkinseed, rock bass, smallmouth bass, spottail shiner, and yellow perch.

Figure 32: Munro Lake (TOMWC)

Douglas Lake

Primary Inflows: Lancaster Creek, Beavertail Creek
Primary Outflows: East Branch of the Maple River
Surface Area: 3,727 acres
Shoreline: 15 miles
Maximum Depth: 80 feet

Douglas Lake is located in Munro Township in northwestern Cheboygan County, Michigan. The lake covers an area of 3,780 acres and has 15.5 miles of shoreline (Cheboygan County GIS, 2012). Major landmarks in the western half of the lake include Marl Bay, Maple Bay, and Pell's Island; North Fishtail Bay and South Fishtail Bay lie to the east. Residential urbanization is seen along the shore of the western half of the lake, while the shoreline of North and South Fishtail Bay remains mostly undeveloped.

Douglas Lake is a kettle lake with five deep kettle holes that were formed by retreating glaciers thousands of years ago (Figure 34). The maximum depth in the lake is 80 feet in kettle holes between Pells Island and Grapevine Point and northwest of Pells Island. The majority of the lake has a depth of less than 30 feet. Lancaster (or Bessie) Creek and Beavertail Creek are the major inlets of Douglas Lake at the northeastern and northwestern shores, respectively. The Maple River East Branch is the major outlet of the lake in the southwestern shore of Maple Bay.

Figure 33: Douglas Lake (TOMWC)

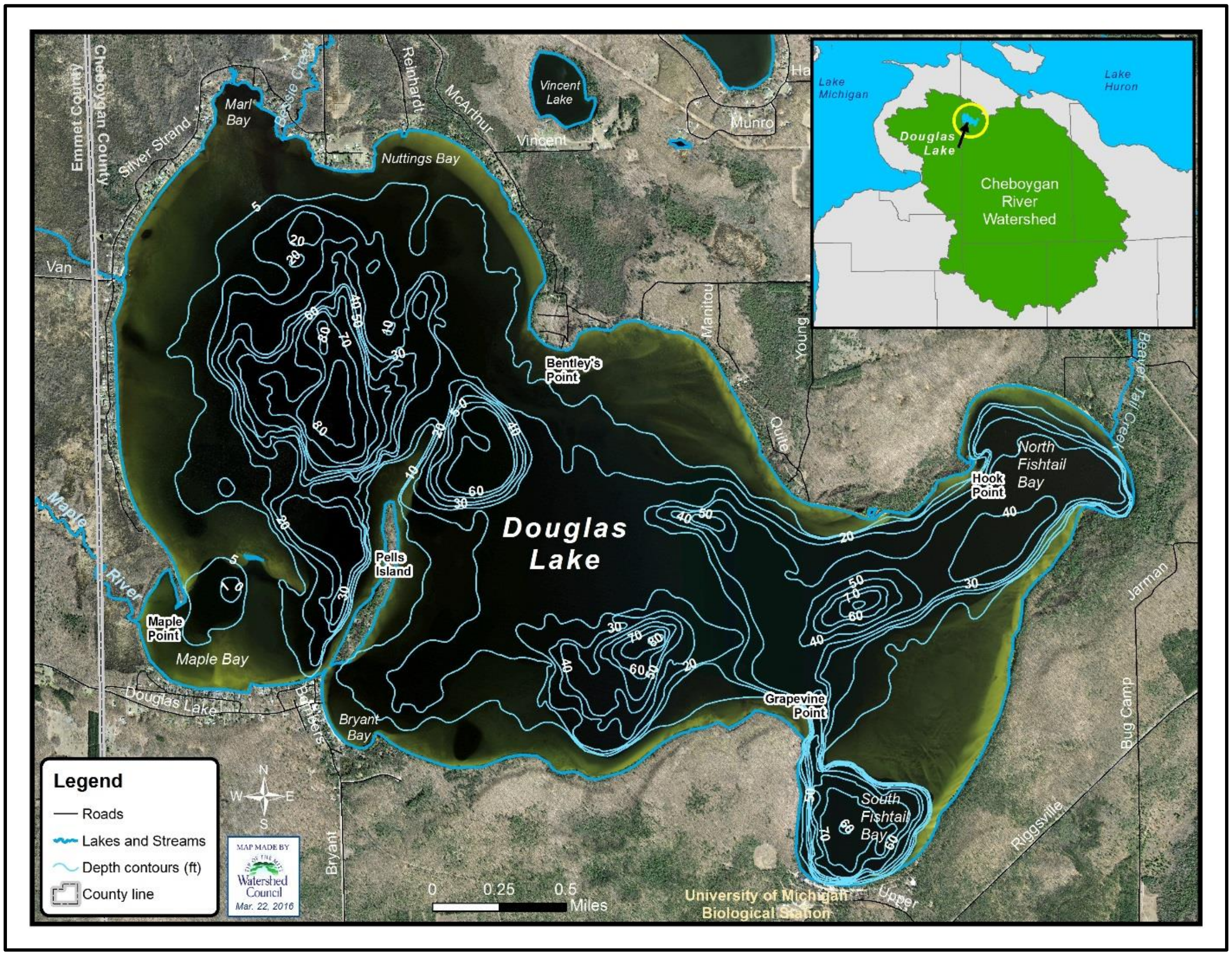


Figure 34: Douglas Lake

The Douglas Lake Watershed covers 27,364 acres; nearly equally split between Emmet and Cheboygan Counties. It stretches 12 miles from near Bliss to the northwest to the Interstate 75 Riggsville Road exit (Figure 35). Seepage from the hills northwest of Levering feeds expansive wetland complexes in the middle of the Watershed that ultimately drain into Lancaster and Douglas Lakes. The Maple River Watershed, including Douglas Lake, comprises the northwest portion of the greater Cheboygan River Watershed, water from which ultimately drains into Lake Huron at the City of Cheboygan.

Douglas Lake is the site of the University of Michigan Biological Station (UMBS), a facility dedicated to education and research in field biology and related environmental sciences. Established in 1909, it is one of the largest and oldest inland biological stations in the country. Douglas Lake is one of the most studied lakes in the world. Work at UMBS has established baseline water resource data for many waters in the Burt Lake Watershed as well as laid the groundwork for many watershed protection activities.

Douglas Lake Wetlands

This large wetland complex mostly lies just west of Douglas Lake, along the East Branch of the Maple River, Van Creek, Bessie Creek, and Lancaster Creek (but it touches Douglas Lake in several spots). It is located in both Emmet and Cheboygan Counties. This wetland is really an approximately 6,000-acre mosaic of wetlands with many, sometimes large, inclusions of slightly higher upland areas. It includes about 20 miles of shoreline. About 4,000 acres are owned by the MDNR or the University of Michigan Biological Station. It is mostly a hardwood swamp with muck or mucky loam sand soils. The portion along Bessie Creek was evaluated by the Tip of the Mitt Watershed Council in 1986 using the Adamus Wetland Evaluation Technique. Part of that portion is operated as a pike spawning marsh by the Douglas Lake Association.

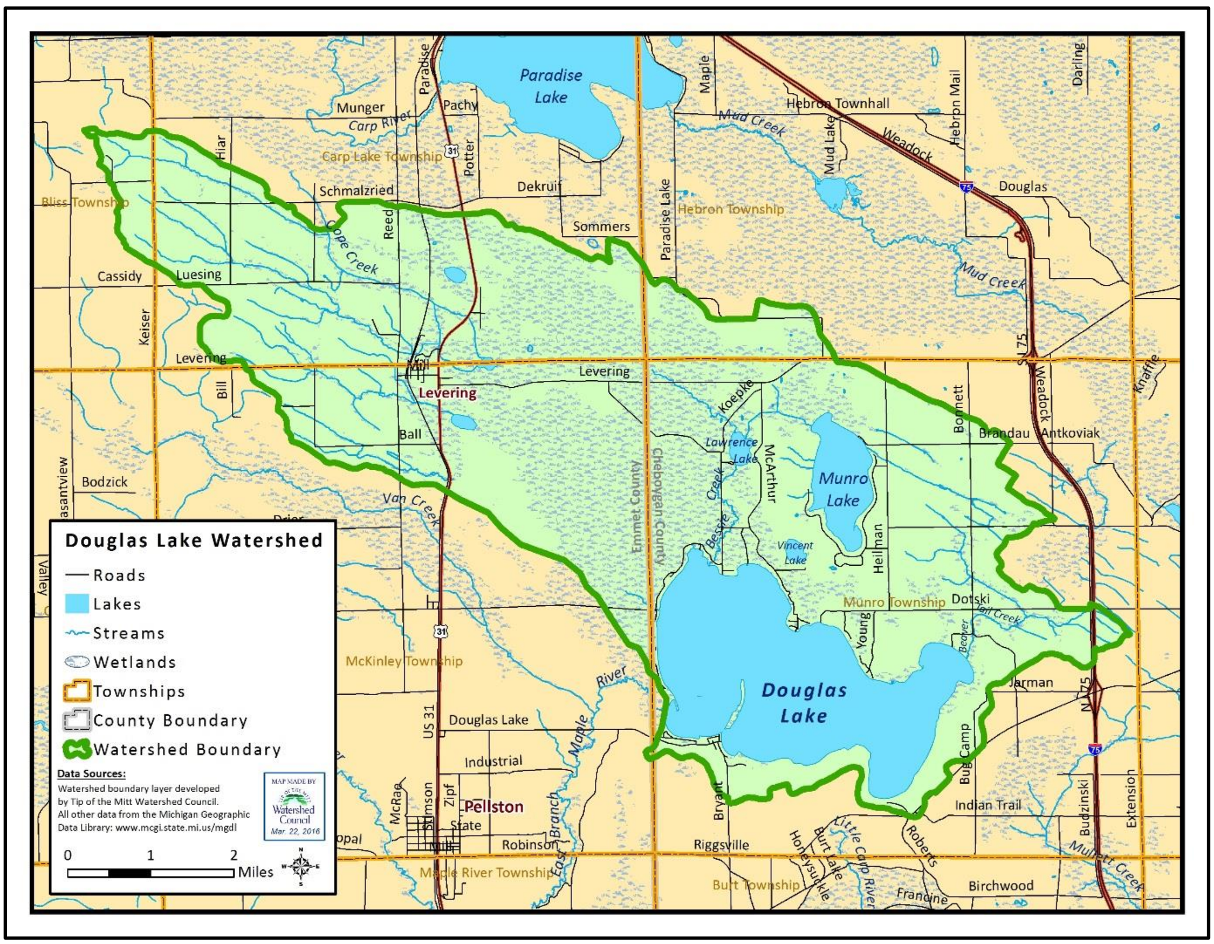


Figure 35: Douglas Lake Watershed

Land cover statistics for the Douglas Lake Watershed were generated using data from the NOAA's Coastal Change Analysis Program (Table 7). Based on 2010 data, a large portion of the Watershed's land cover is natural, consisting of forest, grasslands, and wetlands. Of land cover types that typically lead to water quality degradation, there is little urban/residential (1.6%) and a moderate amount of agricultural (17.6%), relative to other Northern Michigan watersheds. During the 25-year period between 1985 and 2010, agricultural lands increased by nearly 2%, while all other land cover types stayed approximately the same or decreased by less than 0.5%.

Table 7: Douglas Lake Watershed land cover statistics (NOAA CCAP 1985, 2010)

Land Cover Type	1985 (acres)	1985 (percent)	2010 (acres)	2010 (percent)	Change (acres)	Change (percent)
Agriculture	4,319	16	4,816	18	497	1.82
Barren	49	<1	22	<1	-27	-0.10
Forest	6,615	24	6,491	24	-124	-0.45
Grassland	1,567	6	1,478	5	-89	-0.33
Scrub/Shrub	671	2	555	2	-116	-0.42
Urban	516	2	435	2	-81	-0.30
Water	4,437	16	4,425	16	-11	-0.04
Wetland	9,190	34	9,142	33	-48	-0.18
TOTAL	27,364	100.00	27,364	100.00	NA	NA

Larks Lake

Primary Inflows: Groundwater spring outlets
Primary Outflows: Brush Creek
Surface Area: 600 acres
Shoreline: 4 miles
Maximum Depth: 9 feet

Larks Lake is a small, shallow lake located in Center Township in northern Emmet County. Larks Lake is fed by spring outlets. It is the headwaters of Brush Creek; a tributary flowing into the west branch of the Maple River, and also what is known as the Pleasantview Swamp. Larks Lake is considered an important recreation resource for county residents with access provided at the Center Township Park and boat access at the end of Kaz Road. The Larks Lake Watershed land surface area is 4,640 acres. The Larks Lake Watershed is a small subwatershed of the larger Cheboygan River Watershed, which covers 1,461 square miles (935,000 acres) in Cheboygan, Otsego, Emmet, Presque Isle, Montmorency, and Charlevoix Counties. The Larks Lake Watershed land area makes up 0.5% of the Cheboygan River Watershed.

Figure 36: Larks Lake shoreline (TOMWC)

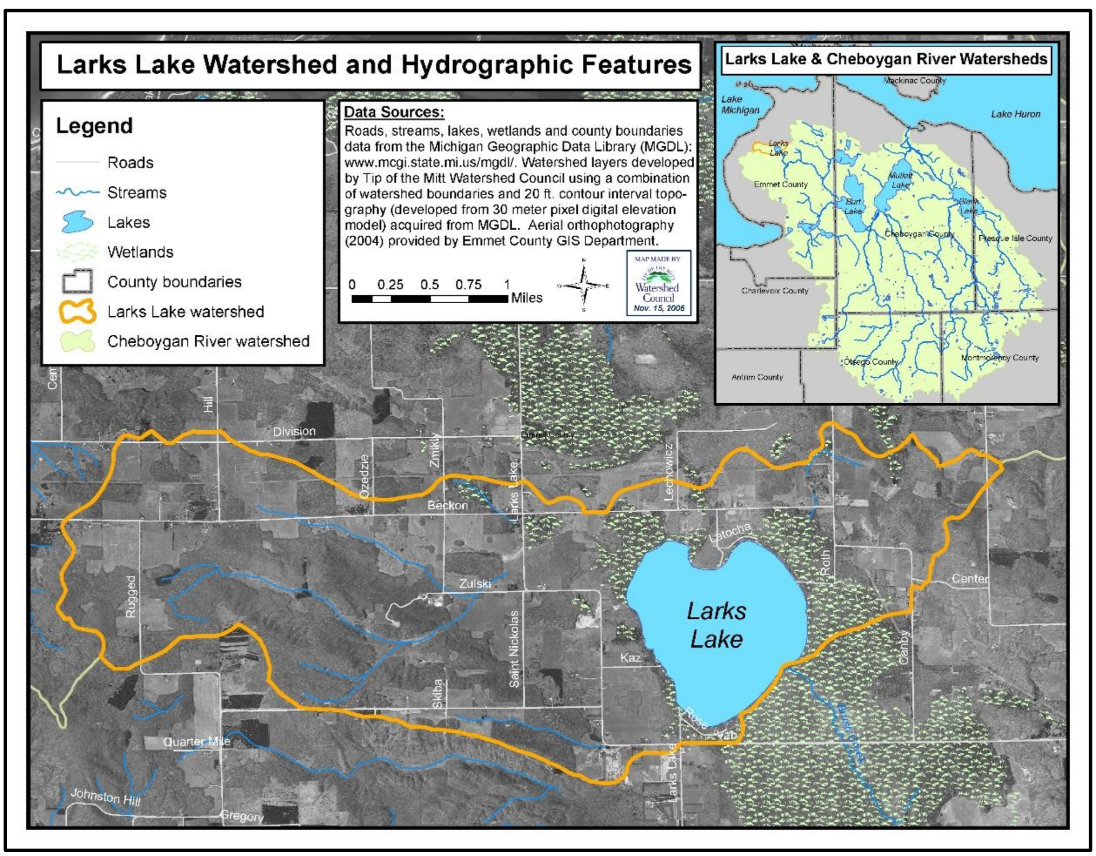


Figure 37: Larks Lake Watershed

Pleasantview Swamp

Covering 6,544 acres, this is one of the biggest, uninterrupted expanses of organic soils in northern Lower Michigan. There are areas of forested swamp, shrub swamp, and emergent marshes. Within the Pleasantview Swamp are four "spring ponds" (called The Four Lakes) that form the headwaters of the Maple River. The swamp has more than 30 miles of shoreline on the Maple River, Brush Creek, Larks Lake, and The Four Lakes. It is home to most of Michigan's large reclusive mammals, including bobcat, black bear, and river otter. Bald eagles and ospreys nest in the swamp. Soils consist of Carbondale and Tawas mucks (Hydrologic Soil Groups D and D/A) with Roscommon mucky sand (Hydrologic Soil Group D) along the margins. Fifty-four percent of the swamp is publicly owned by the State of Michigan (Fuller, 2006).

Crooked River Watershed

The Crooked River Watershed includes:

Crooked Lake, Mud Lake, Pickerel Lake, Round Lake, Spring Lake, Iduna Creek, Weber Lake, Cedar Creek, Crooked River, McPhee Creek, Minnehaha Creek, West Branch Minnehaha Creek, Mud Creek, Oden Creek, Sanford Creek, Silver Creek, Silver Creek Pond, Berry Creek

Landscape, Soils, and Groundwater

Most of the Crooked River Watershed is forested or grasslands except for the village of Alanson, and small farm plots north of Alanson. The village of Alanson is serviced by a sanitary sewer, while a small residential area along the river, known locally as Devil's Elbow, relies on on-site disposal methods.

Some agricultural land exists within the Watershed, but it is primarily in hay, with very little land devoted to row crops. Soils under row crops are generally subject to more erosion than soils under grass and hay. The agricultural land is separated from the river by extensive forested areas. The topography of the Watershed is gently rolling, with level wetland areas adjacent to the river.

The soils of the Crooked River Watershed are wetland soils of the Carbondale-Tawas-Roscommon Association series (Hydrologic Soil Groups D and D/A). Beyond the river bottom wetlands lies a zone of nearly level, well-drained sandy soils of the East Lake-Blue Lake-Kalkaska Association soils (Hydrologic Soil Group A). In some areas, poorly drained sandy to loamy soils of the Thomas-Brevort-Iosco (Hydrologic Soil Groups B and D) Association lie between the wetland soils and those of the East Lake-Blue Lake-Kalkaska Association (Hydrologic Soil Group A). The upland soils areas are well-drained sandy soils of the Blue Lake-Leelanau Association (Hydrologic Soil Group A).

The Pickerel-Crooked Wetlands are found along both sides of the Pickerel-Crooked channel, along Minnehaha Creek (a tributary of Crooked Lake), and extending well inland along the southwest shore of Pickerel Lake in the vicinity of Mud Creek. They are primarily conifer swamp with areas of willow and alder shrubs, a marshy margin along the shorelines, and a deepwater marsh at the mouth of Minnehaha Creek. Bald eagles and loons nest here, and it is undoubtedly an important wildlife travel corridor. This wetland complex is about 1,900 acres in size and has 11.4 miles of shoreline on the Lake, Channel, and creeks. Carbondale muck soils are predominant. About 950 acres are in public ownership. Part of the wetland along the Pickerel-Crooked Channel was recently protected by a combination of acquisition and easement by the Little Traverse Conservancy. The portion of this wetland at the mouth of Minnehaha Creek was evaluated by the Tip of the Mitt Watershed Council in 1986 using the Adamus Wetland Evaluation Technique.

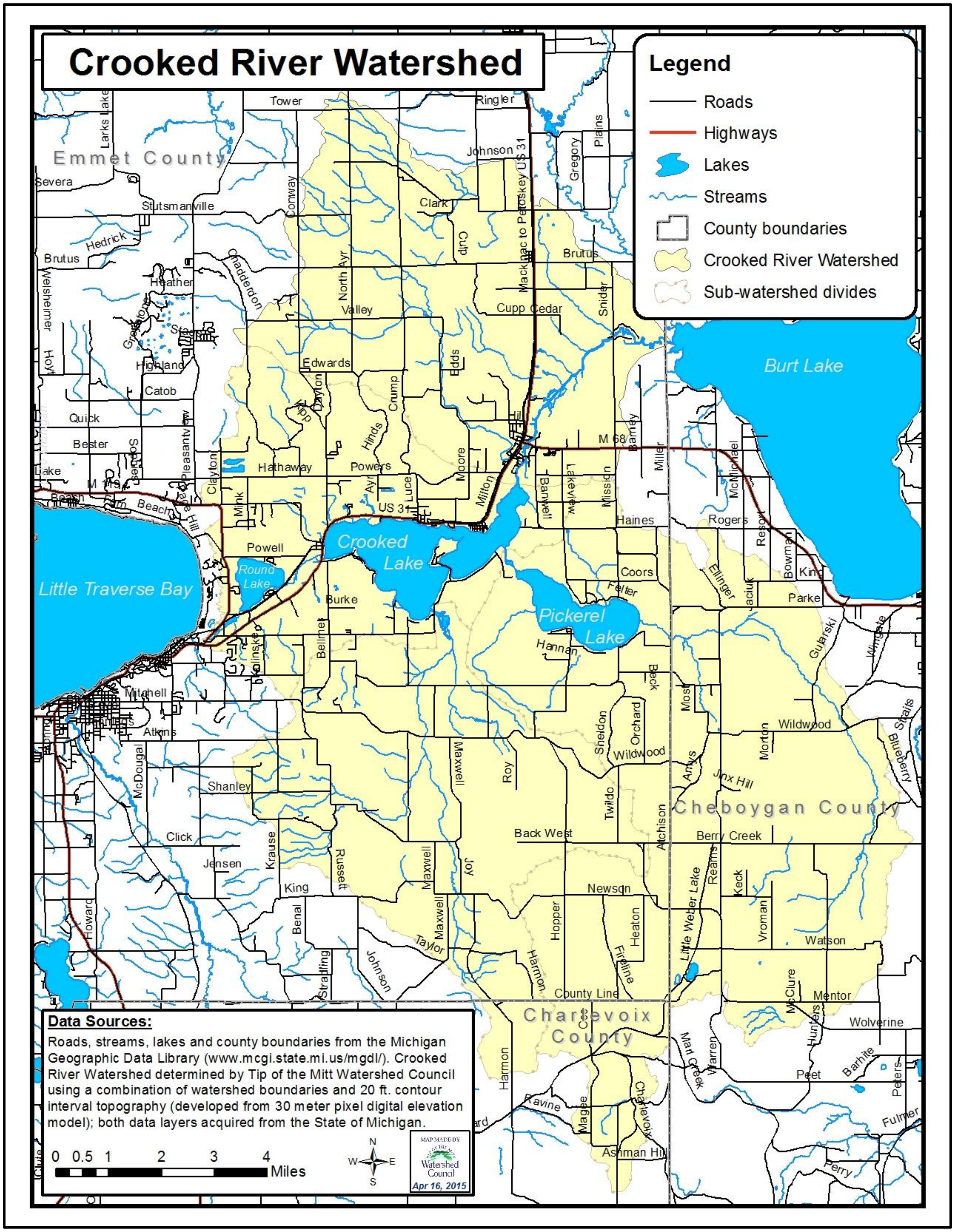


Figure 38: Crooked River Watershed

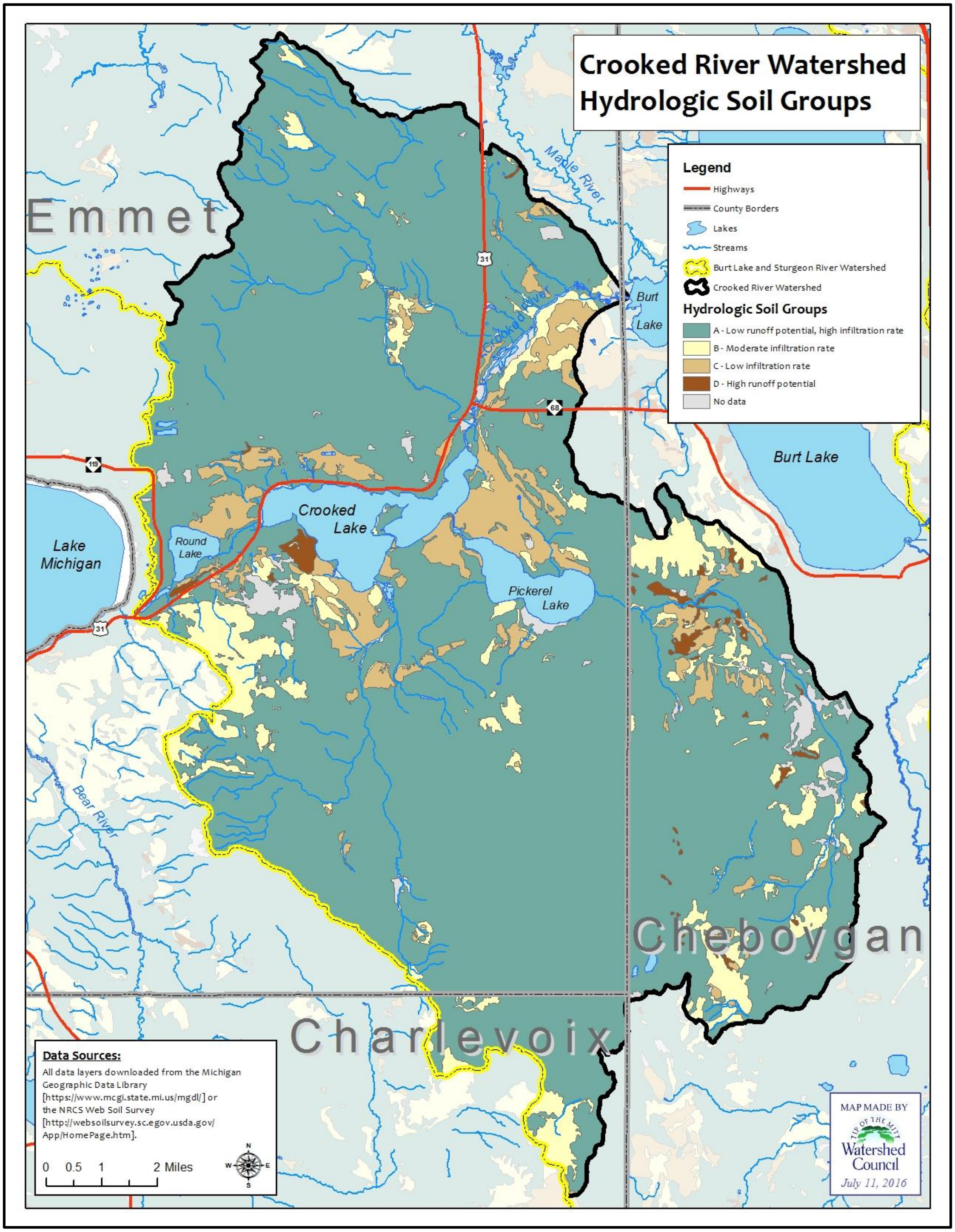


Figure 39: Crooked River Watershed hydrologic soil groups

In watershed areas with steep slopes, hillsides intersect the water table, resulting in groundwater expelling at the land surface. The exposed water table causes horizontal groundwater movement, which releases to create seeps and springs that then form or contribute water to streams and wetlands. The degree of groundwater contributions to surface waters in the Crooked River Watershed is illustrated in Figure 41, The data used to generate the maps are based on the Michigan Rivers Inventory subsurface flux model (MRI-DARCY), which uses digital elevation and hydraulic conductivity inferred from mapped surficial geology to estimate spatial patterns of hydraulic potential. The model is used to predict groundwater delivery to streams and other surface water systems because biological, chemical, and physical attributes of aquatic ecosystems are often strongly influenced by groundwater delivery.

Spring and Mud Lakes

Primary Inflows: Groundwater springs
Primary Outflows: Unnamed Creek to Mud Lake
Surface Area: 6 acres
Shoreline: 0.6 miles
Maximum Depth: 5 Feet

Primary Inflows: Spring Lake Creek
Primary Outflows: Mud Lake Creek
Surface Area: 11.3 acres
Shoreline: 0.7 miles
Maximum Depth: 10 feet

Just east of Petoskey, near the intersection of M119 and US31, a large spring bubbles forth a flowing channel, cutting its way through a wetland that was once the lakebed of Spring Lake. These Crooked River Headwaters are very close to Lake Michigan, a mere 1500 feet from the shores of Little Traverse Bay. The surrounding area is urbanized with various residential and commercial establishments. Spring Lake is connected to Mud Lake by a short channel. Mud Lake has increased natural landcover in its Watershed, and has maintained its open surface area better than Spring Lake. Mud Lake outlets to Round Lake through a small, unnamed creek.

Round Lake

Primary Inflows: Tributary from Mud Lake
Primary Outflows: Iduna Creek
Surface Area: 353 acres
Shoreline: 3.3 miles
Maximum Depth: 12 feet

Round Lake is located in Emmet County, less than one mile east of Little Traverse Bay. The surface area of Round Lake is approximately 360 acres and the shoreline distance totals four miles (Emmet County GIS, 2012). Round Lake consists of a single basin in the shape of a rounded equilateral triangle that measures approximately one mile per side. Residential development exists along the lake's mid-western, mid-eastern, and mid-northern shorelines, while the rest of the lake is largely undeveloped. Developed lakefront properties are served by a sanitary sewer system maintained by the Harbor Springs Area Sewer Authority. Iduna Creek is the only outlet, flowing out of Round Lake's eastern terminus and into the east side of Crooked Lake via 1.25 miles of stream channel.

The Watershed covers 2,367 acres. Based on Coastal Great Lakes Land Cover data (2010), a large portion of the Watershed's land cover is natural, consisting of forest, grasslands, and wetlands. Of land cover types that typically lead to water quality degradation, there is a moderate amount of urban/residential (15.3%) and agricultural (21.8%) land cover in the Watershed. During the 25 year period between 1985 and 2010, agricultural lands decreased slightly (-0.6%) while urban land cover increased (4.6%).

Figure 40: Round Lake (TOMWC)

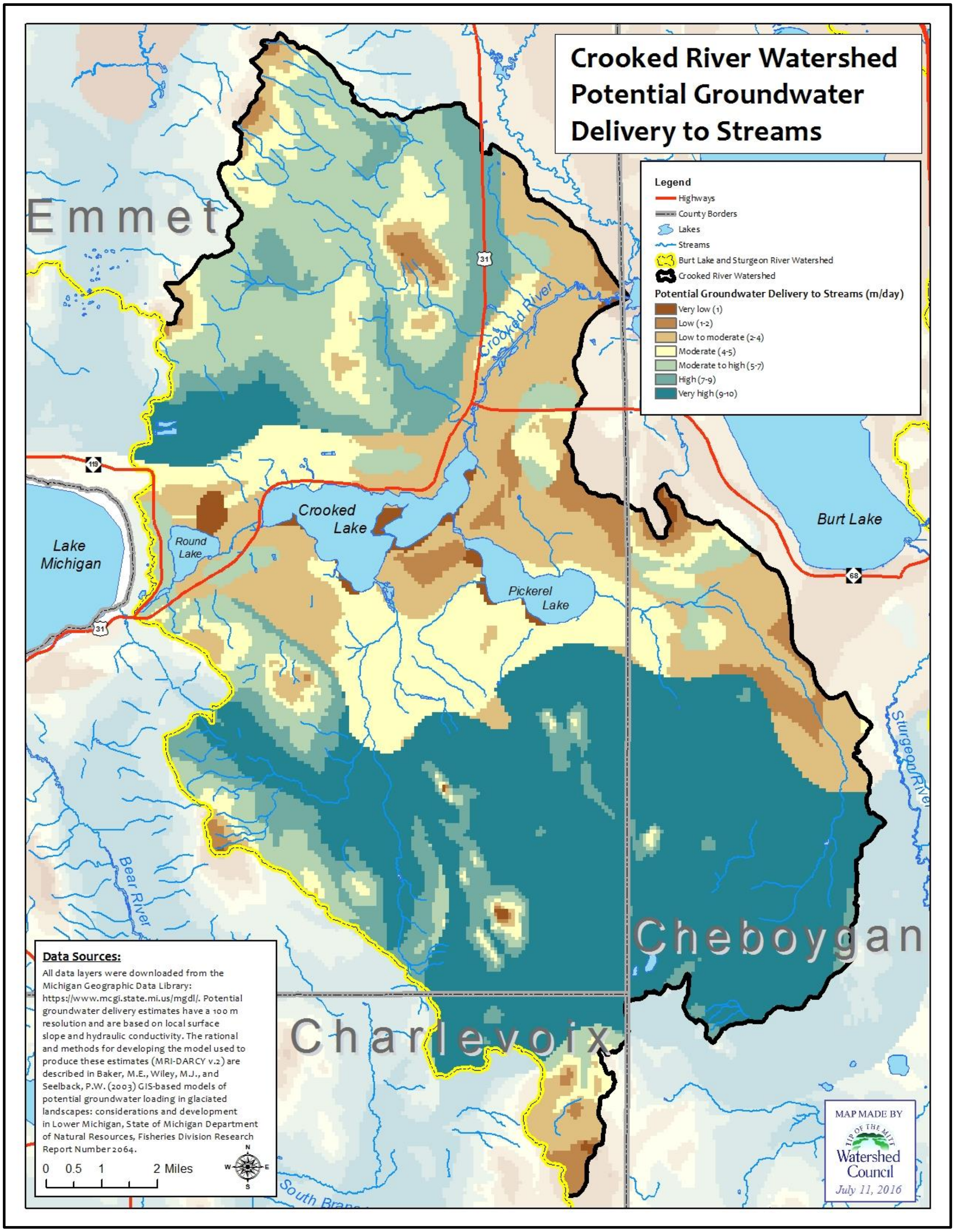


Figure 41: Crooked River Watershed Potential Groundwater Delivery to Streams

Figure 42: Round Lake Watershed

Crooked and Pickerel Lakes

Primary Inflows: Mud Creek, Cedar Creek, Minnehaha Creek
Primary Outflows: Crooked River
Surface Area: 2351 acres (Crooked) and 1082 acres (Pickerel)
Shoreline: 16.3 miles (Crooked) and 7.1 miles (Pickerel)
Maximum Depth: 50 feet (Crooked) and 70 feet (Pickerel)

Figure 43: Pickerel Lake (TOMWC)

Pickerel Lake is primarily fed by ground water seepage. It is a mesotrophic lake, which means there are conditions where there are enough nutrients to produce some algae and aquatic plant growth. Cedar Creek, at the eastern end of the lake is the lake's largest surface water inlet. The outlet for Cedar Creek is located at Camp Pet-O-Sega, an Emmet County park. A significant sized tributary to Pickerel Lake is Mud Creek which enters Pickerel Lake on its southwest side. This stream drains a vast cedar swamp, approximately 1,900 acres in size. This cedar swamp, which occupies a significant portion of the western shoreline of Pickerel Lake, is habitat to such wildlife as bear, bobcat, coyote, and fox. Pickerel Lake is known to be a good fishing lake. The fish most commonly caught in the lake are walleye, largemouth and small mouth bass, perch, rock bass, and northern pike.

The half-mile Black Hole Channel connects the two lakes. Between the two lakes, in the Black Hole Channel, lies the Black Hole Nature Preserve of the Little Traverse Conservancy. A range of wetland communities exist in the channel area. Of particular value from a wildlife and water quality perspective are the cattail marshes, lowland scrub-shrub wetlands, and the lowland hardwoods. Waterfowl use the wetland channel, which rarely freezes. In all seasons and Bald Eagle and Osprey are frequently seen surveying the waters for prey.

The excellent walleye, bass, and northern pike fishing in Pickerel and Crooked Lakes can be attributed in part to the natural habitat of the Black Hole Channel. Boaters enjoy the sense of wildness that the Channel now offers.

Figure 44: The Black Hole Channel (Audrey McMullen)

Like Pickerel Lake, Crooked Lake is a mesotrophic lake. Crooked Lake is known to be a good fishing lake with the most commonly caught species being walleye, largemouth and small mouth bass, perch, rock bass, and northern pike. Crooked Lake is also an excellent location to observe many types of waterfowl. Mergansers, cormorants, and loons are regularly seen diving for food in the open water of the lake.

Figure 45: Crooked Lake (TOMWC)

Minnehaha Creek, Crooked Lake's largest tributary, originates in the hills southeast of Petoskey. The hills are largely forested (much of which is state forest), but the valleys surrounding the stream have agricultural uses with, in some instances, poor riparian management. As the Minnehaha approaches Crooked Lake, it joins Silver Creek in a more heavily forested region.

The water level of Crooked and Pickerel Lakes is controlled by the lock on the Crooked River in Alanson. Water from Crooked and Pickerel Lakes flows through the Crooked River into Burt Lake, and eventually into Lake Huron via the Cheboygan River. However, this has not always been the case. At the end of the last ice age, following the retreating glaciers, water flowed west across the Inland Waterway through Crooked and Pickerel Lakes, and emptied into Little Traverse Bay. Then, around 4,000 years ago, tall sand dunes rose up in the Petoskey State Park area west of Round Lake, thereby cutting off the connection and reversing the flow of the Inland Waterway northeast into Lake Huron.

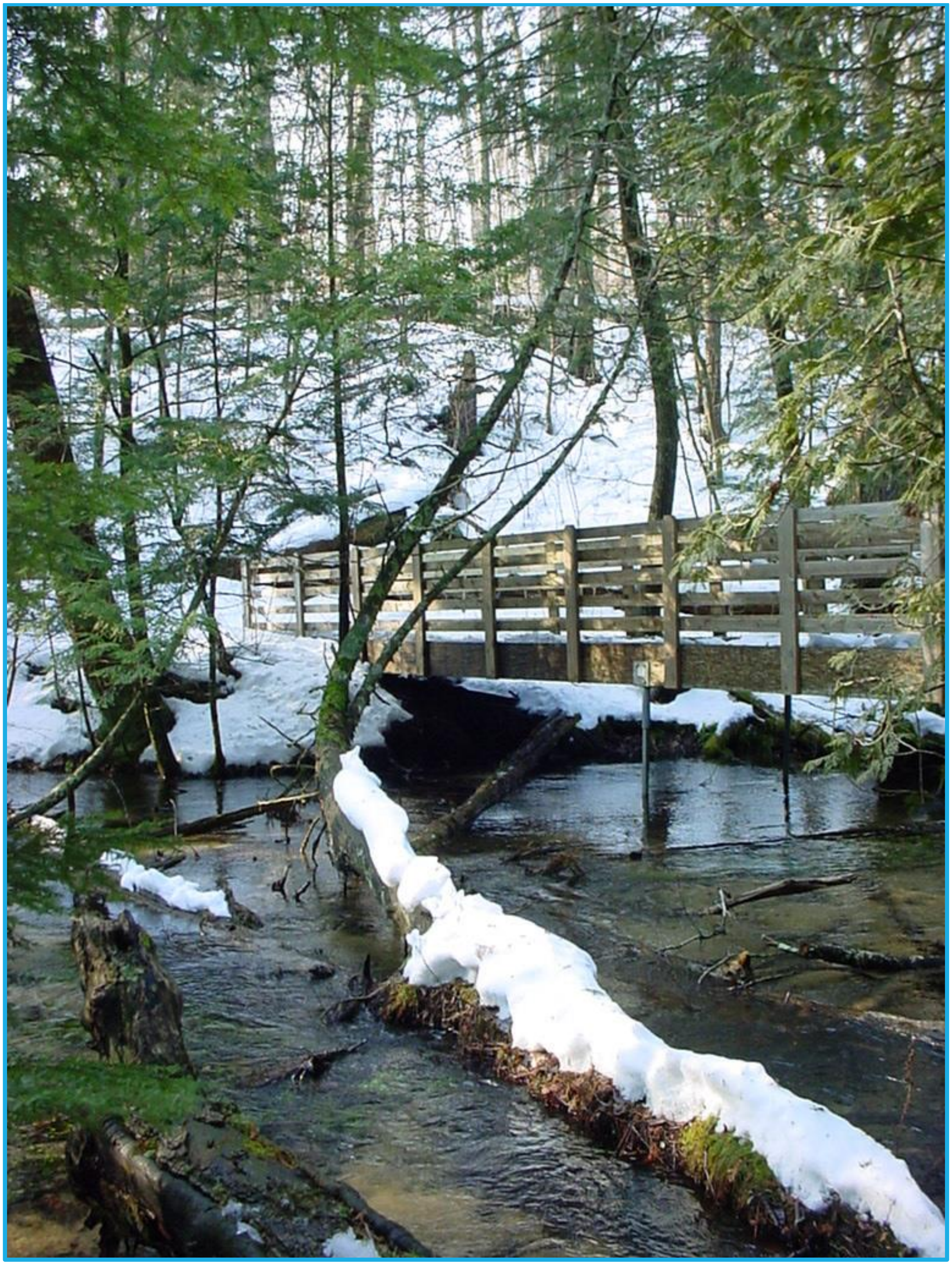


Figure 46: Minnehaha Creek at the McCune Nature Preserve (TOMWC)

Crooked River

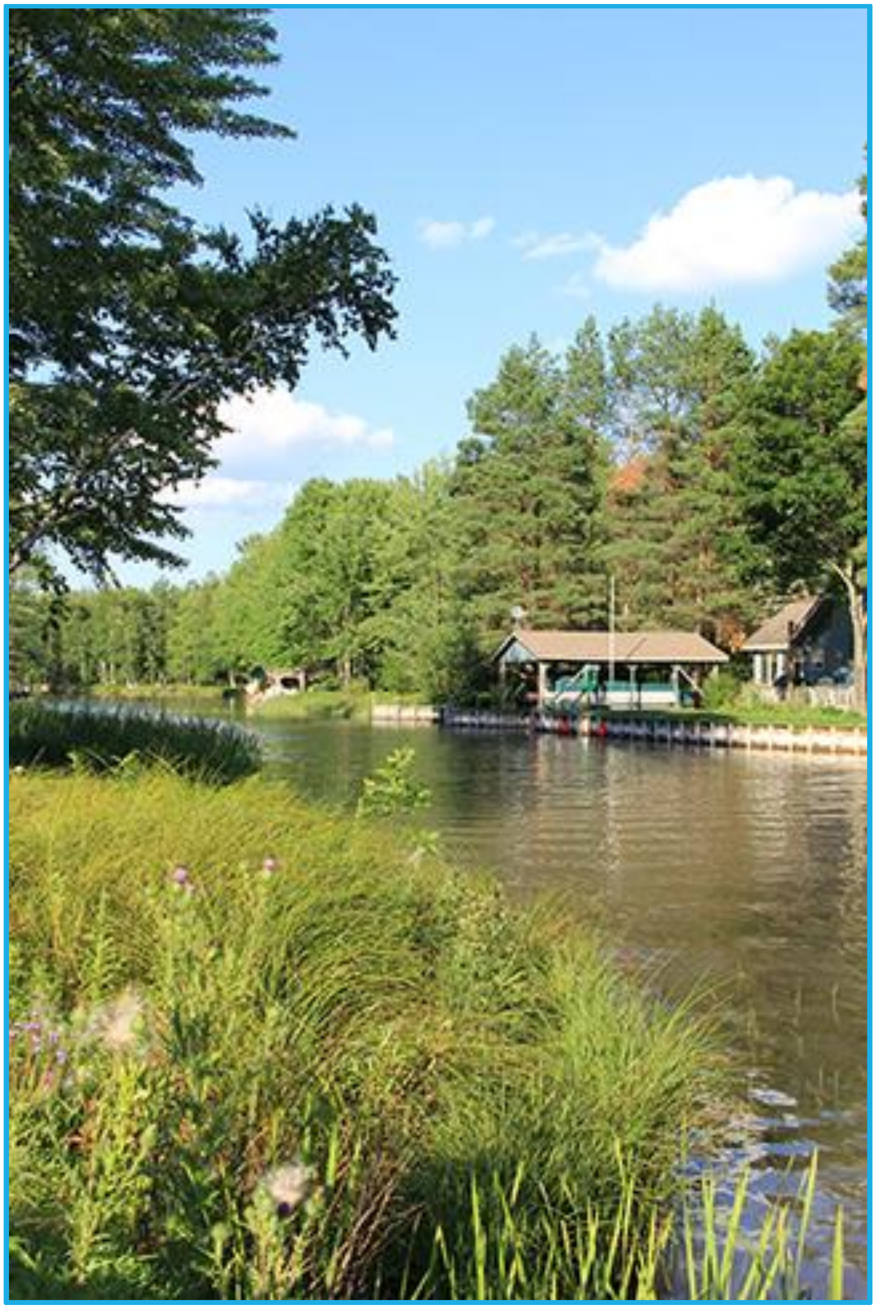


Figure 47: Crooked River (TOMWC)

The Crooked River is about 6.2 miles long and connects Crooked Lake with Burt Lake. The river channel is dredged to provide recreational boating access between the two lakes. A lock and dam is located in the village of Alanson near the river's outlet from Crooked Lake. It is used primarily to regulate the water level of Crooked Lake. The average annual discharge of the Crooked River is 3.8 cms (133 cfs). North of the town of Alanson is a marshy area known as Hay Lake. Tall marsh grasses and rushes line the banks of this mile-long natural open water area within the Crooked River. Several small streams discharge to the Crooked River near Alanson.

Crooked River Marsh

Between Burt Lake's Colonial Point and Kings Point are the river deltas of the Crooked and the Maple Rivers. These two river systems drain much of central and southern Emmet County. The wetlands that comprise the two river deltas are quite distinct, but both are rich wildlife habitat. Along the shoreline of Bullhead Bay and Snake Point is the mouth of the Crooked River. This marsh, covering hundreds of acres, is made up of emergent wetland species such as cattail and bulrush. This marsh is a productive bird watching area and careful observation will yield views of Osprey, Northern Goshawk, Bank Swallow, and many varieties of waterfowl hungrily dabbling for food.

Most of the Crooked River's Watershed is forested or grasslands except for the village of Alanson, and small farm plots north of Alanson. The village of Alanson is serviced by a sanitary sewer, while a small residential area along the river, known locally as Devil's Elbow, relies on on-site disposal methods.

Some agricultural land exists within the Watershed, but it is primarily in hay, with very little land devoted to row crops. Soils under row crops are generally subject to more erosion than soils under grass and hay. The agricultural land is separated from the river by extensive forested areas. The topography of the Watershed is gently rolling, with level wetland areas adjacent to the river.

The soils of the Crooked River Watershed are wetland soils of the Carbondale-Tawas-Roscommon Association series. Beyond the river bottom wetlands lies a zone of nearly level, well-drained sandy soils of the East Lake-Blue Lake-Kalkaska Association soils. In some areas, poorly-drained sandy to loamy soils of the Thomas-Brevort-Iosco Association lie between the wetland soils and those of the East Lake-Blue Lake-Kalkaska Association. The upland soils areas are well-drained sandy soils of the Blue Lake-Leelanau Association.

Sturgeon River Watershed

The Sturgeon River Watershed includes:

Allen Creek, Blackjack Creek, Bradley Creek, Barhite Lake, Berry Lake, Black Lake, Bows Lake, Fitzek Lake, Fleming Lake, Fulmer Lake, Heart Lake, Hoffman Lake, Kidney Lake, Lake Eighteen, Olund Lake, Standard Lake, Storey Lake, Woodin Lake, Huffman Lake, Pickerel Lake (Otsego County), Silver Lake, Mossback Creek, Marl Creek, Pickerel Creek, Stewart Creek, Thumb Lake, Wildwood Lake, Club Stream, Sturgeon River, West Branch Sturgeon River

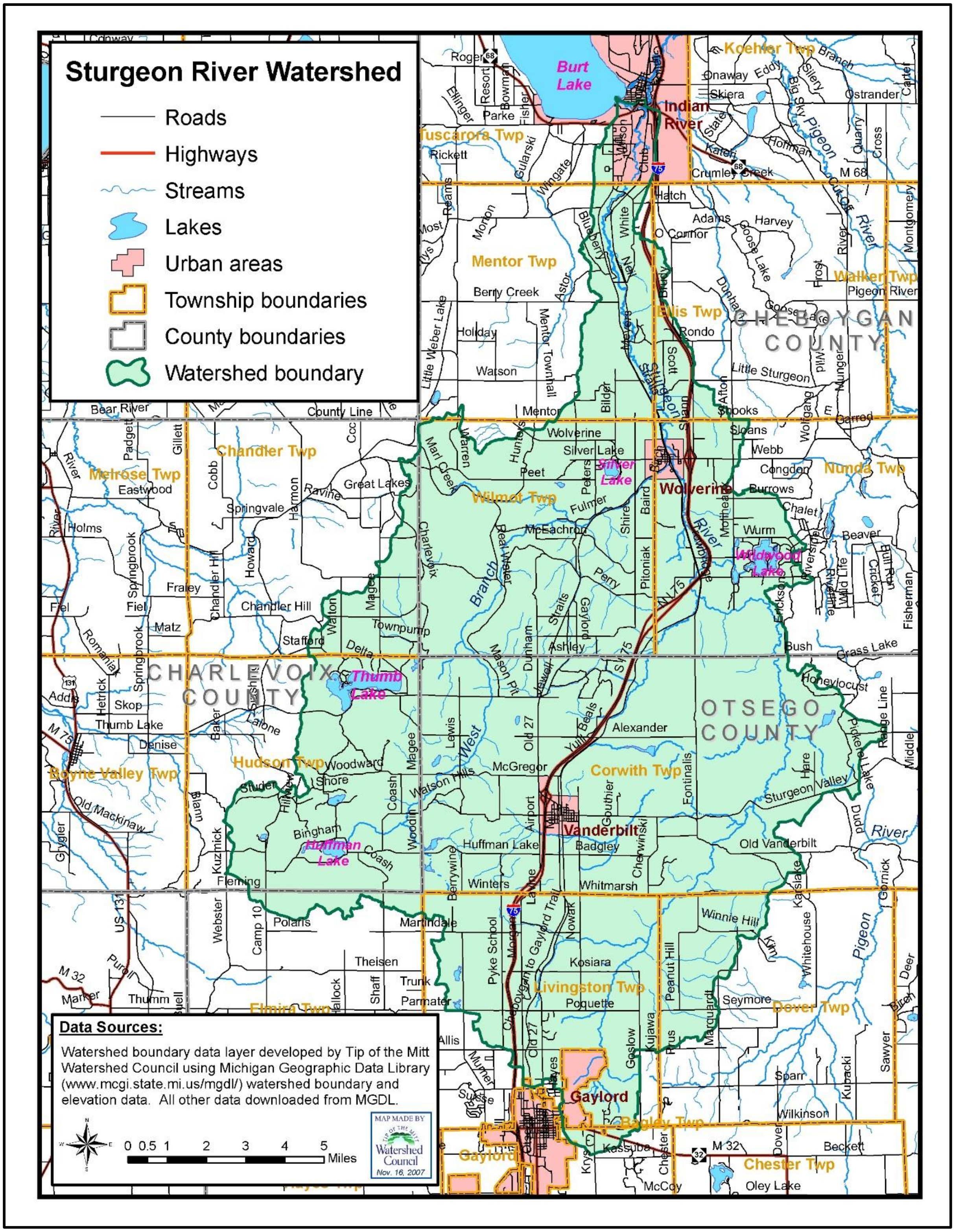


Figure 48: Sturgeon River Watershed

It is important to note that the Sturgeon River Watershed (HUC 0407000401) is listed as a 2015 Priority Watershed in the Michigan Department of Environmental Quality's Nonpoint Source Program Plan (December 3, 2015). The Pigeon River (HUC 0407000403), which drains to Mullett Lake and is part of the Cheboygan River Watershed, is also included.

> The Sturgeon and Pigeon Rivers are high quality, medium-sized, coldwater streams that drain into Burt and Mullett Lakes, respectively, in the Cheboygan River watershed. The Sturgeon River is one of the most pristine and high gradient streams in Michigan's Lower Peninsula and is one of the largest free-flowing trout streams in the state. The Pigeon River is also a high quality trout stream and flows through the Pigeon River Country State Forest. Sediment is the primary NPS pollutant of concern in both these rivers and several dam failures on the Pigeon River have negatively impacted macroinvertebrates and fish.
>
> As a result of a recent grant project, there is renewed focus on these rivers and a watershed coalition has been established to coordinate long-term sustainability. A WMP is currently being developed for the Sturgeon River as part of the Burt Lake watershed planning effort.

Landscape, Soils and Groundwater

Topography within the Watershed is rolling hills with some nearly level areas near the river channel. The upland portion of the Watershed commonly supports a mixture of pine and hardwoods, while cedar, balsam fir, and alders are common along the river channel. The Watershed of the West Branch is composed largely of State Forest Land and is therefore subject to very little cultural impact. Some timber harvesting occurs within the Watershed. However, this occurs on upland areas and the undisturbed cedar swamps that border the river provide an adequate buffer strip. The main branch of the Sturgeon River begins near the city of Gaylord in Otsego County. Its Watershed is also largely forested; however, a small amount of agriculture does exist. The immediate streambank area is well protected by dense cedar swamp wetlands.

The soils of the Sturgeon River Watershed are similar to those of the Maple and Crooked River Watersheds. The soils adjacent to the river are of the nearly level, very poorly drained Carbondale-Lupton-Tawas Association (Hydrologic Soil Groups B, D/B, and D/A). The adjacent steep to rolling uplands are characterized by well-drained soils of the Leelanau-Emmet-Kalkaska Association (Hydrologic Soil Groups A and C) series.

In watershed areas with steep slopes, hillsides intersect the water table, resulting in groundwater expelling at the land surface. The exposed water table causes horizontal groundwater movement, which releases to create seeps and springs that then form or contribute water to streams and wetlands. The degree of groundwater contributions to surface waters in the Sturgeon River Watershed is illustrated in Figure 50. The data used to generate the maps are based on the Michigan Rivers Inventory subsurface flux model (MRI-DARCY), which uses digital elevation and hydraulic conductivity inferred from mapped surficial geology to estimate spatial patterns of hydraulic potential. The model is used to predict groundwater delivery to streams and other surface water systems because biological, chemical, and physical attributes of aquatic ecosystems are often strongly influenced by groundwater delivery.

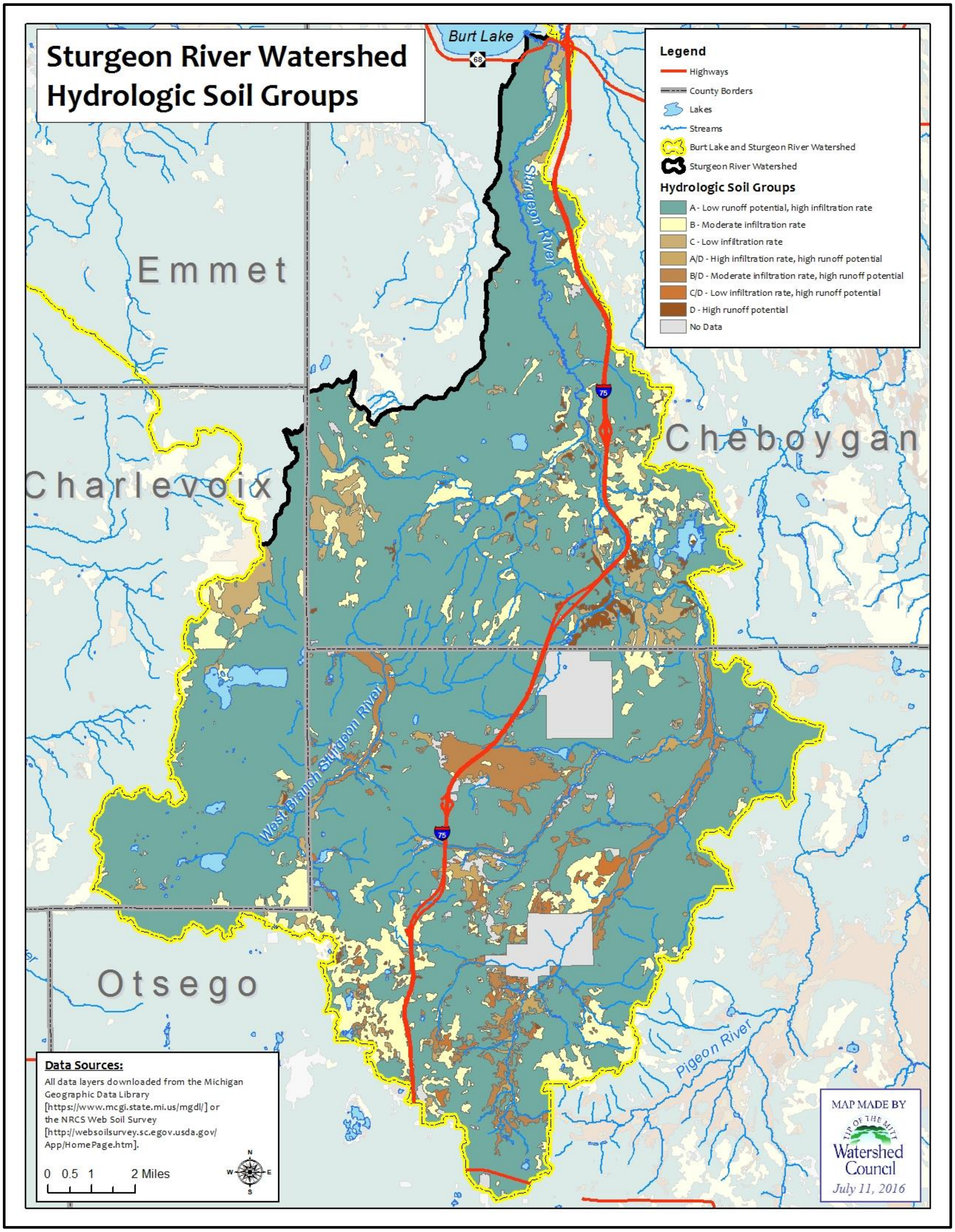


Figure 49: Sturgeon River Watershed hydrologic soil groups

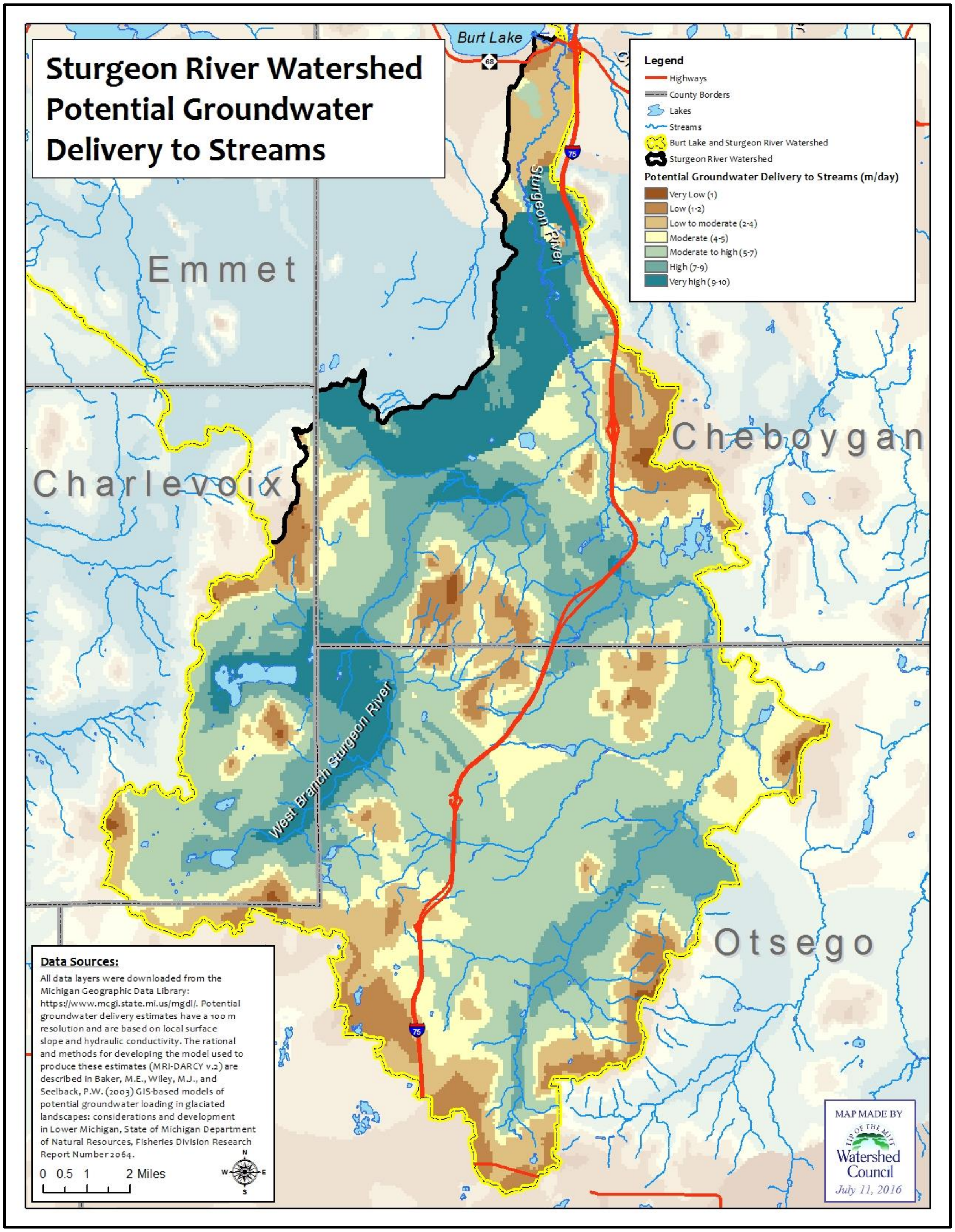


Figure 50: Sturgeon River Watershed Potential Groundwater Delivery to Streams

Sturgeon River

Length: mouth to confluence: 15 miles; E Branch: 10.5 miles; W Branch: 7.5 miles
Headwaters: near Gaylord in Otsego County, as well as eastern Charlevoix County
Mouth: Burt Lake

The Sturgeon River is one of northern Michigan's most scenic, pristine, and high gradient streams in Michigan's Lower Peninsula. The Sturgeon is typical of streams in the region in that it has cold summer water temperatures, moderately hard water, low turbidity during times of base flow, and exceptionally steady discharge, all due to the deep sandy glacial deposits and limestone bedrock. As Burt Lake's largest tributary, it has an average annual discharge of 7.6 cms (270 cfs). The river is also very popular for canoeing and inner tubing. The stretch from the Village of Wolverine to Indian River is the most popular for inner tubing. South of Wolverine, many reaches of the river are impassable to canoes due to downfalls from the bordering cedar swamps.

The Sturgeon River has two branches that merge at the village of Wolverine to form the main stem of the river. The main branch of the Sturgeon begins near Gaylord in Otsego County and flows about 35 miles to its mouth at the southeast end of Burt Lake at the town of Indian River. The Sturgeon's largest tributary is the West Branch of the Sturgeon which has its headwaters at Huffman Lake in Eastern Charlevoix County.

In the early 1900's, the flow of the Sturgeon River was diverted to Burt Lake to facilitate navigation on the Inland Waterway. Prior to the diversion, it had a natural confluence with the Indian River. Since diversion, a delta has been developing at the mouth of the Sturgeon River. In recent years, this delta has caused ice jams that result in the flooding of residential areas near the river's mouth.

Brook trout are found in the headwaters, brown trout are predominant throughout most of the mainstream, and it has runs of anadromous rainbow trout (steelhead) from Burt Lake. Thirty-three miles of both the main stream and the West Branch are designated by the Michigan DNR as a Blue Ribbon Trout stream. A Blue Ribbon Trout Stream must meet certain standards or criteria. It must be one of Michigan's best trout streams, be able to support excellent stocks of wild resident trout, have the physical characteristics to permit fly casting but be shallow enough to wade, produce diverse insect life and good fly hatches, have earned a reputation for providing an excellent (quality) trout fishing experience, and have excellent water quality.

Figure 51: Sturgeon River (TOMWC)

Even though the streambanks of the river are mostly forested, some streambank erosion does occur. It is evidenced by steep, sandy cut-banks at river bends. They are suspected of adversely affecting benthic fish habitat and causing a delta to form at the river's mouth. This has prompted the Department of Natural Resources and Trout Unlimited to undertake certain protection and improvement measures to mitigate the source and delivery of the sand. These measures include streambed sand traps to reduce downstream delivery of sand, and streambank stabilization with riprap and logs.

Huffman Lake

Primary Inflows: Groundwater
Primary Outflows: West Branch of the Sturgeon River
Surface Area: 124 acres
Shoreline: 1.9 miles
Maximum Depth: 30 feet

Huffman Lake is located in Hudson Township in southeastern Charlevoix County, Michigan, in the southwestern most part of the Burt Lake watershed. The lake covers an area of 124 acres and has 1.9 miles of shoreline (Charlevoix County GIS, 2012). A maximum depth of 26' occurs in the center of the lake (Figure 52). Residential development is found throughout Huffman Lake, but less dense along the western half of the south shore.

Huffman Lake is a glacially formed kettle lake that sits at the headwaters of the Sturgeon River. There are at least two small inlet streams; a stream flowing into the northwest corner that connects to Kidney Lake to the west and a stream of unknown origin that flows in at a developed property on the west end of the south side of the lake. The only outlet is located in the northeast cove, which starts the West Branch of the Sturgeon River.

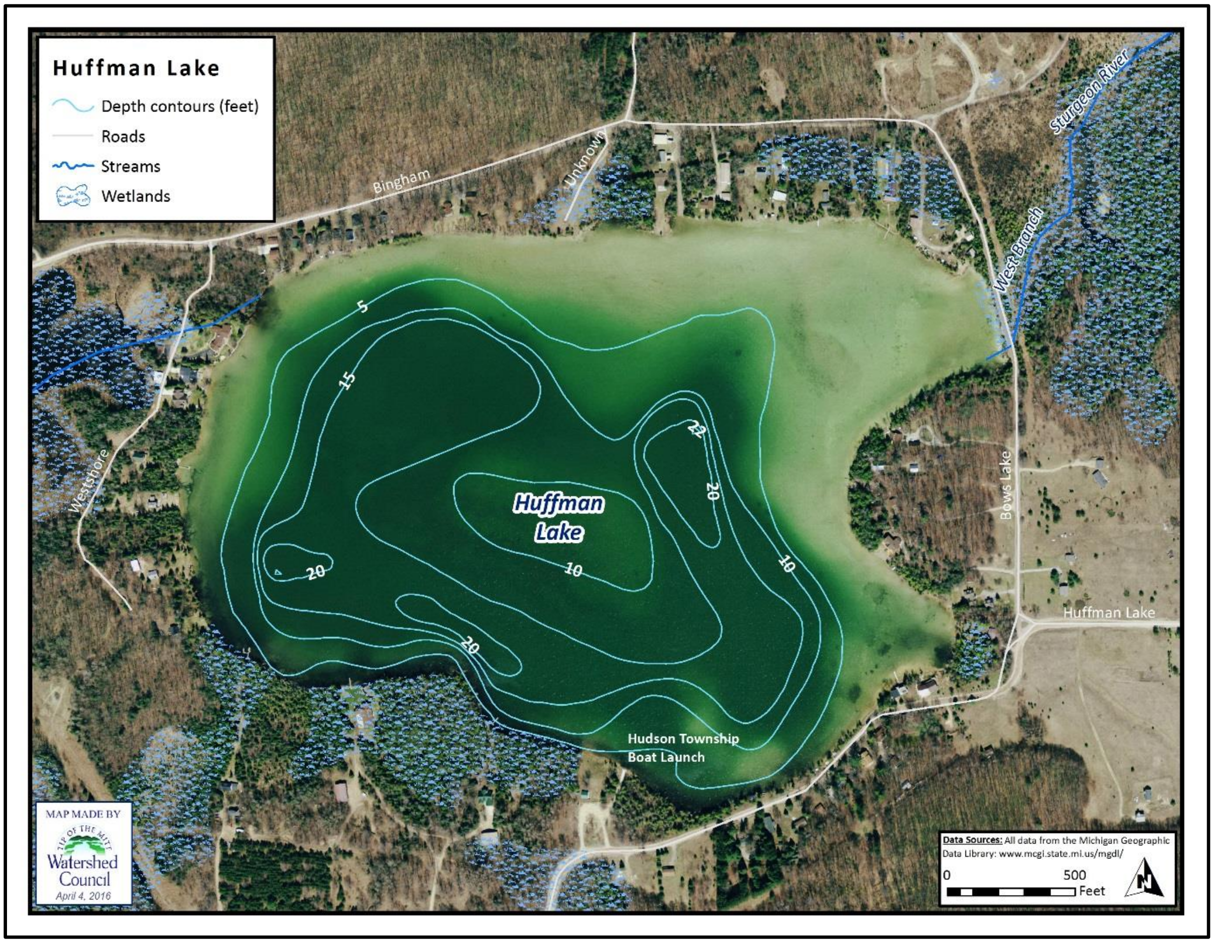


Figure 52: Huffman Lake

The 5,825-acre Huffman Lake Watershed (Figure 53) has a large watershed in relation to the lake's surface area. Measuring approximately 5,700 acres (does not include lake area), the Watershed area to lake surface area ratio is ~46:1, which, compared to other lakes in Michigan, is quite high (e.g., Walloon Lake has a ratio of ~5:1). This ratio provides a statistic for gauging susceptibility of lake water quality to changes in watershed land cover. Essentially, the statistic indicates that the Huffman Lake Watershed is large enough, relative to lake area, to provide a protective buffer, such that small areas of development will probably not negatively impact water quality. Based on land cover 2010 data, over 70% of the Watershed is forested. There is little agricultural (9.0%) and even less urban/residential (1.2%).

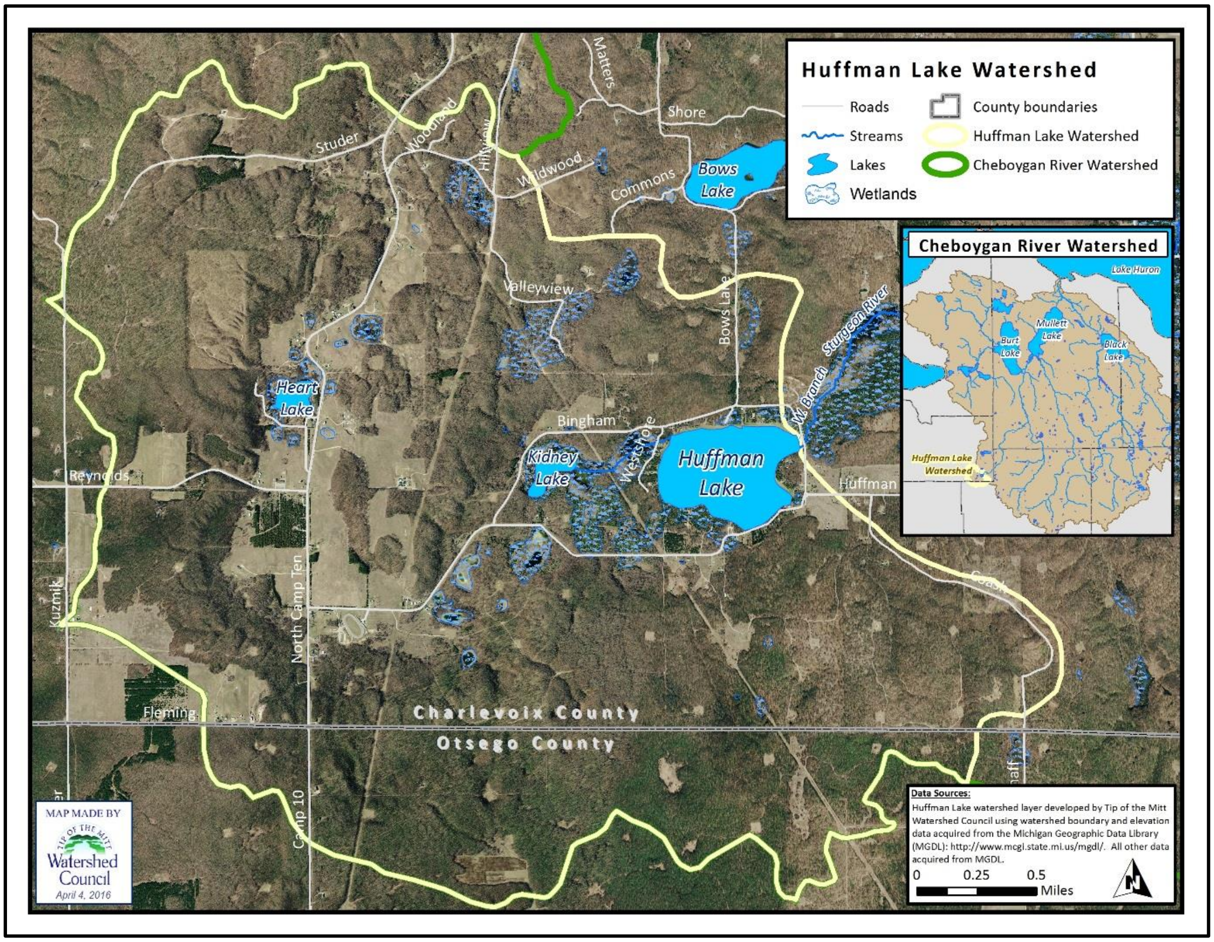


Figure 53: Huffman Lake Watershed

Lance Lake

Primary Inflows: Creek from Wildwood Lake
Primary Outflows: Tributary of Sturgeon River
Surface Area: 24.9 acres
Shoreline: 1.0 miles
Maximum Depth: 80 feet

Lance Lake is located in southwest Cheboygan County. Lance Lake is an elliptical 25-acre glacially formed lake, with approximately one mile of shoreline and two distinct basins. The south basin has a maximum depth of 20 feet and the north basin reaches 80 feet. The lake extends roughly 2000 feet from north to south and less than

1000' from east to west. Most residential development occurs in the south basin, while the north basin is largely undeveloped.

Lance Lake has one major inlet tributary that flows in on the east shore of the north basin. This quarter-mile tributary connects Lance Lake to the Wildwood Lake impoundment. The only outlet is an unnamed tributary at the lake's northern terminus, which flows less than a half mile to the Sturgeon River.

The 2100-acre Lance Lake Watershed (Figure 55) is entirely within western Nunda Township. The Wildwood Lake Watershed (Figure 57) encompasses 1800 acres, leaving approximately 300 acres of direct drainage to Lance Lake. Land cover statistics (NOAA 2010) show a large portion of the Watershed to be natural, consisting of forest, grasslands, and wetlands. Of land cover types that typically lead to water quality degradation, there is little agricultural (5.1%) and even less urban or residential (4.0%) land use in the Watershed.

Figure 54: Lance Lake (TOMWC)

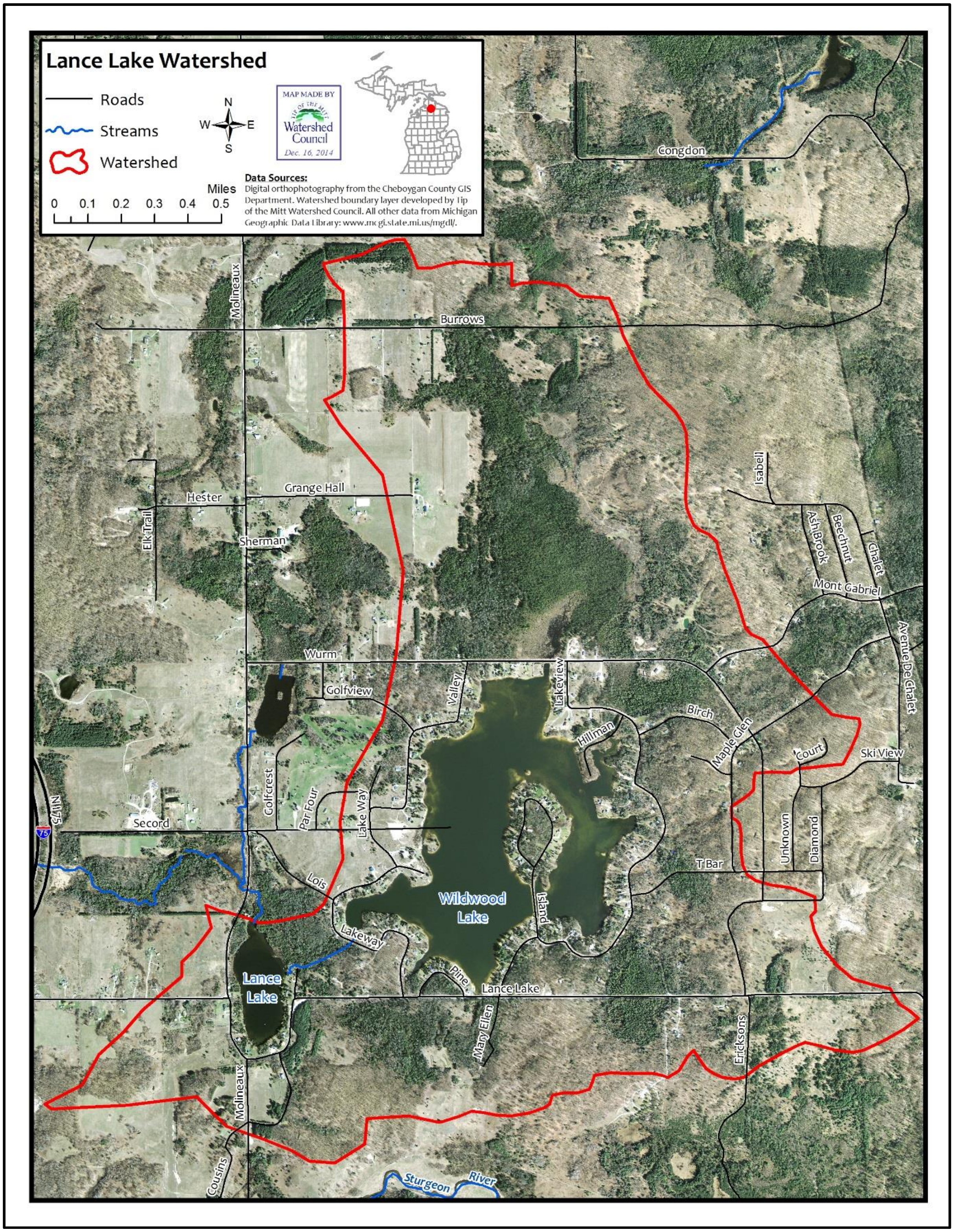


Figure 55: Lance Lake Watershed

Wildwood Lake

Primary Inflows: Groundwater
Primary Outflows: Unnamed Creek to Lance Lake
Surface Area: 227 acres
Shoreline: 6 miles
Maximum Depth: 17 feet

Wildwood Lake is an impoundment with many irregular bays and points. It was formed by damming a small tributary that flows into Lance Lake and the Sturgeon River. A large island in the middle of the lake is connected to Wildwood Lake's south shore by a causeway, while short bridges connect two smaller islands to the northeast and west shores. A maximum depth of 17' is found next to the dam (Figure 56) in the southwest corner of the lake. Residential development is prevalent around the outer shoreline of the lake and along the largest island, while the two smaller islands remain mostly undeveloped.

Wildwood Lake has no major tributaries, though a small wetland area drains into the lake's northeast corner. Wildwood Lake's only outlet is a small creek that flows from the dam at the lake's southwest corner. The creek flows a quarter mile to Lance Lake, which connects to the Sturgeon River by another creek of less than a half mile in length.

Water quality data show the lake to have relatively low levels of nutrients; however, the lake is plagued with heavy aquatic plant growth, which is likely the result of the unnatural formation of the lake, shallow depth, and poor riparian property management.

The approximately 1800-acre Wildwood Lake Watershed is entirely within western Nunda Township (Figure 57). Land cover statistics (NOAA 2010) show a large portion of the Watershed to be natural, consisting of forest, grasslands, and wetlands. Of land cover types that typically lead to water quality degradation, there is little urban or residential (3.8%) and agricultural (4.8%) land use in the Watershed.


Figure 56: Wildwood Lake dam (TOMWC)

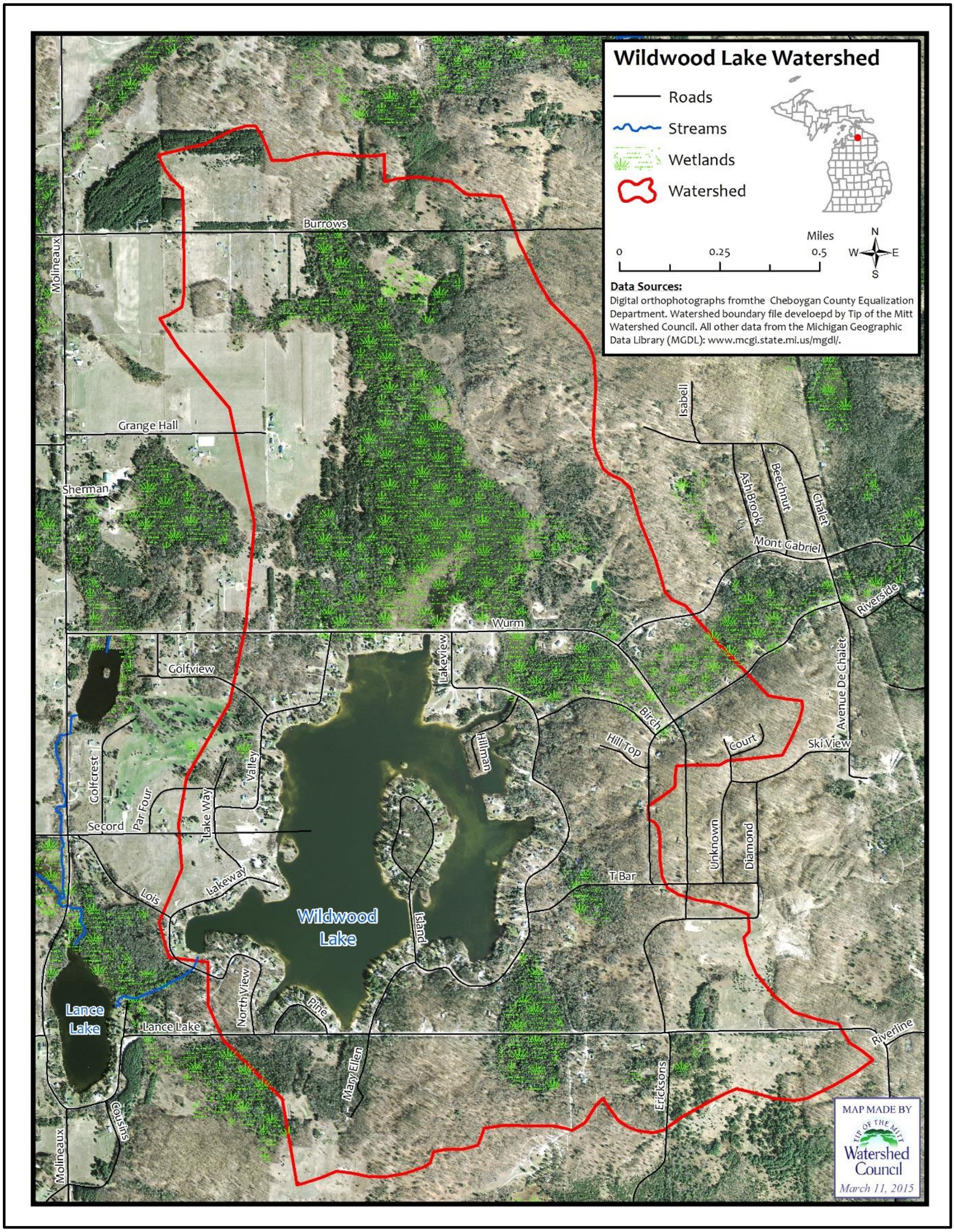


Figure 57: Wildwood Lake Watershed

Silver Lake

Primary Inflows: Groundwater
Primary Outflows: NA
Surface Area: 75 acres
Shoreline: 1.2 miles
Maximum Depth: 85 feet

Silver Lake sits just to the west of Wolverine. It is a kettle lake, formed by a large ice chunk left behind by the glaciers, with no inlets or outlets. Silver Lake is quite small, but very deep. Although much of the shoreline is developed, the lake continues to boast high water quality.

Figure 58: Silver Lake (TOMWC)

CHAPTER 2

State Water Quality Standards, Designated Uses and Desired Uses

The Environmental Protection Agency's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* describes water quality standards and designated uses as follows:

- Water quality standards set the goals, pollution limits, and protection requirements for each waterbody. Meeting these limits helps to ensure that waters will remain useful to both humans and aquatic life. Standards also drive water quality restoration activities because they help to determine which waterbodies must be addressed, what level of restoration is required, and which activities need to be modified to ensure that the waterbody meets its minimum standards.
- Standards are developed by designating one or more beneficial uses for each waterbody, establishing a set of measurable criteria that protect those uses and implementing policies and procedures that keep higher-quality waters from degrading.
- Designated or beneficial uses are descriptions of water quality expectations or water quality goals. A designated use is a legally recognized description of a desired use of the waterbody, such as aquatic life support, body contact recreation, fish consumption, or public drinking water supply. State and tribal governments are primarily responsible for designating uses of waterbodies within their jurisdictions.
- Two types of criteria are used to measure whether standards are being met. Numeric criteria set numeric limits for water quality parameters; narrative criteria are nonnumeric descriptions of desirable or undesirable water quality conditions.

State Water Quality Standards

The MDEQ monitors the waters of the State on a five-year rotating watershed cycle to facilitate effective watershed management. Michigan has 57 major watersheds based on the USGS's 8-digit Hydrologic Unit Codes (HUC). Water quality assessment efforts focus on a subset (approximately 20%) of these major watersheds each year. The Burt Lake Watershed, included in the Cheboygan Watershed (HUC#04070004), was last assessed by the DEQ in 2015, and is scheduled to be assessed every 5 years. The next assessment will be in 2020.

The State of Michigan has developed water quality standards (WQS) under Part 4 of the Administrative Rules issued pursuant to Part 31 of the Natural Resources and Environmental Protection Act (1994 PA451, as amended). These standards can be found in Table 8. The State uses quantitative water quality standards to help determine if designated uses are impaired.

Table 8: Michigan water quality standards

<table>
<tr><th>Parameter</th><th>Water Quality Standards</th><th>Designated Uses Affected</th></tr>
<tr><td>Dissolved Solids</td><td>Not to exceed 500 mg/L monthly average or 750 mg/L at any time as a result of controllable point sources</td><td>All</td></tr>
<tr><td>pH</td><td>Between 6.5 to 9.0</td><td>All</td></tr>
<tr><td>Taste or odor producing substances</td><td>The surface waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair or many impair their use for a public, industrial, or agricultural water supply source or which impair the palatability of fish as measured by test procedures approved by the department.</td><td>Public Water Supply*
Industrial Water Supply
Agricultural Water Supply
Fish Consumption</td></tr>
<tr><td>Toxic substances (selected shown here; see rule for complete listing)</td><td>DDT and metabolites: below 0.00011 µg/L
Mercury, including methylmercury: below 0.0013 µg/L
PCBs (class): below 0.00012 µg/L
2,3,7,8 - TCDD: below 0.0000000031 µg/L</td><td>All but navigation</td></tr>
<tr><td>Radioactive substances</td><td>Pursuant to U.S nuclear regulatory commission and EPA standards</td><td>All but navigation</td></tr>
<tr><td>Plant nutrients</td><td>Phosphorus: 1 mg/L maximum monthly average for permitted point source discharges. Regulation for surface waters is limited to the following narrative standard from Rule 60 (323.1060): “nutrients shall be limited to the extent necessary to prevent stimulation of growth 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.”</td><td>All</td></tr>
<tr><td>Microorganisms</td><td>30-Day Geometric Mean: below 130 E. coli per 100 ml

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

Daily Maximum Geometric Mean: below 1,000 E. coli per 100 ml
Human sewage discharges (treated or untreated) below 200 fecal coliform per 100 ml 30-day mean or 400 fecal coliform per 100 ml in 7 days or less</td><td>Total body contact

Total body contact

Partial body contact

Total body contact</td></tr>
<tr><td>Dissolved oxygen</td><td>Minimum 7 mg/L for coldwater designated streams, inland lakes, and Great Lakes/connecting waters; minimum 5 mg/L for all other waters
Minimum 5 mg/L daily average</td><td>Cold water fishery

Warm water fishery</td></tr>
<tr><td>Temperature</td><td>Natural daily and seasonal temperature fluctuations shall be preserved:
Maximum monthly averages for inland lakes:
<table>
<tr><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>P</td><td>O</td><td>N</td><td>D</td></tr>
<tr><td>45</td><td>45</td><td>50</td><td>60</td><td>70</td><td>75</td><td>80</td><td>85</td><td>80</td><td>70</td><td>60</td><td>50</td></tr>
</table>
Maximum monthly averages for warm water streams in this watershed:
<table>
<tr><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>P</td><td>O</td><td>N</td><td>D</td></tr>
<tr><td>38</td><td>38</td><td>41</td><td>56</td><td>70</td><td>80</td><td>83</td><td>81</td><td>74</td><td>64</td><td>49</td><td>39</td></tr>
</table>
Maximum monthly averages for cold water streams in this watershed:
<table>
<tr><td>J</td><td>F</td><td>M</td><td>A</td><td>M</td><td>J</td><td>J</td><td>A</td><td>P</td><td>O</td><td>N</td><td>D</td></tr>
<tr><td>38</td><td>38</td><td>43</td><td>54</td><td>65</td><td>68</td><td>68</td><td>68</td><td>63</td><td>56</td><td>48</td><td>40</td></tr>
</table>
</td><td>Cold water fishery
Other indigenous aquatic life and wildlife

Warm water fishery

Cold water fishery</td></tr>
</table>

All surface waters of the state that are identified in the publication "Public Water Supply Intakes in Michigan," dated December 9, 1999, are designated and protected as public water supply sources at the point of water intake and in such contiguous areas as the department may determine necessary for assured protection.

Designated Uses

The State of Michigan has established a set of designated uses that can be measured for impairment based on the water quality standards described in the previous section. Rule 100 (R323.1100) of the water quality standards states that all surface waters of the State are designated for, and shall be protected for, eight particular uses (Table 9).

Table 9: Surface water designated uses of the State

Designated Use	General Definition
Agriculture	Livestock watering, irrigation, and crop spraying
Navigation	Navigation of inland waters
Warmwater fishery	Supports warmwater species
Coldwater fishery	Support coldwater species
Other Indigenous aquatic life and wildlife	Supports other indigenous animals, plants, and macroinvertebrates
Partial body contact recreation	Supports boating, wading, and fishing activities
Total body contact recreation	Supports swimming activities between May 1 to October 31
Public water supply*	Surface waters meet human cancer and non-cancer values set for drinking water
Industrial water supply	Water utilized in industrial or commercial applications
Fish Consumption	There is a statewide, mercury-based fish consumption advisory that applies to all of Michigan's inland lakes, including those within the Burt Lake Watershed.

All surface waters of the state that are identified in the publication "Public Water Supply Intakes in Michigan," dated December 9, 1999, are designated and protected as public water supply sources at the point of water intake and in such contiguous areas as the department may determine necessary for assured protection.

The Burt Lake Watershed includes both coldwater and warm water fisheries. The coldwater fishery designation differs from the warmwater fishery because there are different water quality standard levels for dissolved oxygen, water temperature, and other chemical, physical, and biological parameters. The coldwater fishery lakes and streams are considered "Designated Trout Streams" or "Designated Trout Lakes" for the State of Michigan.

The Coldwater Fishery designated use only applies to MDNR designated coldwater streams. Coldwater lakes and streams in the State of Michigan are defined under section R323.1100 as:

(4)All inland lakes identified in the publication entitled *Coldwater Lakes of Michigan*, as published in 1976 by the department of natural resources, are designated and protected for coldwater fisheries. (5) All Great Lakes and their connecting waters, except for the entire Keweenaw waterway, including Portage lake, Houghton county, and Lake St. Clair, are designated and protected for coldwater fisheries. (6) All lakes listed in the publication entitled "Designated Trout Lakes and Regulations," issued September 10, 1998, by the director of the department of natural resources under the authority of part 411 of 1994 PA 451, MCL 324.41101 et seq., are designated and protected for coldwater fisheries. (7) All waters listed in the publication entitled "Designated Trout Streams for the State of Michigan," Director's Order No. DFI-101.97, by the director of the department of natural resources under the authority of section 48701(m) of 1994 PA 451, MCL 324.48701(m) are designated and protected for coldwater fisheries.

Coldwater streams and lakes within the Watershed (Table 10) are therefore designated and protected for coldwater fisheries.

Table 10: Coldwater lakes and streams

Subwatershed	Coldwater Streams	Coldwater Lakes
Burt Lake Direct Drainage	Carp Creek	Burt Lake
Maple River Watershed	Maple River, East Branch Maple River, West Branch Maple River, Cold Creek, Brush Creek	Douglas Lake, Lancaster Lake
Crooked River Watershed	Whites Creek, McPhee Creek, Minnehaha Creek (except Silver Creek Pond), Mud Creek, Cedar Creek,	Crooked Lake, Pickerel Lake, Round Lake
Sturgeon River Watershed	Beebee Creek, W. Branch Sturgeon River, Marl Creek, Allend Creek, Bairds Creek, Mud Creek, Bradley Creek, Stewart Creek, Pickerel Creek, Club Stream, Mossback Creek	Lance Lake, Silver Lake, Thumb Lake

The status of a designated use in a watershed can be met, impaired, threatened, or under review/unknown. The use is unimpaired if the available physical and analytical data indicates that all applicable WQS are being consistently met. If the available physical and analytical data indicates that WQS are not being consistently met, then the designated use is considered to be impaired. A threatened status occurs when water quality data analysis demonstrates a declining trend that is expected to cause that water body to not attain WQS by the next listing cycle (Integrated Report). If an assessment unit is expected to not meet a particular designated use within the next two years (Integrated Report listing cycle), it is identified as threatened. A use that is designated as under review or unknown means there is insufficient physical or analytical data available to determine a status for the use, and additional studies are necessary.

The Clean Water Act (CWA) requires Michigan to prepare a biennial report on the quality of its water resources as the principal means of conveying water quality protection/monitoring information to the United States Environmental Protection Agency (USEPA) and the United States Congress. The *Water Quality and Pollution Control in Michigan, Sections 303(d), 305 (b), and 314 Integrated Report (Integrated Report) (MDEQ 2016),* satisfies the listing requirements of Section 303(d) and the reporting requirements of Section 305(b) and 314 of the CWA. The Section 303(d) list includes Michigan water bodies that are not attaining one or more designated uses and require the establishment of Total Maximum Daily Loads (TMDLs) to meet and maintain Water Quality Standards.

At this time, no water bodies in the Burt Lake Watershed are included on the 303(D) list.

No water bodies in the Burt Lake Watershed are listed as impaired or threatened in the Michigan 2016 Integrated Report due to nonpoint sources in the Watershed (Integrated Report, Appendix C). However, some water bodies are listed as not meeting the fish consumption designated use because of state fish consumption advisories that have been issued due to elevated fish tissue levels of mercury and PCBs in some species due to atmospheric deposition of these pollutants. This issue is being addressed at the state and regional levels and is beyond the scope of this Watershed Management Plan.

While the majority of assessed surface waters in the Burt Lake Watershed are currently meeting all of the designated uses of the State, it should be noted that the Watershed remains vulnerable to nonpoint source pollution and other environmental stressors. Existing and future activities will invariably create risk of degradation to some or all of the designated uses and it is critical to enact preventative and restorative actions to ensure future use of watershed resources.

CHAPTER 3

Water Quality of the Burt Lake Watershed

Water quality data for the Burt Lake Watershed was obtained from the Michigan Department of Environmental Quality (MDEQ), United States Environmental Protection Agency (USEPA), Tip of the Mitt Watershed Council (TOMWC), United States Geological Survey (USGS), University of Michigan Biological Station (UMBS), Lakeshore Environmental, Health Department of Northwest Michigan (HDNWM), and the Little Traverse Bay Bands of Odawa Indians (LTBB). The National Water Quality Monitoring Council Data Portal, EPA STORET database, and Michigan Surface Water Information Management System were used to retrieve much of the data. "Legacy" water quality data, collected prior to the year 2000, was obtained from the MDEQ. Over 20,000 records of data were collected for this summary from the years 1957 to 2015.

Water Quality Parameter Descriptions

Approximately 255 parameters have been monitored in the Burt Lake Watershed. Charts showing the average and standard deviations of these parameters by subwatershed are included as well. More detailed tables specific to water bodies for each of these parameters are in Appendix E,

Alkalinity, Hardness, and pH

Alkalinity, Hardness, and pH are important indicators for the acid neutralizing capacity (ANC) of lakes, utility of water, and suitability for aquatic life. pH is a measurement of the acidity or alkalinity of a water body. Distilled water has a pH of 7.0 and is considered pH neutral. Acidic waters have a pH below 7.0, while alkaline waters have a pH above 7.0. The MDEQ water quality standard for pH is 6.5 to 9.0. Outside of this range, the acidity or alkalinity of the water can become harmful to freshwater organisms. Due to the alkaline limestone bedrock of the region, pH is typically between 7.5 and 8.5.

Alkalinity is a measurement of a water body's ability to neutralize an acid. It is measured in equivalent mg/L calcium carbonate ($CaCO_3$). The EPA recommendation for aquatic life is that alkalinity stays above 20 mg/L $CaCO_3$; otherwise, the pH of the water will be highly vulnerable to changes that could become harmful to aquatic life. Waters in the region typically have high alkalinity due to limestone bedrock rich in $CaCO_3$.

Hardness is a measure of the concentration of cations in a water body, such as magnesium, calcium, and iron. Soft water will have low concentrations of these cations, while hard water has high concentrations. Hardness is affected by both geology and pollution in a water body. Hard water can be a nuisance to industry and utilities, as it leaves a scale on equipment and is difficult to clean (hence why many homes use water softeners). Hardness is measured in equivalent mg/L $CaCO_3$. The USGS applies the following classification to water hardness: 0 to 60mg/L $CaCO_3$

is soft water, 61 to 120mg/L $CaCO_3$ is moderately hard, 121 to 180mg/L $CaCO_3$ is hard, and greater than 180 mg/L $CaCO_3$ is very hard.

Conductivity and Chloride

Conductivity is a measure of the ability of water to conduct an electric current, which is dependent upon the concentration of charged particles (ions) dissolved in the water. It is measured in micro-Siemens per centimeter (µS/cm). Specific conductance is simply conductivity standardized to a temperature of 25 degrees Celsius. Chloride, a component of salt, is a negatively charged particle that contributes to the conductivity of water. Chloride is a "mobile ion," meaning it is not removed by chemical or biological processes in soil or water. Chloride is measured in mg/L. Many products associated with human activities contain chloride (e.g., de-icers, water softeners, fertilizers, and bleach). Conductivity and chloride levels in lakes and streams tend to increase as population and human activity in a watershed increase. Research shows that both conductivity and chloride levels in surface waters are good indicators of human disturbance in a watershed, particularly from urban land use (Jones and Clark 1987, Lenat and Crawford 1992, Herlihy et al. 1988).

The MDEQ water quality limit for chloride in surface waters designated as a public water supply source is a maximum monthly average of 125mg/L. Although there is no standard for specific conductance, higher values can signify an increased likelihood of water quality impairment.

Dissolved Oxygen

Dissolved oxygen is one of the most important parameters monitored for assessing water quality. Oxygen is required by almost all organisms, including those that live in the water. Oxygen dissolves into the water from the atmosphere and through photosynthesis of aquatic plants and algae. State law requires that a minimum of 7 mg/L be maintained in lakes and streams designated as a cold-water fishery, and 5 mg/L for warmwater lakes. However, the hypolimnion (depths below the thermocline) of stratified lakes can have low oxygen due to aerobic decomposition and limited replenishment; these instances are not necessarily indicative of impairment.

Nutrients: Phosphorus and Nitrogen

Nutrients are chemicals needed by organisms to live, grow, and reproduce. Nutrients occur naturally and can be found in soils, bedrock, water, air, plants, and animals. Phosphorus and nitrogen are essential nutrients for plant growth and important for maintaining healthy, vibrant aquatic ecosystems. However, excess nutrients from sources such as fertilizers, faulty septic systems, and stormwater runoff lead to nutrient pollution, which can have negative impacts on surface waters.

Lakes and streams in the region are typically phosphorus limited, meaning that added phosphorus increases growth of aquatic plants and algae, while added nitrogen may not increase growth. It has been estimated that one pound of phosphorus could stimulate 500 or more pounds of algae growth. Therefore, heavy phosphorus inputs to lakes and streams can result in nuisance algae and plant growth, which could, in turn, degrade water quality and alter the natural lake ecosystem.

Due to the negative impacts that phosphorus can have on surface waters, legislation was first passed in Michigan to ban phosphorus in soaps and detergents and more recently, phosphorus use in fertilizers has been regulated. Michigan water quality standards do not include a numerical standard for nutrient concentration limits for surface waters. Regulation for surface waters is limited to the following narrative standard from Rule 60 (323.1060): "nutrients shall be limited to the extent necessary to prevent stimulation of growth 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." However, a total phosphorus concentration of 12 micrograms per liter (µg/L) or less for streams in the Northern Michigan ecoregion (EcoregionVIII) is considered the ideal reference condition by the EPA "because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility" (EPA, 2001). The EPA reference condition for total nitrogen in Ecoregion VIII is 440 µg/L or less. In addition, Michigan drinking water standards require that nitrate-nitrogen concentrations be less than 10 mg/L.

Water Clarity and Trophic Conditions

Water clarity is a simple and valuable way to assess water quality. The clarity of water is principally determined by the concentration of algae or suspended and dissolved solids in the water. An eight-inch disc with alternating black and white quadrants, called a Secchi disc, is used to measure water clarity by noting the depth at which the disc disappears. Water samples are often collected in conjunction with the Secchi disc measurement for chlorophyll-a analysis; chlorophyll-a is a pigment found in green plants. Chlorophyll-a data provide an approximation of the amount of algae in the water, which is useful for determining whether changes in water clarity are caused by sediments or algae.

Water clarity, chlorophyll-a, and phosphorus data are used to determine the biological productivity, or trophic status, of a lake. The Trophic Status Index (TSI) is a tool developed by Bob Carlson, Ph.D. from Kent State University that utilizes these data to place a water body on a scale of biological productivity. TSI values range from zero to 100: lower values (0-38) indicate an oligotrophic or low productive system, medium values (39-49) indicate a mesotrophic or moderately productive system, and higher values (50+) indicate a eutrophic or highly productive system.

Lakes with greater water clarity and smaller phytoplankton populations would score on the low end of the scale, while lakes with greater turbidity and more phytoplankton would be on the high end. Oligotrophic lakes are characteristically deep, clear, nutrient poor, and with abundant oxygen. On the other end of the spectrum, eutrophic lakes are shallow, nutrient rich, and full of productivity. A highly productive eutrophic lake could have problems with oxygen depletion whereas the low-productivity oligotrophic lake may have a lackluster fishery. Mesotrophic lakes lie somewhere in between and are moderately productive.

Table 11: Trophic status categories (adapted from Carlson 1996*)

Trophic State	TSI	Chl-a (µg/L)	Secchi (ft)	TP (µg/L)
Oligotrophic	<40	<2.6	>13.1	<12.0
Mesotrophic	40-50	2.6-7.3	6.6-13.1	12.0-24.0
Eutrophic	50-70	7.3-56.0	1.6-6.6	24-96
Hypereutrophic	>70	>56	<1.64	>96

*Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Depending upon variables such as age, depth, and soils, lakes are sometimes naturally eutrophic. However, nutrient and sediment pollution caused by humans can lead to the premature eutrophication of a lake, referred to as "cultural eutrophication". A lake that undergoes cultural eutrophication can affect the fisheries, cause excess plant growth, and result in algal blooms that can be both a nuisance and a public health concern.

Bacteriological Monitoring

Monitoring for harmful pathogens in a water body is typically performed by monitoring *Escherichia coli* (*E. coli*) bacteria at popular access points during the summer. The measurement is determined by the number of *E. coli* in a 100mL water sample. *E. coli* usually do not pose a direct danger to human health, but are rather indicators of the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that originate in human and animal digestive systems. However, it is worth noting that human *E. coli* is a greater disease risk to humans, than *E. coli* from other animals. Consequently, *E. coli* from a residential septic system would indicate a much higher risk to human health than *E. coli* from livestock or wildlife. Because human *E. coli* can only be differentiated from other animal *E. coli* via costly DNA analysis, the presence of *E. coli* is applied to the general standard.

Rule 62 (R 323.1062) of MDEQ Part 4 Water Quality Standards does have a provision for *E. coli* concentrations in surface water: "All waters of the state protected for total body contact recreation shall not contain more than 130 *Escherichia coli* per 100 milliliters, as a 30-day geometric mean." Rule 62 also states: "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 milliliters." In addition, the Daily Maximum Geometric Mean for partial body contact is 1,000 *E. coli* per 100 ml.

Information regarding *E. coli* monitoring results, including public beach closings, can be found at www.beachguard.com and www.mi.gov/miswim. It is worth noting that Beach Guard's historical data for beach advisories and closings does not appear to be updated regularly.

Biological Monitoring

Biological data are collected primarily by sampling macroinvertebrate communities in streams. Healthy streams typically have a high diversity of macroinvertebrates, especially taxa sensitive to pollution. Biological data were assessed using three metrics: 1) total taxa = the total number of macroinvertebrate families found at a site; 2) EPT taxa = the number of families belonging to three insect orders that are largely intolerant of pollution (mayflies, stoneflies, and caddisflies); and 3) sensitive taxa = the number of macroinvertebrate families that are the most intolerant of pollution (those that rate 0, 1, or 2 in PhD William Hilsenhoff's family-level sensitivity classification system). At sites monitored by both DEQ and TOMWC, DEQ found higher numbers of total, EPT, and sensitive taxa, which is attributed to DEQ field biologists having more experience than TOMWC volunteers. LTBB also collects biological data in the Burt Lake Watershed for water quality analysis; however, they have a different collection methodology which makes data incomparable using the above three indices.

Water Quality of the Burt Lake Direct Drainage

Lakes

Water quality of lakes in the Burt Lake Direct Drainage has been monitored at 12 sites (Figure 59). All these sites are on Burt Lake. Monitors include the LTBB, HDNWM, MDEQ, TOMWC, and USGS. Data for specific parameters is summarized below.

Alkalinity, Hardness, and pH

Alkalinity, Hardness, and pH data for lakes of the Burt Lake Direct Drainage indicate that the water contains relatively high amounts of calcium carbonate (CaCO3), which makes it moderately alkaline with a high buffering capacity (i.e. acid neutralizing), and that the drinking what is hard. Alkalinity data from the MDEQ and USGS for 11 samples have an average value of 143.9 mg/L CaCO3, with a standard deviation of 6.6 mg/L CaCO3. All alkalinity measurements are above the EPA recommended minimum value of 20 mg/L CaCO3. However, one hardness measurement from the MDEQ is 165 mg/L CaCO3, indicating hard water. pH data from the MDEQ, TOMWC, and USGS (for 117 samples) have an average pH of 8.1 with a standard deviation of 0.4. All of the pH measurements are inside the MDEQ water quality standard of 6.5 to 9.0.

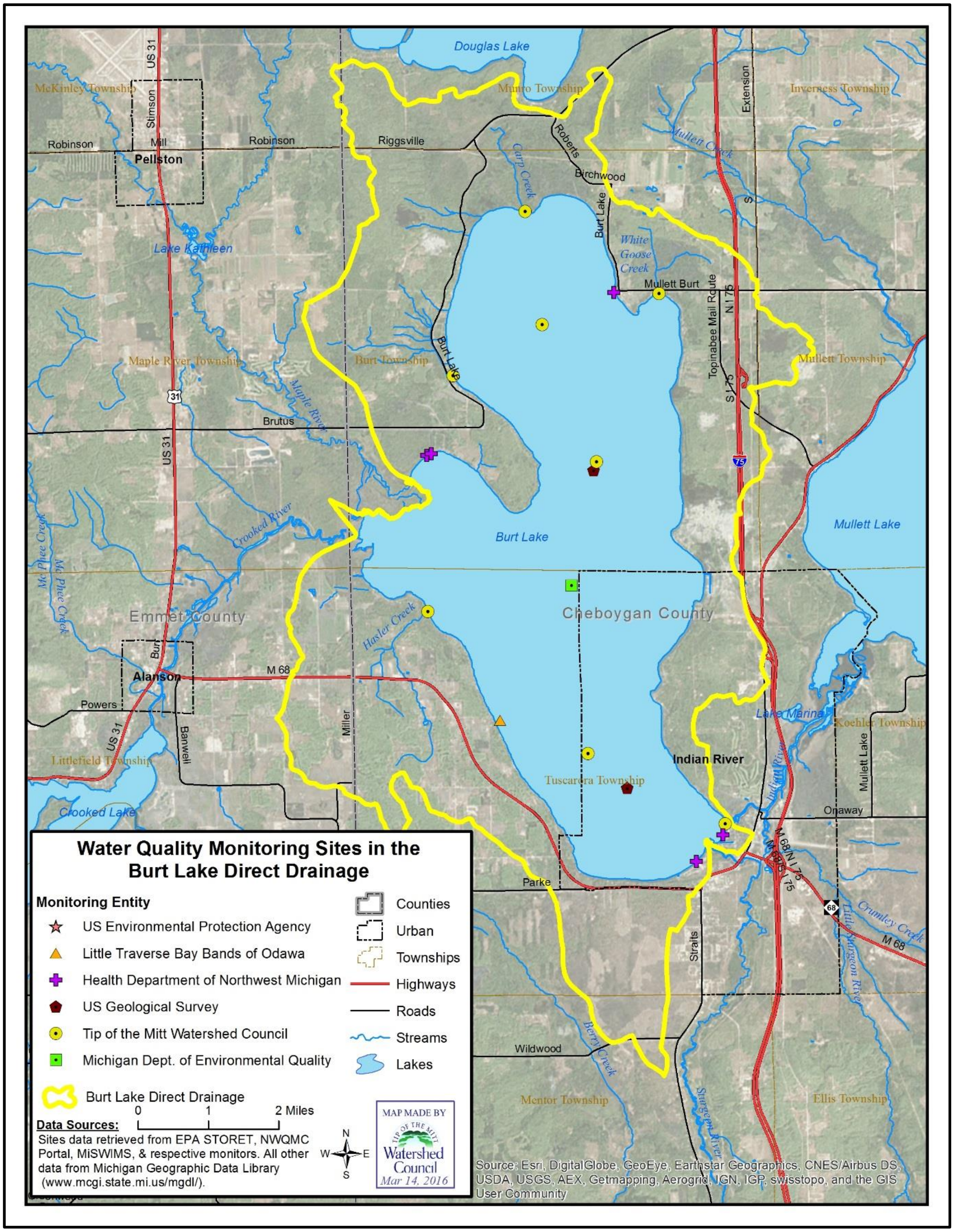


Figure 59: Burt Lake Direct Drainage water quality monitoring sites

Conductivity and Chloride

Specific conductance and chloride data for lakes of the Burt Lake Direct Drainage indicate that the water contains the typical amounts of chloride and other dissolved particles for the region. Specific conductance data from the MDEQ, TOMWC, and USGS (for 125 samples) have an average of 314.8 µS/cm, with a standard deviation of 33.5 µS/cm. Chloride data from the same monitors for 47 samples have an average of 10.2 mg/L, with a standard deviation of 11.9 mg/L. No chloride measurements approach the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

Dissolved Oxygen

Dissolved Oxygen data for lakes in the Burt Lake Direct drainage indicate the water contains ample dissolved oxygen for coldwater aquatic life, though can experience low-oxygen conditions in the hypolimnion (depths of the lake beneath the thermocline) during stratification. Dissolved oxygen data from the MDEQ, TOMWC, and USGS (for 124 samples) have an average of 8.7 mg/L, with a standard deviation of 3.5 mg/L. Of these, 24 are below the MDEQ water quality standard of 7 mg/L for coldwater aquatic life; however, nearly all these measurements are at depths of 40 to 70 feet. The low oxygen is likely due to limited replenishment in the hypolimnion and not necessarily indicative of impairment.

Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen data for lakes in the Burt Lake Direct Drainage indicate the water is phosphorus limited. Total phosphorus data from the MDEQ, TOMWC, and USGS (for 60 samples) have an average of 6.7 µg/L with a standard deviation of 4.0 µg/L. 12 of these measurements are above the EPA reference condition of 9.69 µg/L for lakes within Ecoregion VIII (EPA 2000), though still within the range for oligotrophic to mesotrophic lakes. Total nitrogen data from the same monitors (from 57 samples) have an average of 392.2 µg/L with a standard deviation of 255.6 µg/L. 16 measurements are above the EPA reference condition of 400 µg/L, though within typical ranges for lakes in the region. Nitrate nitrogen data from the MDEQ and TOMWC for 35 samples have an average of 105.7 µgN/L, with a standard deviation of 24.7 µgN/L. Although there is no MDEQ numerical standard for surface water, none of these measurements are anywhere near exceedance of the drinking water standard of 10,000 µgN/L.

Water Clarity and Trophic Conditions

Water clarity and chlorophyll-a data for lakes in the Burt Lake Direct Drainage indicate the water is oligotrophic (i.e. low biological productivity). This data is available for Burt Lake. Water clarity data collected with a Secchi disc from the MDEQ, TOMWC, and USGS (for 662 samples) have an average of 16.1 feet, with a standard deviation of 4.83 feet. No measurements were anywhere near the hypereutrophic (overly high biological productivity) classification of the North

American Lake Management Society of 1.6 feet. Chlorophyll-a data from the MDEQ, TOMWC, and USGS (for 356 samples) have an average of 1.1 µg/L, with a standard deviation of 0.9 µg/L. No measurements approached the hypereutrophic classification of 56 µg/L.

Bacteriological Monitoring

Bacteriological monitoring data for lakes in the Burt Lake Direct Drainage indicate the water is almost always suitable for total body contact. *E. coli* count data from the HDNWM (for 160 samples) have an average of 26.0 *E. coli*/100mL, with a standard deviation of 192.7 *E. coli*/100mL. In only two circumstances has the MDEQ standard for total body contact of 300 *E. coli*/100mL been exceeded, both at Devoe Beach.

Streams

The water quality of streams in the Burt Lake Direct Drainage has been monitored at five sites by TOMWC. These sites occur at the mouths of Hasler Creek, Maple Bay Creek, Unnamed Creek of West Burt Lake Road, Carp Creek, and White Goose Creek. Data for specific parameters is summarized below. No bacteriological or biological monitoring data is available for these creeks.

Alkalinity, Hardness, and pH

No alkalinity or hardness data is available for streams of the Burt Lake Direct Drainage. pH data indicates the water is moderately alkaline. This data is available for Hasler Creek, Unnamed Creek of West Burt Lake Road, Carp Creek, and White Goose Creek. pH data from TOMWC (for 51 samples) have an average of 7.8, with a standard deviation of 0.5. None of these pH measurements are outside the MDEQ water quality standard of 6.5 to 9.0.

Conductivity and Chloride

Specific conductance and chloride data for streams of the Burt Lake Direct Drainage indicate the water contains amounts of chloride and other dissolved particles typical for the region. These data are available for Hasler Creek, Maple Bay Creek, Unnamed Creek of West Burt Lake Road, Carp Creek, and White Goose Creek. Specific conductance data from TOMWC (for 52 samples) have an average of 323.1 µS/cm, with a standard deviation of 77.3 µS/cm. Chloride data from TOMWC (for 52 samples) have an average of 13.5 mg/L, with a standard deviation of 8.6 µg/L. No chloride measurements approach the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

Dissolved Oxygen

Dissolved oxygen data for streams in the Burt Lake Direct Drainage indicate the water typically has ample dissolved oxygen for coldwater aquatic life, though can drop slightly below the standard in some streams. This data is available for Hasler Creek, Maple Bay Creek, Unnamed Creek of West Burt Lake Road, Carp Creek, and White Goose Creek. Dissolved oxygen data from TOMWC for 51 samples have an average of 9.0 mg/L, with a standard deviation of 1.2 mg/L. Three out of 11 measurements at Maple Bay Creek and one out of 12 measurements for White Goose Creek are below the MDEQ water quality standard of 7 mg/L for coldwater aquatic life. The lowest of these measurements for both streams is slightly below the standard at 6.6 mg/L.

Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen data for streams in the Burt Lake Direct Drainage indicate the water is phosphorus limited and above EPA reference conditions. This data is available for Hasler Creek, Maple Bay Creek, Unnamed Creek of West Burt Lake Road, Carp Creek, and White Goose Creek. Total phosphorus data from TOMWC for 52 samples have an average of 19.6 µg/L, with a standard deviation of 12.7 µg/L. The majority of measurements for Maple Bay Creek, Unnamed Creek of West Burt Lake Road, and White Goose Creek are above the EPA reference condition of 12 µg/L. Maple Bay Creek has the highest average of 31.4 µg/L, while White Goose Creek has the highest individual measurement at 54 µg/L.

Total Nitrogen data from TOMWC for 52 samples have an average of 511.5 µg/L, with a standard deviation of 312.1 µg/L. The majority of measurements for Hasler Creek, Maple Bay Creek, Unnamed Creek of West Burt Lake Road, and White Goose Creek are above the EPA reference condition of 440 µg/L. Maple Bay Creek has the highest average of 654 µg/L, while White Goose Creek has the highest individual measurement of 1,758 µg/L. Nitrate nitrogen data from TOMWC for 43 samples have an average of 125.2 µg/L, with a standard deviation of 113.8 µg/L. Hasler Creek has the highest average of 252.9 µg/L. Although there is no MDEQ numerical standard for surface water, none of these measurements are anywhere near exceeding the drinking water standard of 10,000 µgN/L.

Water Quality of the Maple River Watershed

Lakes

Water quality of lakes of the Maple River Watershed has been monitored at 11 sites. The monitored lakes are Douglas, Lancaster, Larks, and Munro. Monitors include the LTBB, MDEQ, TOMWC, HDNWM, and USGS. Data for specific parameters are summarized below.

Alkalinity, Hardness, and pH

Alkalinity, Hardness, and pH data for lakes of the Maple River Watershed indicate the water contains relatively high amounts of calcium carbonate, which makes it moderately alkaline with a high acid neutralizing capacity, and hard water. These data are available for Douglas, Lancaster, Larks, and Munro Lakes. Alkalinity data from the MDEQ, UMBS, and USGS for 17 samples have an average of 121.0 mg/L $CaCO_3$, with a standard deviation of 32.7 mg/L $CaCO_3$. No measurements are below the EPA recommended minimum value of 20 mg/L $CaCO_3$. Total hardness data from the MDEQ for three samples has an average of 141.2 mg/L $CaCO_3$, with a standard deviation of 18.0 mg/L $CaCO_3$, indicating hard water. pH data from LTBB, MDEQ, TOMWC, UMBS, and USGS have an average of 8.2, with a standard deviation of 0.6. Douglas Lake has an average pH of 7.96 and has exceeded the MDEQ standard of 6.5 to 9.0 once out of 31 samples. The pH of Larks Lake is the highest of the Watershed with an average of 8.49, and nine of 137 measurements exceeding the standard. This high pH is likely due to calcium carbonate originating in the limestone bedrock. pH should be continually monitored to ensure the lake does not become too alkaline for aquatic life. The highest pH measurement of lakes in the Watershed is at Douglas Lake with a pH of 9.40.

Conductivity and Chloride

Specific conductance and chloride data for lakes of the Maple River Watershed indicate the water contains amounts of chloride and other dissolved particles typical for the region. These data are available for Douglas Lake, Lancaster Lake, Larks Lake, and Munro Lake. Specific conductance data from LTBB, MDEQ, TOMWC, UMBS, and USGS for 261 samples have an average of 242.3 µS/cm, with a standard deviation of 76.1 µS/cm. Chloride data from LTBB, MDEQ, TOMWC, and USGS for 128 samples have an average of 4.8 mg/L, with a standard deviation of 1.9 mg/L. No chloride measurements approach the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

Dissolved Oxygen

Dissolved oxygen data for lakes of the Maple River Watershed indicate that some lakes experience low dissolved oxygen at various depths, which are not necessarily indicative of impairment. However, one lake is experiencing broader dissolved oxygen issues. Data is available for Douglas Lake, Lancaster Lake, Larks Lake, and Munro Lake.

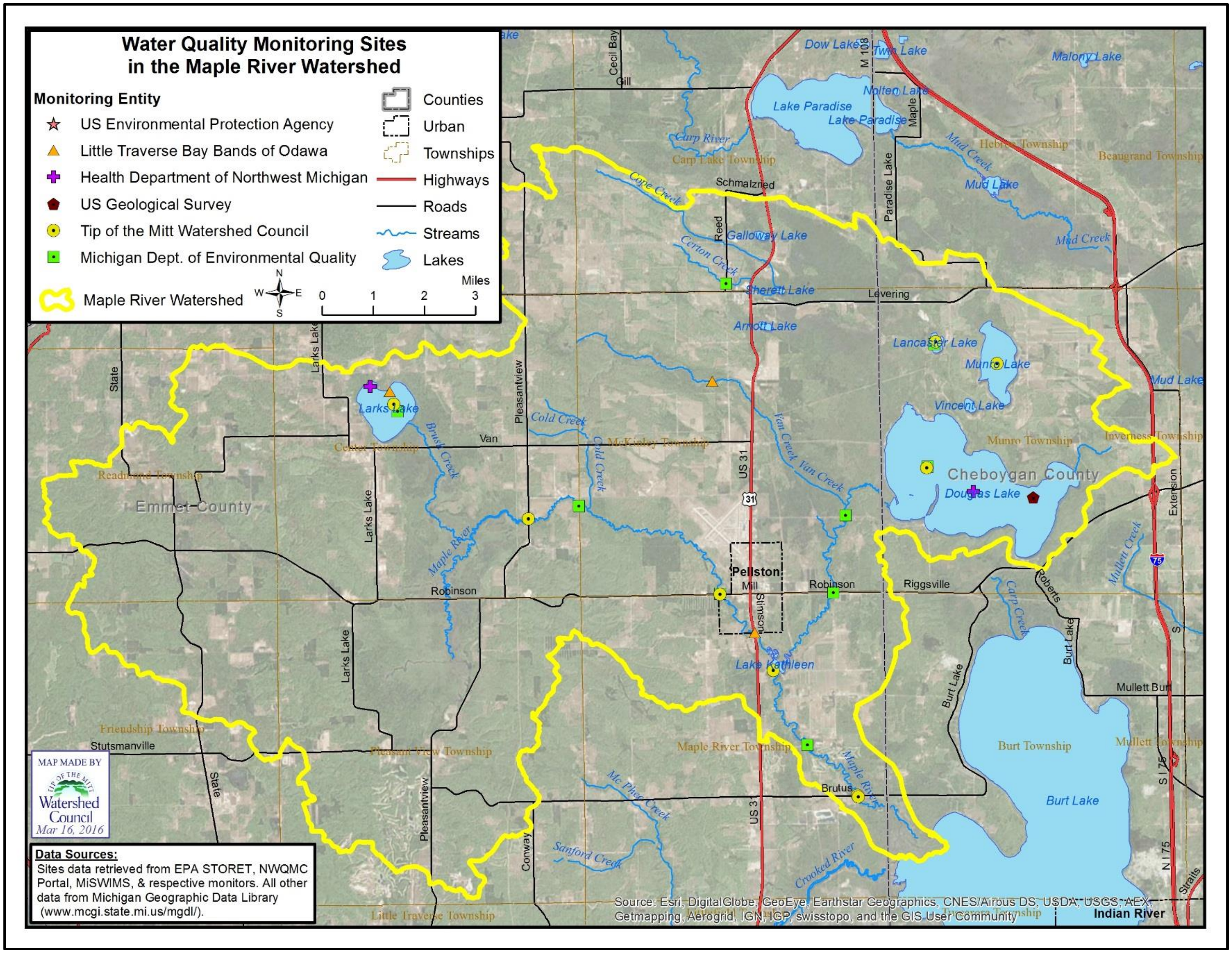


Figure 60: Maple River Watershed water quality monitoring sites

Dissolved oxygen data from LTBB, MDEQ, TOMWC, and USGS have an average of 8.5 mg/L, with a standard deviation of 3.7 mg/L. Douglas Lake, Larks Lake, and Munro Lake have ample dissolved oxygen for coldwater life, with averages of 10.0, 10.1, and 9.6 mg/L, respectively. However, Lancaster Lake has an average of only 3.6 mg/L, well below the standards of 7 mg/L and 5 mg/L for coldwater and warmwater fisheries, respectively. 43 of 59 measurements for Lancaster Lake are below the 7 mg/L standard, while 37 of these are also below 5 mg/L. This indicates that Lancaster Lake could be experiencing problems with low dissolved oxygen.

Lancaster Lake typically has high dissolved oxygen near the surface, with an average of 8.4 mg/L within the first 10 feet of depth. Then oxygen drops drastically, with an average of 2.1 mg/L from 10 feet to the deepest point of 56 feet. This low oxygen could be due to a high concentration of nutrients, particularly phosphorus, which increases oxygen demand. With these low measurements, there are potential impacts on the fishery and other aquatic life of Lancaster Lake that should be investigated further.

Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen data for lakes in the Maple River Watershed indicate that the water is phosphorus limited, though nutrient levels can be higher than EPA reference conditions. Total phosphorus data from LTBB, MDEQ, TOMWC, UMBS, and USGS for 142 samples have an average of 11.3 µg/L, with a standard deviation of 8.5 µg/L. Lancaster Lake has the highest phosphorus concentration with an average of 19.28 µg/L and a maximum measurement of 74.0 µg/L. The EPA reference condition for lakes in the Ecoregion VIII is 9.69 µg/L.

Total nitrogen data from the LTBB, MDEQ, TOMWC, and USGS for 147 samples have an average of 653.0 µg/L, with a standard deviation of 223.1 µg/L. The EPA reference condition is 400 µg/L. The total nitrogen of Lancaster Lake averages 550.4 µg/L, which is less than the average for all lakes in the Watershed. Nitrate nitrogen data from the MDEQ, TOMWC, and USGS have an average of 84.2 µg/L, with a standard deviation of 107.4 µg/L. Although there is no MDEQ numerical standard for surface water, none of these nitrate measurements approached the drinking water standard of 10,000 µgN/L.

Water Clarity and Trophic Conditions

Water clarity and chlorophyll-a data for lakes in the Maple River Watershed indicate that the lakes are typically mesotrophic, or moderately productive. Water clarity data collected by Secchi disc for these lakes from the LTBB, MDEQ, TOMWC, and USGS for 642 samples have an average of 11.3 feet, with a standard deviation of 2.4 feet. Chlorophyll-a data from the LTBB, MDEQ, TOMWC, UMBS, and USGS have an average of 2.6 µg/L, with a standard deviation of 2.9 µg/L. Secchi data is typically in the mesotrophic state, while chlorophyll-a data borders between mesotrophy and oligotrophy (low productivity).

Bacteriological Monitoring

Bacteriological monitoring data for lakes of the Maple River Watershed have no instances when the water was not suitable for total body contact. This data is available for Douglas and Larks Lakes from the HDNWM. 53 samples have an average of 7.5 *E. coli*per 100mL, with a standard deviation of 21.8 *E. coli*per 100mL. This is well below the MDEQ standard of 300 *E. coli*/ 100mL.

Streams

Water quality of streams in the Maple River Watershed has been monitored at 11 sites. The monitored streams are the Maple River, Maple River West Branch, Maple River East Branch, Van Creek, and Certon Creek. Monitors include the LTBB, MDEQ, and TOMWC. Data for specific parameters is summarized below. No bacteriological data is available for streams in the Watershed.

Alkalinity, Hardness, and pH

Alkalinity, hardness, and pH data for streams of the Maple River Watershed indicate the water contains relatively high amounts of calcium carbonate (CaCO3), which makes it moderately alkaline with a high buffering capacity (i.e. acid neutralizing), and hard water. These data are available for the Maple River, Maple River East Branch, Maple River West Branch, and Van Creek. Alkalinity data from the LTBB, MDEQ, and TOMWC for three samples have an average of 132.0 mg/L CaCO3, with a standard deviation of 14.2 µg/L CaCO3. No alkalinity measurements are below the EPA recommended minimum value of 20 mg/L CaCO3. One hardness measurement from the MDEQ is 145.0 µg/L CaCO3, indicating hard water. pH data from the LTBB, MDEQ, and TOMWC for 123 samples have an average of 7.8, with a standard deviation of 0.5. None of these pH measurements are outside the MDEQ water quality standard of 6.5 to 9.0.

Conductivity and Chloride

Specific conductance and chloride data for streams of the Maple River Watershed indicate the water contains amounts of chloride and other dissolved particles typical for streams of the region. These data are available for the Maple River, Maple River East Branch, Maple River West Branch, and Van Creek. Specific conductance data from the LTBB, MDEQ, and TOMWC for 125 samples have an average of 308.6 µS/cm, with a standard deviation of 57.8 µS/cm. Chloride data from the same monitors for 126 samples have an average of 4.6 µS/cm, with a standard deviation of 2.1 µS/cm. No chloride measurements approach the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

Dissolved Oxygen

Dissolved oxygen data for streams of the Maple River Watershed indicates most streams have ample dissolved oxygen for coldwater aquatic life, though Van Creek is borderline. Dissolved oxygen data from the LTBB, MDEQ, and TOMWC for 124 samples have an average of 8.5 mg/L, with a standard deviation of 1.9 mg/L. The Maple River has high oxygen throughout monitored sites on its branches, averaging 10.6 mg/L on the East Branch, 8.7 mg/L on the West Branch, and 10.3 mg/L below the confluence. Only five of 91 measurements on these branches are below the coldwater standard of 7 mg/L. Van Creek has an average of 7.1 mg/L, which is only very slightly above the standard for a coldwater fishery. Twelve of 33 measurements on Van Creek are below 7 mg/L. Further study of Van Creek is needed to identify any problems contributing to the low dissolved oxygen measurements.

Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen data for streams in the Maple River Watershed indicate the water is phosphorus limited, though nutrients are above EPA reference conditions. Total phosphorus data from the LTBB, MDEQ, and TOMWC for 127 samples have an average of 13.7 µg/L, with a standard deviation of 11.7 µg/L. This is slightly above the EPA reference condition of 12 µg/L. Van Creek has the highest phosphorus concentration with an average of 23.4 µg/L and a high of 100.8 µg/L. Total nitrogen data from the same monitors for 126 samples has an average of 672.5 µg/L, with a standard deviation of 286.1 µg/L. This is above the EPA reference condition of 400 µg/L. The total nitrogen average for Van Creek is 582.7 µg/L, which is below the average for all streams in the Watershed. Nitrate nitrogen data from the Watershed Council for 15 samples have an average of 200.7 µgN/L, with a standard deviation of 91.8 µgN/L. This data is only available for the Maple River below the confluence. Although there is no MDEQ numerical standard for surface water, none of these nitrate measurements approaches the drinking water standard of 10,000 µgN/L.

Biological Monitoring

Macroinvertebrate communities of streams in the Maple River Watershed have been monitored at six sites by the MDEQ and TOMWC, with a total of 31 samples. These sites have an average of 24 total taxa, 10 EPT taxa, and 4 sensitive taxa. Data from Brutus Road near the mouth, Woodland Road downstream of the Lake Kathleen Dam, and Robinson Road on the west branch in Pellston all show spectacular diversity. Lower diversity at the Pleasantview Road site is at least partly attributed to naturally slow flow and warmer water temperatures, but could also be the result of agricultural activity in that part of the Watershed.

Water Quality of the Crooked River Watershed

Lakes

Water quality of lakes in the Crooked River Watershed has been monitored at 19 sites. The monitored lakes are Spring Lake, Mud Lake, Crooked Lake, Pickerel Lake, and Weber Lake. Monitors include the EPA, LTBB, HDNWM, USGS, UMBS, TOMWC, and MDEQ. Data for specific parameters is summarized below. Spring, Round, and Mud Lakes have concerns with some parameters that should be addressed.

Alkalinity, Hardness, and pH

Alkalinity, hardness, and pH data for lakes of the Crooked River Watershed indicate the water contains relatively high amounts of calcium carbonate, which makes it moderately alkaline with a high buffering capacity (i.e. acid neutralizing), and very hard water. These data are available for Crooked, Mud, Pickerel, Round, and Spring Lakes. Alkalinity data from the MDEQ, UMBS, and USGS for 17 samples have an average of 138.9 mg/L CaCO3, with a standard deviation of 8.8 mg/L CaCO3. No measurements are below the EPA recommended minimum value of 20 mg/L CaCO3. Two hardness measurements from the MDEQ have an average of 186.5 mg/L CaCO3, with a standard deviation of 18.3 mg/L CaCO3, indicating the water of the lakes is very hard. pH data from the EPA, LTBB, MDEQ, TOMWC, UMBS, and USGS for 773 samples have an average of 8.1, with a standard deviation of 0.4. None of these pH measurements are outside the MDEQ water quality standard of 6.5 to 9.0.

Conductivity and Chloride

Specific conductance and chloride data for lakes of the Crooked River Watershed indicate that some of the lakes have higher amounts of chloride and other dissolved particles than other lakes in the region. Specific conductance data from the EPA, LTBB, MDEQ, TOMWC, UMBS, and USGS for 739 samples have an average of 349.1 µS/cm, with a standard deviation of 98.7 µS/cm. Spring and Mud Lakes have particularly high specific conductance, averaging 538.3 and 524.4, respectively. One measurement in Spring Lake is the highest of the Burt Lake Watershed at over 1,190 µS/cm. Urbanization in the Watersheds of these two small lakes likely contributes to the high levels.

Chloride data from the EPA, LTBB, MDEQ, TOMWC, UMBS, and USGS for 398 samples have an average of 25.0 mg/L, with a standard deviation of 24.6 mg/L. Similar to specific conductance, Spring and Mud Lakes have the highest concentrations, averaging 59.6 and 51.6 mg/L, respectively. Two measurements in Spring Lake are over the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

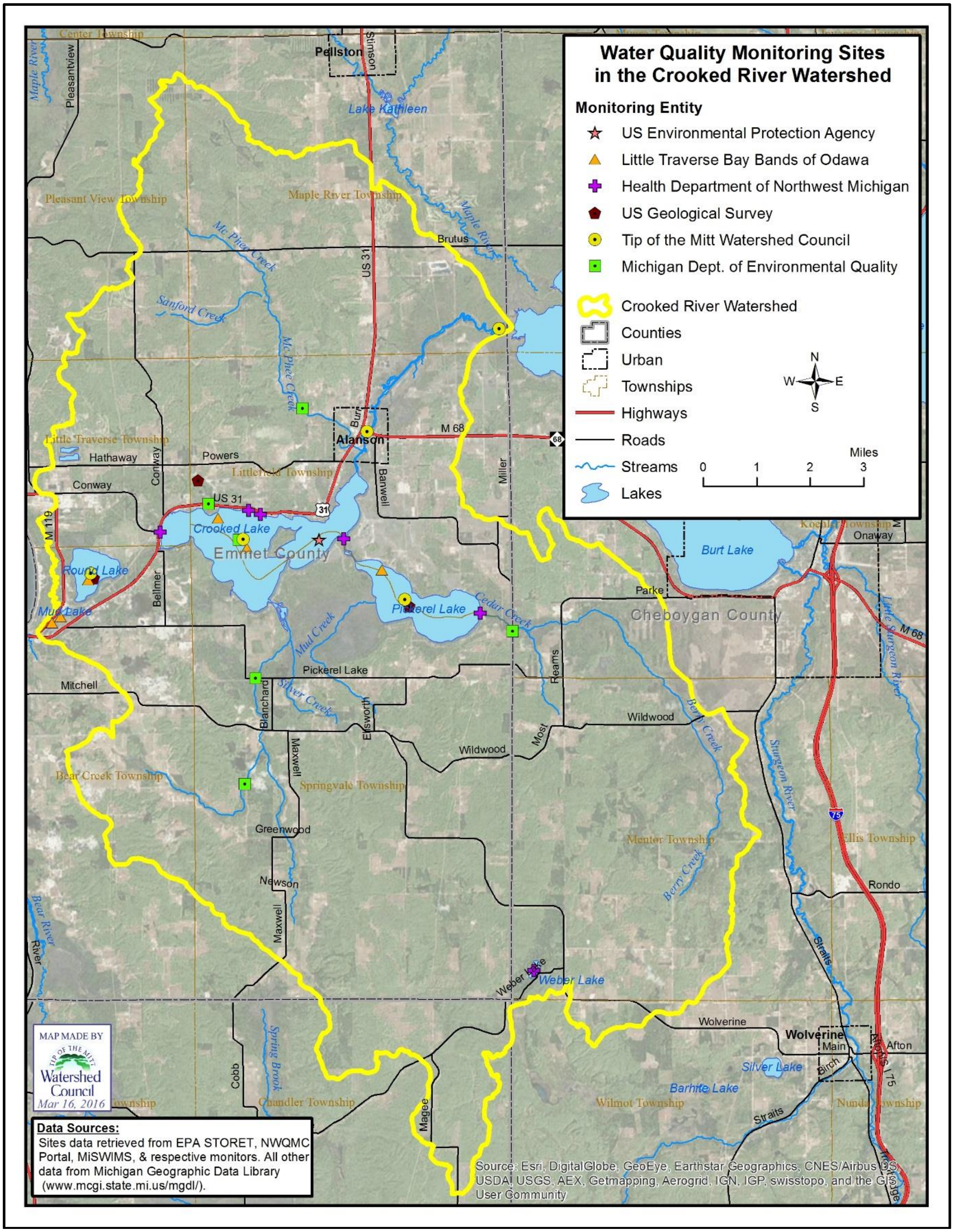


Figure 61: Crooked River Watershed water quality monitoring sites

Dissolved Oxygen

Dissolved oxygen data for lakes of the Crooked River Watershed indicate that the lakes usually have ample dissolved oxygen for coldwater aquatic life, though can experience low-oxygen conditions at various depths or times of the year. Dissolved oxygen data from the EPA, LTBB, MDEQ, TOMWC, and USGS for 754 samples have an average of 8.5 mg/L, with a standard deviation of 3.3 mg/L. Crooked Lake is below the 7 mg/L coldwater standard for 97 out of 414 measurements, though above 7 mg/L for all measurements less than 24 feet deep. Pickerel Lake is below 7 mg/L for 17 out of 70 measurements, though above 7 mg/L for all measurements less than 35' deep. It is likely the low measurements in the depths of these two lakes are due to low oxygen in the hypolimnion and not indicating impairment. Mud Lake is below 7 mg/L for five out of 58 measurements, three of which are also below the warmwater standard 5 mg/L. Spring Lake is below 7 mg/L for three of 64 measurements, two of which were also below 5 mg/L. The low oxygen for these three lakes is likely due high nutrient levels increasing oxygen demand. Round Lake is below 7 mg/L for 13 of 148 measurements, and below 5 mg/L for eight of these. Six of these eight measurements below 5 mg/L were taken in February, likely beneath the ice, while the other two are near the lake bottom at over 14 feet of depth. It is possible that Round Lake has dissolved oxygen concerns, though more data throughout the year are needed to confirm this.

Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen data for lakes in the Crooked River Watershed indicate that the water is phosphorus limited, and some lakes have relatively high levels of nitrogen. Total phosphorus data from the EPA, LTBB, MDEQ, TOMWC, and USGS for 442 samples have an average of 7.9 µg/L, with a standard deviation of 4.2 µg/L. 129 of these measurements are above the EPA reference condition of 9.69 µg/L, though none are higher than 30 µg/L.

Total nitrogen data from the EPA, LTBB, MDEQ, TOMWC, and USGS for 424 samples have an average of 713.5 µg/L, with a standard deviation of 425.6 µg/L. 338 of these measurements are above the EPA reference condition of 400 µg/L. The average is also well above the reference condition. Mud and Spring Lakes have the highest nitrogen with averages of 1,119 µg/L each. Nitrate nitrogen data from the EPA, LTBB, MDEQ, TOMWC, and UMBS have an average of 273.6 µgN/L, with a standard deviation of 343.1 µgN/L. The high average and standard deviation are due to high nitrate measurements in Spring and Mud Lakes; Spring Lake specifically is over 1000 µgN/L in three of eight measurements. These high nitrogen concentrations could be from the lakes accumulating lots of organic matter, along with historic nutrient inputs from the surrounding land use.

Water Clarity and Trophic Conditions

Water clarity and chlorophyll-a data for lakes in the Crooked River Watershed indicate that Crooked, Pickerel, and Round Lakes are mesotrophic (moderately productive). Water clarity data collected with a Secchi disc for these lakes from the EPA, LTBB, MDEQ, TOMWC, and USGS for 758 samples have an average of 9.8 feet, with a standard deviation of 2.9 feet. Chlorophyll-a data is available for Crooked, Pickerel, Round, Mud, and Spring Lakes. Chlorophyll-a data from the EPA, LTBB, MDEQ, TOMWC, UMBS, and USGS for 427 samples have an average of 1.7 µg/L, with a standard deviation of 1.6 µg/L. Mud, Spring, and Round Lakes have the highest chlorophyll-a averages of over 2 µg/L. However, none of the chlorophyll-a measurements approach the North American Lake Management Society hypereutrophic classification of 56+ µg/L.

Bacteriological Monitoring

Bacteriological monitoring data for lakes of the Crooked River Watershed have had no instances when the water was not suitable for total body contact. This data is available for Crooked, Pickerel, and Weber Lakes from the HDNWM. 287 samples have an average of 16.6 *E. coli*/ 100mL, with a standard deviation of 32.4 *E. coli*/ 100 mL. The MDEQ standard of 300 *E. coli*/ 100mL has not been exceeded.

Streams

Water quality of streams in the Crooked River Watershed has been monitored at seven sites by the MDEQ and TOMWC. These sites occur on the Crooked River, Cedar Creek, McPhee Creek, Minnehaha Creek, Minnehaha Creek West Branch, and Oden Creek. Data for specific parameters is summarized below. No bacteriological data is available for streams in the Watershed.

Alkalinity, Hardness, and pH

Alkalinity and pH data for streams of the Crooked River Watershed indicate the water contains relatively high amounts of calcium carbonate, which makes it moderately alkaline with a high acid neutralizing capacity. These data are available for the Crooked River, Cedar Creek, Mud Creek, McPhee Creek, and Minnehaha Creek. No hardness data is available for streams in the Watershed. Alkalinity data from the MDEQ for three samples have an average of 171.0 mg/L CaCO3, with a standard deviation of 8.8 mg/L CaCO3. No measurements are below the EPA recommended minimum value of 20 mg/L CaCO3. pH data from TOMWC for 143 sites have an average of 8.5, with a standard deviation of 0.4. None of these pH measurements are outside the MDEQ water quality standard of 6.5 to 9.0.

Conductivity and Chloride

Specific conductance and chloride data for streams of the Crooked River Watershed indicate the water contains amounts of chloride and other dissolved particles typical for the region. These data are available for Cedar Creek, Crooked River, McPhee Creek, and Minnehaha Creek. Conductivity data from the MDEQ and TOMWC for 146 samples have an average of 308.2 µS/cm, with a standard deviation of 12.2 µS/cm. Chloride data from the same monitors for 20 samples have an average of 9.0 mg/L, with a standard deviation of 2.9 mg/L. No chloride measurements approach the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

Dissolved Oxygen

Dissolved oxygen data for streams of the Crooked River Watershed is available for only the Crooked River. 143 samples by TOMWC have an average of 10.4 mg/L, with a standard deviation of 0.9 mg/L. None of these measurements are below the MDEQ standard of 7 mg/L, indicating the river has ample dissolved oxygen for coldwater aquatic life.

Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen data for streams in the Crooked River Watershed indicate the water is phosphorus limited and has nutrient concentrations similar to or less than EPA reference conditions. This data is available for the Crooked River, Minnehaha Creek, Cedar Creek, McPhee Creek, and Oden Creek. Total Phosphorus data from the MDEQ and TOMWC for 18 samples have an average of 8.9 µg/L, with a standard deviation of 8.1 µg/L. This average is below the EPA reference condition of 12.0 µg/L. Three of these measurements are above the EPA reference condition; the highest measurement is on the Crooked River at 29.0 µg/L.

Total nitrogen data from the same monitors for 22 samples have an average of 468.0 µg/L, with a standard deviation of 205.2 µg/L. This average is similar to the EPA reference condition of 440 µg/L for streams in the region. Nine of these measurements are above 440 µg/L; the highest measurement is on Minnehaha Creek at 980 µg/L. Nitrate data from TOMWC for 17 samples on the Crooked River have an average of 141.6 µgN/L, with a standard deviation of 65.3 µgN/L. Although there is no MDEQ numerical standard for surface water, none of these measurements are anywhere near exceedance of the drinking water standard of 10,000 µgN/L.

Biological Monitoring

Limited macroinvertebrate monitoring data from the MDEQ is available for streams of the Crooked River Watershed. This data is available for McPhee and Minnehaha Creeks. Two samples of McPhee Creek have an average of 25 total taxa, 11 EPT taxa, and 5 sensitive taxa. One sample of Minnehaha Creek has an average of 21 total taxa, 9 EPT taxa, and 4 sensitive taxa. These scores are similar to averages of the other major subwatersheds of Burt Lake. However, more data is needed to accurately summarize the biological health of streams in the Watershed.

Water Quality of the Sturgeon River Watershed

Lakes

Lakes of the Sturgeon River Watershed have been monitored at 13 sites by the HDNWM, MDEQ, TOMWC, USGS, and Lakeshore Environmental. The monitored lakes are Silver, Wildwood, Pickerel (Otsego), Thumb, and Huffman. Data for specific parameters is summarized below.

Alkalinity, Hardness, and pH

Alkalinity, hardness, and pH data for lakes of the Sturgeon River Watershed indicate the water contains relatively high amounts of calcium carbonate, which makes it moderately alkaline with a high buffering capacity (i.e. acid neutralizing), and hard water. Alkalinity data from the MDEQ, USGS, and Lakeshore Environmental for 36 samples have an average of 124.1 mg/L $CaCO3$, with a standard deviation of 21.9 mg/L $CaCO3$. No measurements are below the EPA recommended minimum value of 20 mg/L $CaCO3$. Four hardness measurements from the MDEQ have an average of 137.5 mg/L $CaCO3$, with a standard deviation of 18.9 mg/L $CaCO3$, indicating hard water. pH data from the MDEQ, TOMWC, USGS, and Lakeshore Environmental for 386 samples have an average of 7.9, with a standard deviation of 0.5. Seven of 247 pH measurements of Thumb Lake are outside the MDEQ standard of 6.5 to 9.0. All of these seven measurements are between 9.0 and 9.5, which is more alkaline than the standard.

Conductivity and Chloride

Specific conductance and chloride data for lakes of the Sturgeon River Watershed indicate that the lakes have similar amounts of chloride and dissolved particles as other lakes of the region. Data is available for Huffman, Pickerel (Otsego), Silver, Thumb, and Wildwood Lakes. Specific conductance data from MDEQ, TOMWC, USGS, and Lakeshore Environmental for 370 samples have an average of 236.2 µS/cm, with a standard deviation of 44.0 µS/cm. Chloride data from MDEQ, TOMWC, and USGS for 97 samples have an average of 4.2 mg/L, with a standard deviation of 3.3 mg/L. No chloride measurements approach the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

Dissolved Oxygen

Dissolved oxygen data for lakes of the Sturgeon River Watershed indicate the water contains ample dissolved oxygen for coldwater aquatic life, though can experience low-oxygen conditions in the hypolimnion (depths of the lake beneath the thermocline) during stratification. This data is available for Huffman, Pickerel

(Otsego), Silver, Thumb, and Wildwood Lakes. Dissolved oxygen data from MDEQ, TOMWC, USGS, and Lakeshore Environmental for 384 measurements have an average of 7.9 mg/L, with a standard deviation of 3.5 mg/L. 104 of these measurements are below the coldwater standard of 7 mg/L and are described in more detail below.

Five of 37 dissolved oxygen measurements for Huffman Lake are below the 7 mg/L coldwater standard, though none are below the warmwater standard of 5 mg/L. Six of 38 measurements for Pickerel Lake (Otsego) are below 7 mg/L, while four are below 5 mg/L. However, all four of these measurements are near the bottom of the lake at greater than 25' depth, so not necessarily indicative of impairment. 13 of 48 measurements for Silver Lake are below the coldwater standard of 7 mg/L, six of which are also below 5 mg/L. However, all these six are near the bottom of the lake at greater than 70 feet depth. 79 of 245 measurements for Thumb Lake are below 7 mg/L, while 69 of these are also below 5 mg/L. However, none of these measurements below 7 mg/L are within 20 feet of the surface, and 49 of them are at depths 50 feet or greater. The low measurements in these lakes are likely due to reduced oxygen in the hypolimnion due to limited replenishment with waters near the surface.

Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen data for lakes in the Sturgeon River Watershed indicate the water is phosphorus limited, but slightly above EPA reference conditions. Data is available for Huffman, Pickerel (Otsego), Silver, Thumb, and Wildwood Lakes. Total phosphorus data from MDEQ, TOMWC, and USGS have an average of 12.6 µg/L, with a standard deviation of 13.0 µg/L. This is slightly above the EPA reference condition of 9.69 µg/L. Total nitrogen data from the same monitors have an average of 495.8 µg/L, with a standard deviation of 339.5 µg/L. This is slightly above the EPA reference condition of 400 µg/L. Nitrate nitrogen data from the same monitors have an average of 78.6 µgN/L, with a standard deviation of 100.9 µg/L. Although there is no MDEQ numerical standard for surface water, none of these measurements are anywhere near exceedance of the drinking water standard of 10,000 µgN/L.

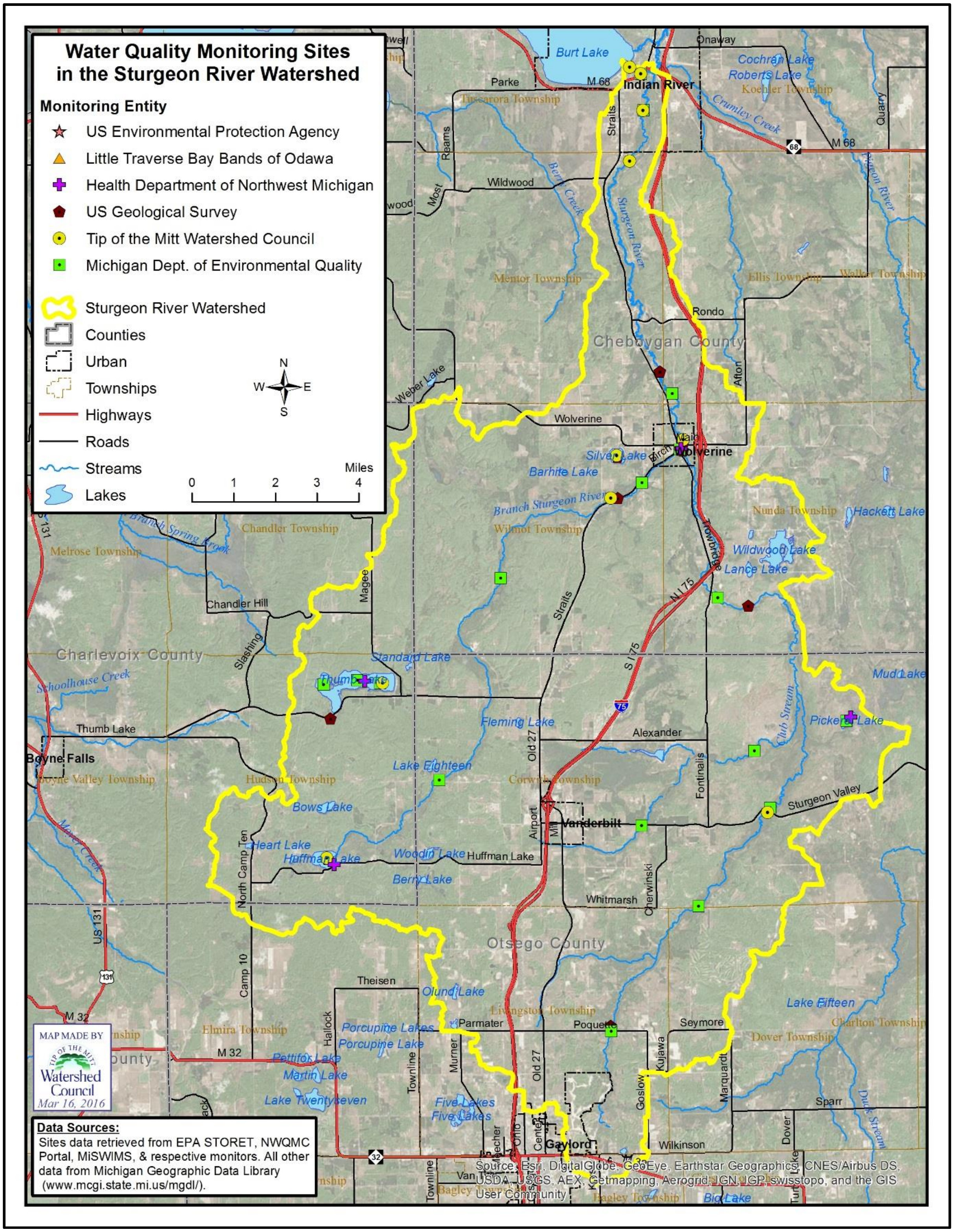


Figure 62: Sturgeon River Watershed water quality monitoring sites

Water Clarity and Trophic Conditions

Water clarity and chlorophyll-a data for lakes in the Sturgeon River Watershed indicate the lakes vary from oligotrophy (low productivity) to mesotrophy (moderate productivity). Water clarity data from MDEQ, TOMWC, and USGS have an average of 18.1 feet, with a standard deviation of 9.4 feet. Pickerel Lake (Otsego), Silver Lake, and Thumb Lake fit into the oligotrophic category with average Secchi depths of 15.1, 27.0, and 19.4 feet. Huffman Lake is mesotrophic with average Secchi depths of 7.0 feet, though borders on eutrophy (high productivity). Chlorophyll-a data from the same monitors have an average of 1.0 µg/L, with a standard deviation of 1.2 µg/L, typical for oligotrophic lakes.

Bacteriological Monitoring

Bacteriological monitoring data for lakes of the Sturgeon River Watershed have no instances when the water wasn't suitable for total body contact. This data is available for Huffman, Pickerel (Otsego), and Thumb Lakes. 158 samples have an average of 5.9 *E. coli*/ 100mL, with a standard deviation of 15.8 *E. coli*/ 100mL. The MDEQ standard of 300 *E. coli*/ 100mL has not been exceeded.

Streams

Water quality of streams of the Surgeon River Watershed has been monitored at 21 sites. The monitored streams are the Sturgeon River, Sturgeon River West Branch, and Club Stream. Monitors include the HDNWM, MDEQ, TOMWC, and USGS. Data for specific parameters is summarized below.

Alkalinity, Hardness, and pH

Alkalinity, hardness, and pH data for streams of the Sturgeon River Watershed indicate the water contains relatively high amounts of calcium carbonate (CaCO3), which makes it moderately alkaline with a high buffering capacity (i.e. acid neutralizing), and very hard water. These data are available for the Sturgeon River, Sturgeon River West Branch, and Club Stream. Alkalinity data from the MDEQ and USGS for 33 samples have an average of 182.1 mg/L CaCO3, with a standard deviation of 16.4 µg/L CaCO3. No alkalinity measurements are below the EPA recommended minimum value of 20 mg/L CaCO3. Hardness data from the MDEQ for 22 samples have an average of 194.9 mg/L CaCO3, with a standard deviation of 8.0 mg/L CaCO3. Nearly all of these measurements are above 180 mg/L CaCO3, indicating streams of the Watershed have very hard water. pH data from MDEQ, TOMWC, and USGS for 77 measurements have an average of 8.1, with a standard deviation of 0.4. No pH measurements are outside the MDEQ standard of 6.5 to 9.0.

Conductivity and Chloride

Specific conductance and chloride data for streams of the Sturgeon River Watershed indicate that the streams have similar amounts of chloride and dissolved particles as other streams in the region. Data is available for the Sturgeon River, Sturgeon River West Branch, and Club Stream. Specific conductance data from MDEQ, TOMWC, and USGS for 78 measurements have an average of 385.7 µS/cm, with a standard deviation of 78.6 µS/cm. Chloride data from the same monitors for 58 samples have an average of 7.9 mg/L, with a standard deviation of 5.8 mg/L. No chloride measurements approach the MDEQ standard of 125 mg/L for waters designated as a public water supply source.

Dissolved Oxygen
Dissolved oxygen data for streams of the Sturgeon River Watershed indicate the streams have high dissolved oxygen to support coldwater aquatic life. Data is available for the Sturgeon River and Sturgeon River West Branch. Dissolved oxygen data from MDEQ and TOMWC for 45 measurements have an average of 11.1 mg/L, with a standard deviation of 1.5 mg/L. No measurements are below the MDEQ coldwater standard of 7.0 mg/L.

Nutrients: Phosphorus and Nitrogen
Phosphorus and nitrogen data for streams in the Sturgeon River Watershed indicate the water is phosphorus limited and has similar or lesser nutrient concentrations as EPA reference conditions. Data is available for the Sturgeon River, Sturgeon River West Branch, and Club Stream. Total Phosphorus data from MDEQ and TOMWC for 43 samples have an average of 9.1 mg/L, with a standard deviation of 5.7 mg/L. This is slightly lower than the EPA reference condition of 12 µg/L for streams in the region. Total nitrogen data from the same monitors for 35 samples have an average of 476.6 µg/L, with a standard deviation of 492.6 µg/L. This is similar to the EPA reference condition of 440 µg/L for streams in the region. Nitrate nitrogen data from MDEQ, TOMWC, and USGS for 25 samples have an average of 211.9 µgN/L, with a standard deviation of 109.3 µgN/L. Although there is no MDEQ numerical standard for surface water, none of these nitrate measurements approach the drinking water standard of 10,000 µgN/L.

Biological Monitoring
Macroinvertebrate communities of streams have been monitored at 17 sites by MDEQ and TOMWC, with a total of 56 samples. These sites have an average of 24 total taxa, 12 EPT taxa, and 7 sensitive taxa. This data indicates the Sturgeon River Watershed supports very diverse, healthy macroinvertebrate communities at all sites monitored.

Bacteriological Monitoring
Limited bacteriological monitoring data is available for streams of the Sturgeon River Watershed. Four samples by HDNWM on the Sturgeon River West Branch have an

average of 55.8 *E. coli*/ 100 mL, with a standard deviation of 64.2 *E. coli*/ 100 mL. The MDEQ standard of 300 *E. coli*/ 100mL has not been exceeded.

Figure 63: Giant Stonefly (*Pteronarcyidae*) found in the Sturgeon River

Comparison of Water Quality of Large Tributaries and Burt Lake

The Burt Lake Tributaries Monitoring Project monitored pollutant concentrations and loads near the mouths of eight tributaries of Burt Lake in 2014 and 2015. Dissolved oxygen, temperature, specific conductance, and pH were also monitored. Each site was monitored twice during each spring and fall, for a total of eight monitoring events, capturing both wet event and dry conditions. Sample sites included the mouth of the Crooked River; the Maple River at Brutus Road; Maple Bay Creek at the end of Maple Bay Road; near the mouth of an Unnamed Creek at 3016 West Burt Lake Road; Carp Creek near the mouth; White Goose Creek near the mouth; the Sturgeon River at the mouth; and Hasler Creek at Ellinger Road (Figure 119).

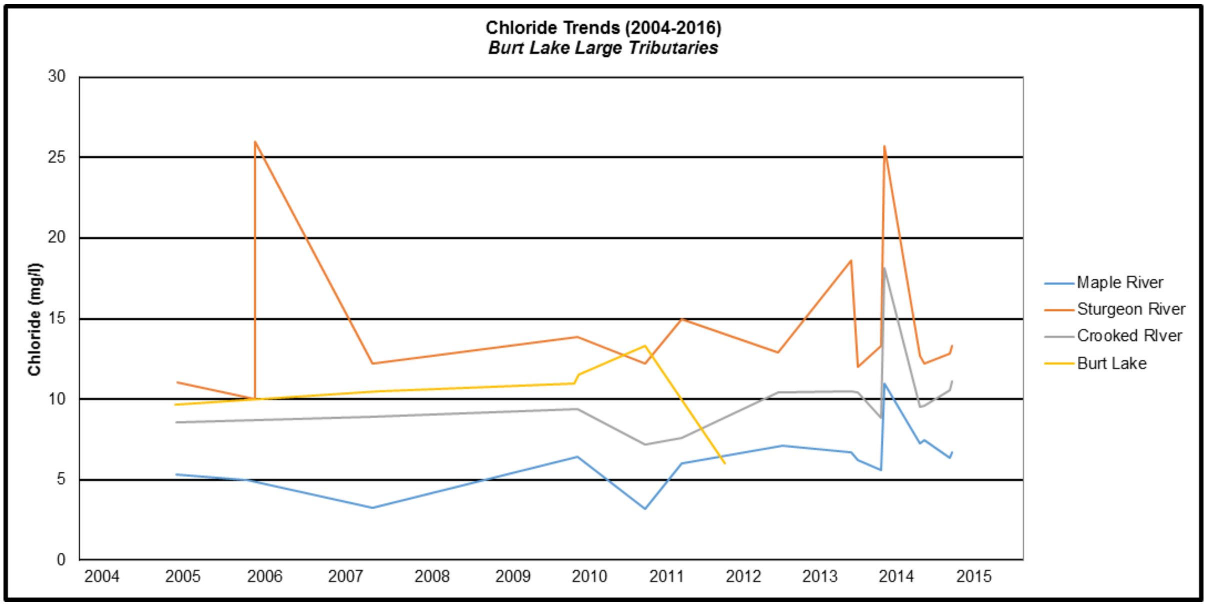


Figure 64: Burt Lake Watershed large tributaries: chloride trends

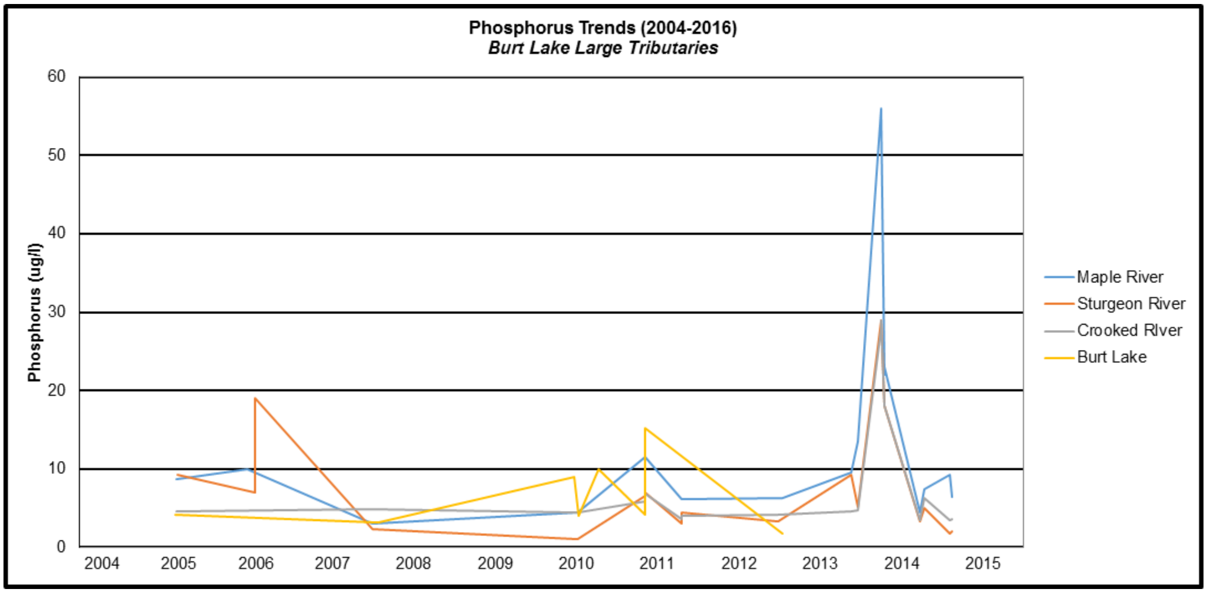


Figure 65: Burt Lake Watershed large tributaries: total phosphorus trends

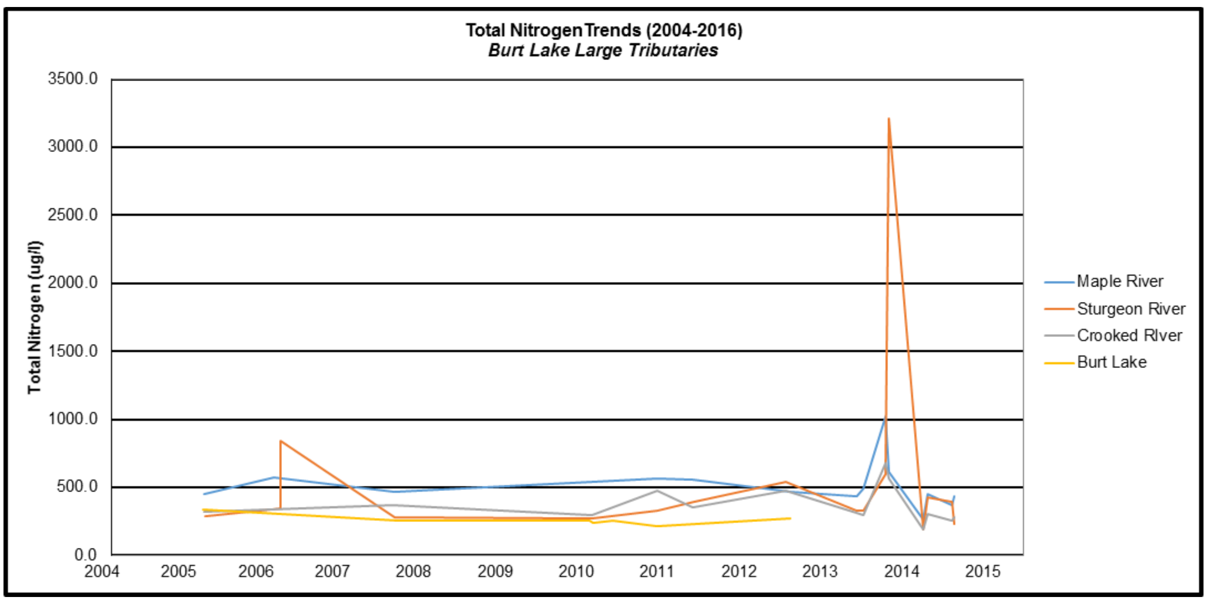


Figure 66: Burt Lake Watershed large tributaries: total nitrogen trends

Chloride Concentrations (mg/l)	2014				2015				Average
Sample Site	May	Jun	Oct	Nov	May	Jun	Oct	Nov	
Crooked River, Mouth	10.5	10.4	8.8	18.1	9.5	9.6	10.6	11.1	11.1
Maple River, Brutus Rd	6.7	6.2	5.6	11.0	7.3	7.5	6.4	6.7	7.2
Sturgeon River, Mouth	18.6	12.0	13.3	25.7	12.7	12.2	12.8	13.3	15.1

Figure 67: Burt Lake Watershed major tributaries (2014/2015): chloride concentrations

Dissolved Oxygen (mg/l)	2014				2015				Average
Sample Site	May	Jun	Oct	Nov	May	Jun	Oct	Nov	
Crooked River, Mouth	9.92	8.53	10.28	11.09	8.82	8.92	8.40	9.55	9.4
Maple River, Brutus Rd	9.40	9.27	10.71	11.48	9.56	8.56	10.06	9.81	9.9
Sturgeon River, Mouth	10.62	9.87	12.06	13.69	9.68	9.98	9.11	10.02	10.6

Figure 68: Burt Lake Watershed major tributaries (2014/2015): dissolved oxygen

Total Phosphorus Concentrations (µg/l)	2014				2015				Average
Sample Site	May	Jun	Oct	Nov	May	Jun	Oct	Nov	
Crooked River, Mouth	4.6	4.7	29.0	18.0	3.4	6.3	3.5	3.6	9.1
Maple River, Brutus Rd	9.6	13.5	56.0	22.0	4.4	7.4	9.2	6.5	16.1
Sturgeon River, Mouth	9.2	5.1	29.0	18.0	3.3	5.0	1.8	2.1	9.2

Figure 69: Burt Lake Watershed major tributaries (2014/2015): total phosphorus

Total Nitrogen Concentrations (µg/l)	2014				2015				Average
Sample Site	May	Jun	Oct	Nov	May	Jun	Oct	Nov	
Crooked River, Mouth	316	293	682	567	191	302	258	277	361
Maple River, Brutus Rd	438	489	1025	615	268	455	369	432	511
Sturgeon River, Mouth	327	332	596	3214	188	429	398	229	714

Figure 70: Burt Lake Watershed major tributaries (2014/2015): total nitrogen

CHAPTER 4

Resource Inventories of the Burt Lake Watershed

Land Cover

Evaluation of nonpoint source (NPS) pollutants generated by the various land cover types within the Burt Lake Watershed was carried out using Purdue University's Long Term Hydrologic Impact Analysis (L-THIA) tool. L-THIA estimates changes in recharge, runoff, and nonpoint source pollution resulting from past or proposed development. L-THIA is useful for determining impacts of overland runoff within a watershed to the receiving waters. Historic precipitation data for the Watershed's counties, soil permeability and land use types, as well as event mean concentration (EMC) pollution coefficients are used by the model to predict NPS loadings at the outlet of a watershed. Although originally intended to evaluate smaller, urban watersheds, L-THIA utilizes key soil permeability properties that benefit an analysis for larger rural watersheds. This means that L-THIA takes into account rain "soaking in" to the ground, failing to create runoff, and yielding less NPS pollution.

NPS loadings results for the following land cover types are calculated: forest, agricultural, grass/pasture, residential, and commercial (Table 12). This is useful for identifying the largest contributors of nonpoint source pollutants within the Watershed. Annual loads are calculated for the following pollutants: phosphorus, nitrogen, suspended solids, lead, copper, zinc, and oil/grease. Biological Oxygen Demand (BOD) and Fecal Coliform are also calculated. Table 12 highlights the pollutants of most concern within the Burt Lake Watershed.

Table 12: Total pollutant loading for the Burt Lake Watershed (L-THIA): pounds per year

	Nitrogen*	**Phosphorus***	**Suspended Solids***	**BOD***	**Oil and Grease***	**Fecal Coliform (million CFU / Year)**
Sturgeon	12159	3134	256810	52596	4676	346991
Maple	31340	9048	741189	44941	1181	850203
Crooked	11831	3268	264505	32118	1533	333099
Burt Lake Direct	4027	1039	85773	17427	1593	115275
Total	59357	16489	1348277	147082	8983	1645568

**lbs/year*

Table 13: Total pollutant loading for the Burt Lake Watershed (L-THIA): pounds per acre

	Nitrogen*	**Phosphorus***	**Suspended Solids***	**BOD***	**Oil and Grease***	**Fecal Coliform (million CFU / Year)**
Sturgeon	0.097	0.025	2.038	0.433	0.037	2.754
Maple	0.291	0.084	6.887	0.418	0.011	7.900
Crooked	0.122	0.034	2.717	0.330	0.016	3.422
Burt Lake Direct	0.100	0.026	2.132	0.433	0.040	2.866
Total	0.160	0.044	3.632	0.396	0.024	4.433

**lbs/acre*

Interestingly, the model's results show the Maple River Watershed with the greatest pollutant loading for nitrogen, phosphorus, suspended solids, and fecal coliform. This is likely due to a combination of the Watershed's comparatively significant amount of agriculture and wetlands, as well as soil types. Furthermore, agriculture within the Watershed tends to be in areas where soils have lower infiltration rates. With less potential for infiltration, farm runoff is more readily created from rain events, with the potential to carry fertilizer, manure, or other organic material into a nearby water body. Sediment is another pollutant associated with agriculture. Suspended solids loads from agricultural land cover were also disproportionately high, likely due to the reasons described above.

Table 14: Total Nitrogen Loading by land cover type (L-THIA)

L-THIA Modeled Total Nitrogen Loading (lbs/year)				
Land Cover	Sturgeon River Watershed	Maple River Watershed	Crooked River Watershed	Burt Lake Direct Drainage
Residential	2,813	1,264	1,640	918
Commercial	303	0	0	108
Forest	1,373	519	576	451
Grass/Pasture	342	303	315	99
Agriculture	7,328	29,254	9,300	2,451
Total	12,159	31,340	11,831	4,027

Table 15: Total Phosphorus Loading by land cover type (L-THIA)

L-THIA Modeled Total Phosphorus Loading (lbs/year)				
Land Cover	Sturgeon River Watershed	Maple River Watershed	Crooked River Watershed	Burt Lake Direct Drainage
Residential	878	394	512	286
Commercial	72	0	0	24
Forest	17	7	7	5
Grass/Pasture	4	4	3	1
Agriculture	2,163	8,643	2,746	723
Total	3,134	9,048	3,268	1,039

Table 16: Total Suspended Solids Loading by land cover type (L-THIA)

L-THIA Modeled Total Suspended Solids Loading (lbs/year)				
Land Cover	Sturgeon River Watershed	Maple River Watershed	Crooked River Watershed	Burt Lake Direct Drainage
Residential	63,472	28,559	37,028	20,785
Commercial	12,638	0	0	4,535
Forest	1,961	742	824	645
Grass/Pasture	488	433	451	142
Agriculture	178,251	711,455	226,202	59,666
Total	256,810	741,189	264,505	85,773

Table 17: Total Fecal Coliform Loading by land cover type (L-THIA)

L-THIA Modeled Total Fecal Coliform (million cfu / year)				
Land Cover	Sturgeon River Watershed	Maple River Watershed	Crooked River Watershed	Burt Lake Direct Drainage
Residential	140,745	63,331	82,101	46,094
Commercial	7,141	0	0	2,562
Forest	1,782	673	748	587
Grass/Pasture	444	394	410	130
Agriculture	196,879	785,805	249,840	65,902
Total	346,991	850,203	333,099	115,275

Table 18: Biological Oxygen Demand by land cover type (L-THIA)

L-THIA Modeled Total Biological Oxygen Demand (lbs/year)				
Land Cover	Sturgeon River Watershed	Maple River Watershed	Crooked River Watershed	Burt Lake Direct Drainage
Residential	39,476	17,761	23,027	12,928
Commercial	5,236	0	0	1,878
Forest	980	370	412	322
Grass/Pasture	243	215	225	70
Agriculture	6,661	26,595	8,454	2,229
Total	52,596	44,941	32,118	17,427

Stormwater

Stormwater runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not infiltrate into the ground. As the runoff flows over the land or impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates pollutants that can adversely affect water quality if the runoff is discharged untreated. Nutrients used in fertilizers applied to lawns and gardens, pet waste, and sediments from soil particles that are washed away from bare spots in lawns and gardens, roadways, and other areas of exposed soils are just a few examples of nonpoint source pollutants.

Stormwater runoff occurs naturally, but increases as a result of landscape development and urbanization. As forests, grasslands, wetlands, and pastures are replaced by impervious surfaces such as streets, roofs, sidewalks, and parking lots, the amount of stormwater runoff generated by a storm event increases dramatically. The negative effects of stormwater runoff on aquatic ecosystems have been well documented. Increased stormwater runoff alters the natural flow regime of streams by scouring stream banks and streambeds, increasing sedimentation, and reducing water quality and aquatic habitat for fish, aquatic insects, and other aquatic organisms. In addition, stormwater carries many harmful substances found in urban areas, such as bacteria from pet and animal wastes, fertilizers, oil, grease, deicing road salts, sediments, heavy metals, and pesticides, which wash into receiving water bodies.

The Burt Lake Watershed contains seven urban areas where stormwater runoff potentially degrades the water quality and aquatic habitat of receiving water bodies. Developed areas of Alanson, Pellston, Indian River, Gaylord, Vanderbilt, and Wolverine lie within the Burt Lake Watershed. The commercial corridor of US 31 just east of Petoskey is also of concern. Many of these urban areas possess paved streets with curbs, gutters, and subsurface drainage pipes called storm sewers. These storm sewers prevent flooding and water damage within the urban areas, but also have the potential to negatively impact local surface water resources.

As part of the Burt Lake Watershed Management Plan, Watershed Council staff conducted inventories in 2014 and 2015 of storm sewer systems in each of the seven urban areas in the Watershed. The inventories involved review of storm sewer maps provided by local and state governments, delineating different drainage catchment areas, and identifying locations of stormwater inlets and outlets. This approach essentially delineates "urban watersheds," each contributing flow to an outlet at the lowest elevation point in the system, often near lakes, streams, or wetlands. Occasionally, a stormwater basin will not contribute stormwater to surface waters – rainfall simply soaks into the ground. For this reason, low-density development in pervious soils often have no stormwater management as there is no need. In runoff-producing systems, retention basins, bio-swales, and rain gardens are human designed depressions that collect stormwater and encourage infiltration. Basins that outlet to such structures are considered "internal infiltration" and do not contribute pollutants to surface waters. Wetlands also have the ability to filter pollutants from runoff, and stormwater systems that outlet to wetlands are generally considered less impactful than those that outlet to lakes, rivers, or streams.

Inventory data for each basin consisted of basin area, percentage impervious surface, average yearly rainfall, and retention status of effluent. This data was entered into an empirical model to predict pollutant loadings in each urban area for four major pollutants: sediment, nutrients, metals, and bacteria. These predicted loadings can be used to prioritize basins for stormwater BMP installation.

Alanson

Alanson was found to have 12 major stormwater basins, most of which outlet to the Crooked River (Figure 71). Large areas in the northern residential portion of the Village have no stormwater management, and one area, the fire station, was found to have an infiltration basin (Figure 72). Towards the southern portion of the Village, dense commercial development is serviced by stormwater infrastructure. US 31 was found to have curbs and gutters that contribute to an MDOT installed stormwater culvert. This system catches runoff from the adjacent hillside and highly impervious commercial corridor, outletting to a ditch at the end of East Street. The ditch conveys polluted water directly to the Crooked River. Recent contamination of this stormwater system has helped to highlight the system's efficient conveyance of pollutants to the River. A tanker-truck spill of cooking oil in 2012 sent hundreds of gallons of used cooking oil down the storm drains and into the Crooked River (Figure 73). In 2014, a white substance (allegedly white paint) was introduced into the system and flowed out the East Street ditch into the River (Figure 74). The US 31 / East Street stormwater basin was modeled to contribute 7.28 pounds of lead, 37.31 pounds of phosphorus, and 286.96 pounds of nitrogen to the Crooked River annually. The model also indicates that over 7800 pounds of sediment flush into the Crooked River every year at this location.

Other stormwater basins within the village of Alanson outlet to the Crooked River. A larger L-shaped ditch can be found just south of the East Street ditch. This ditch receives runoff from the surrounding downtown parking lots and post office facility. Further south, stormwater runs down River Street, first in gutters, then in underground pipes, and outlets at sub-surface outfalls in the Crooked River, near the Village's famed swing-bridge.

McPhee Creek also receives stormwater runoff from adjacent developed areas, most notably from the gas station on the Creek's northern bank.

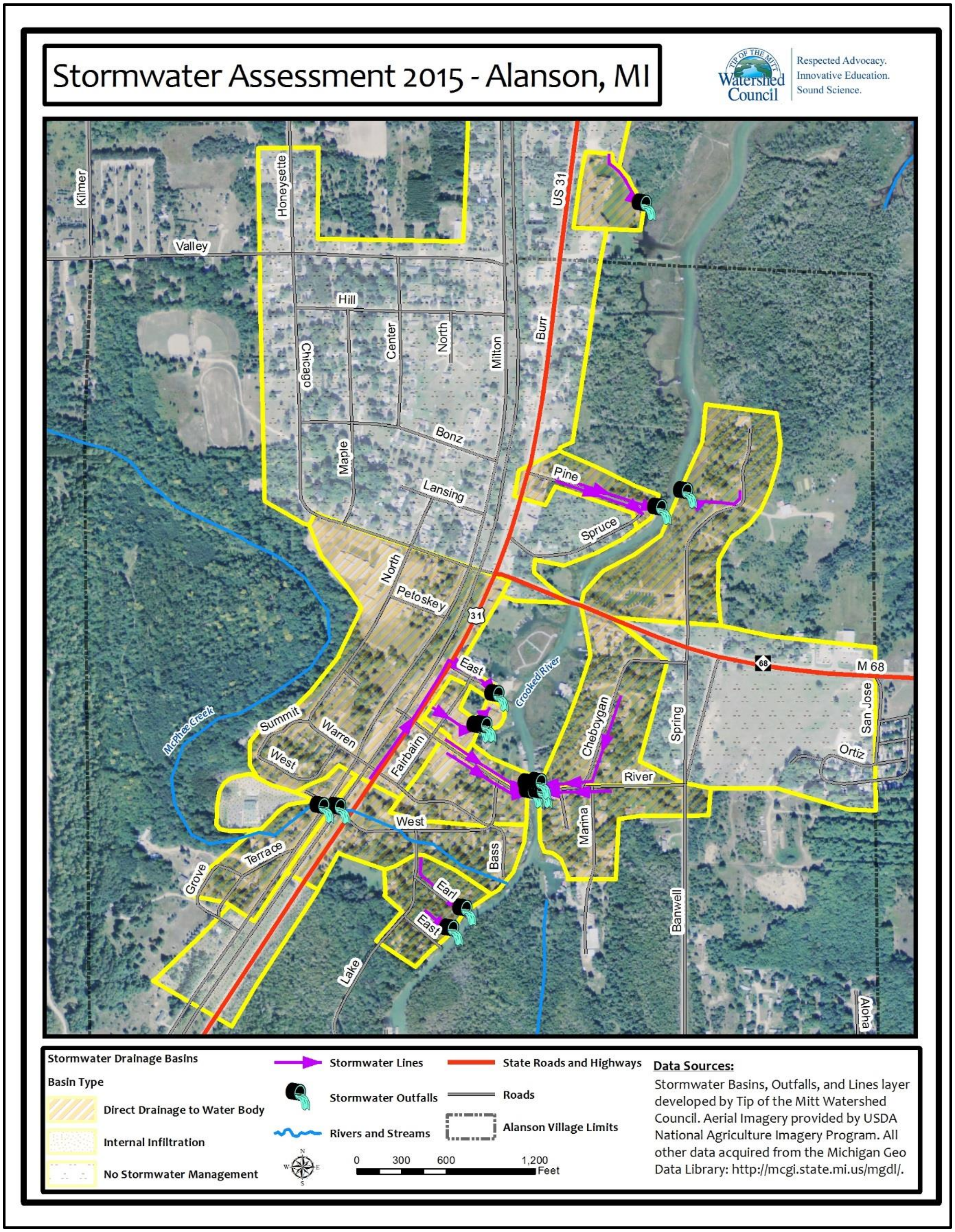


Figure 71: Stormwater Assessment-Alanson

Figure 72: An infiltration basin at the Alanson Fire Station development (TOMWC)

Figure 73: Cooking oil spill on Crooked River in Alanson (TOMWC)

Figure 74: Illicit substance discharged from the East St. outfall in Alanson (TOMWC)

Indian River

Indian River, although situated on the shoreline of Burt Lake, is only partially within the Watershed. Five stormwater basins deliver urban runoff to either the Sturgeon River or Burt Lake itself, while 12 basins deliver runoff to the Indian River as it flows out of Burt Lake. These 12 basins are not within the Burt Lake Watershed. The largest stormwater basin of Indian River, primarily residential, outlets to a channel between Holden and Burchfield Streets. MDOT stormwater culverts provide drainage for M-68 within the vicinity of the Sturgeon River, discharging to the River at the M-68 bridge on the south side of town. This stormwater basin was modeled to contribute more pollutants than other Indian River basins at 12.94 pounds of phosphorus, 99.58 pounds of nitrogen, 2.52 pounds of lead, and 2713.42 pounds of sediment, annually. Nearby commercial areas drain straight east, out of the Watershed, and into a channel that eventually outlets to the Little Sturgeon River. While these pollutants have negative impacts elsewhere, this is a boon for Burt Lake. Within the village development, over 230 developed acres lie within the Mullett Lake Watershed, whereas roughly 120 developed acres are within the Burt Lake Watershed.

Indian River is known for abundant water, both in surface water and groundwater. Numerous artesian wells flow fourth from within the city, and provide a steady source of clean and cold water to Burt Lake. Along any given section of riverfront, these wells can be seen as steadily flowing pipes, usually 2" to 4" in diameter, constantly discharging clean water. In some situations, these may have the appearance of a stormwater outfall. At times, groundwater may flow into stormwater infrastructure, allowing for continuous flow despite dry conditions.

Ditches are used within the village to move this water, along with stormwater, out of the city. While meeting with local officials, it was made clear that flooding had been a problem in the past, and the best means to mitigate the risk of future flooding is to channel groundwater, along with stormwater, into infrastructure that leads to surface water. Such a situation poses challenges to conventional stormwater BMPs that focus on infiltration of excess water. Much of Indian River sits on muck soils that do not allow for efficient infiltration of runoff.

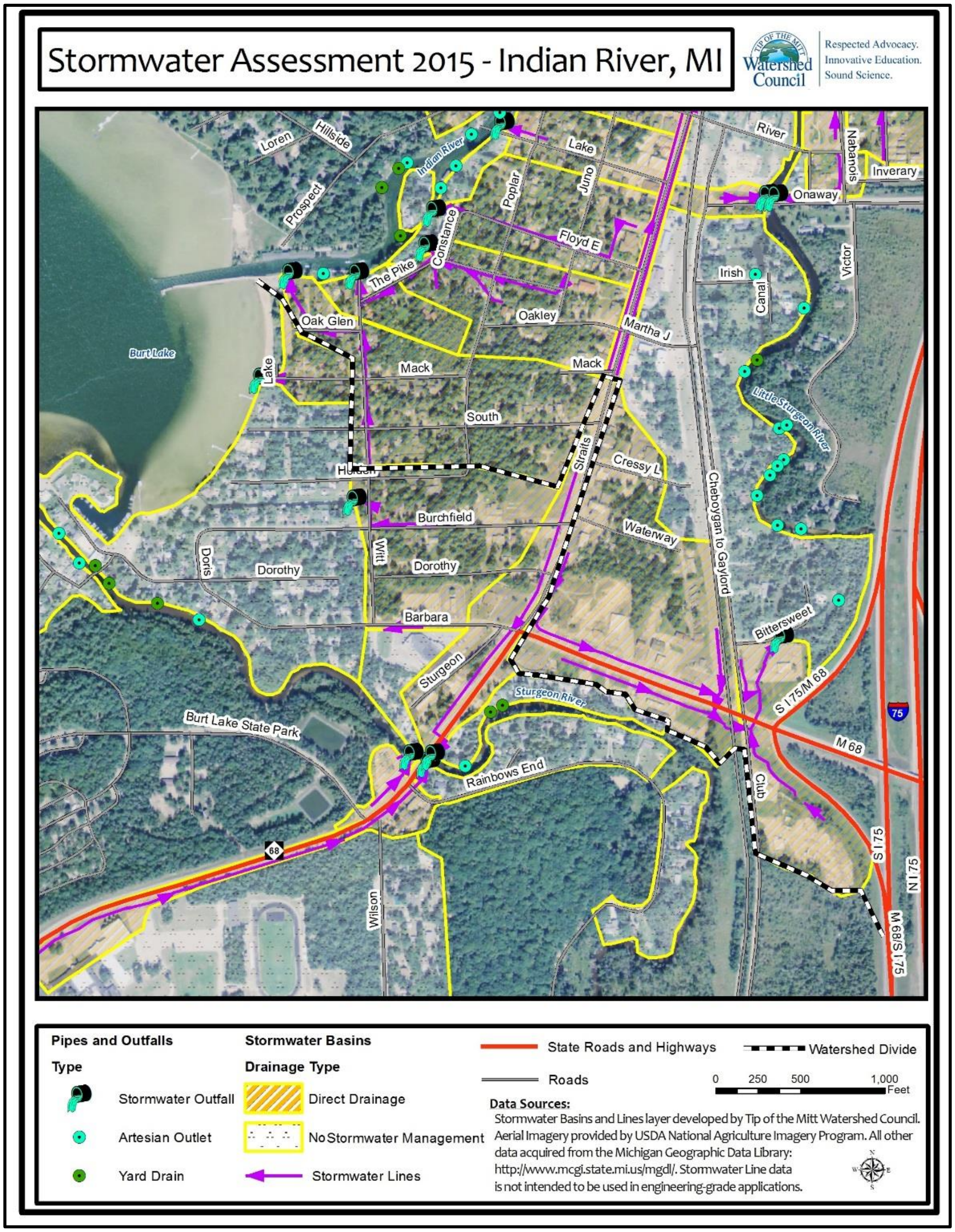


Figure 75: Stormwater Assessment-Indian River

Gaylord

A northern portion of Gaylord is encompassed within the southern fringe of the Sturgeon River Subwatershed. Light industrial development lies west of Old 27, and Livingston Boulevard to the east hosts office buildings, a school, and associated parking lots. Eight individual stormwater basins were identified here. Five of these basins outlet to wetlands, and three of these basins are routed to infiltration swales. No basins within North Gaylord contribute runoff to a lake, river, or stream.

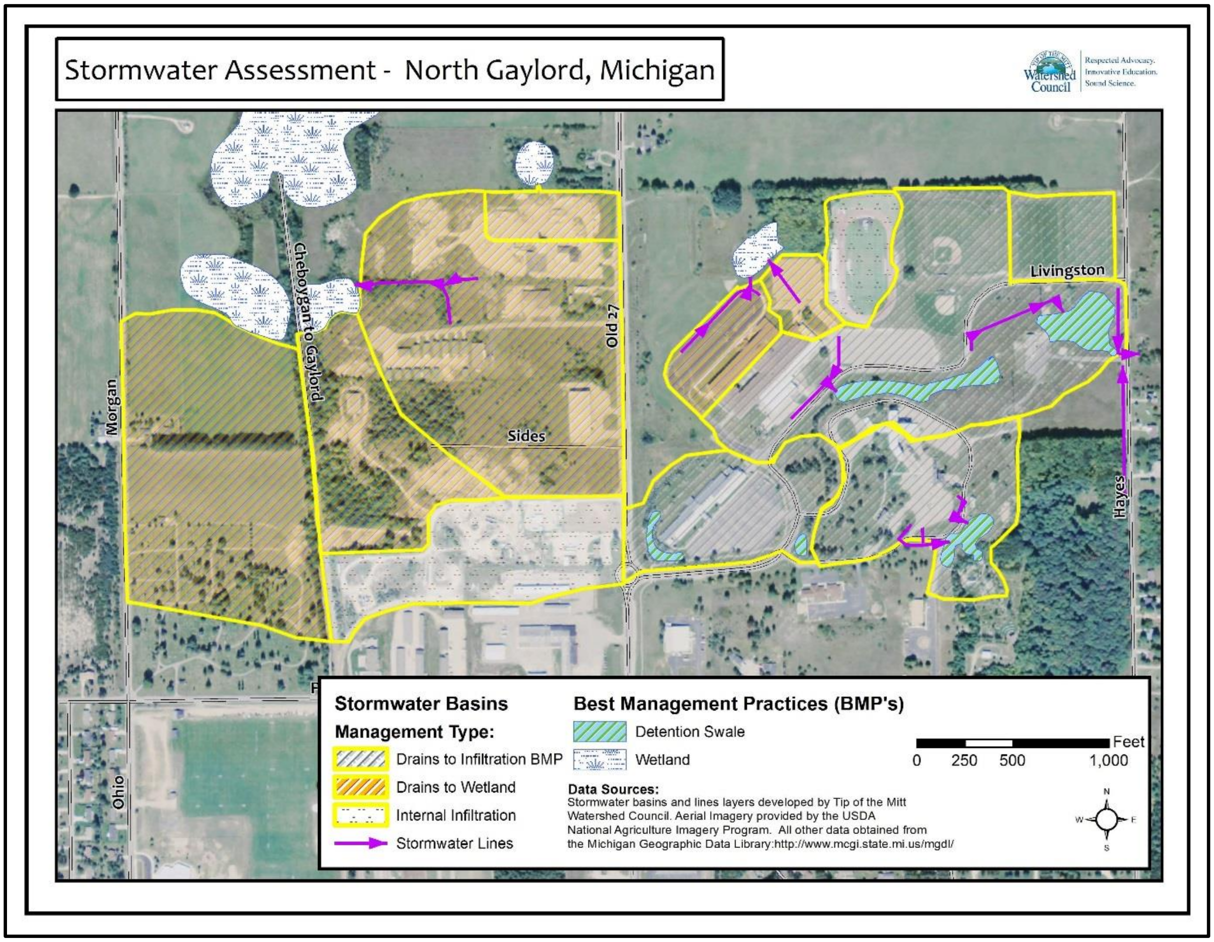


Figure 76: Stormwater Assessment-North Gaylord

Pellston

The Village of Pellston is perched between flat, sandy plains and the Maple River's West Branch. Very little development has occurred in the river valley - most is situated on flat ground nearly a half mile away from the River. The dominant soil type here is Rubicon sand – a soil type known to be highly permeable, allowing rainwater to soak in efficiently. Due to this, and to low density development across much of the Village, no stormwater management is needed. The downtown area is serviced by a curb and gutter system, which flows through M-DOT storm drains southward. These drains open up into roadside depressions on the outskirts of town, allowing rainwater to soak in. The Watershed Council found no evidence of runoff from Pellston entering the Maple River or any other surface waters.

Petoskey (Bear Creek Township, Spring and Mud Lakes)

At the headwaters of the Inland Waterway (Crooked River Subwatershed), the M-119 / US -31 junction is an area of dense commercial development. Four small stormwater basins were identified, all draining to Spring Lake via ditch or pipe. While the drainage area may be small, Spring Lake also has a small watershed – roughly 88 acres. Land cover analysis of this area indicates over 25 acres are developed. Drainage basin delineation shows that 20 acres of developed land directly contributes urban runoff through ditches or pipes. Considering roughly one quarter of the Watershed is developed and hydrologically altered, Spring Lake may be one of the most degraded water bodies in the entire Burt Lake Watershed. Monitoring data supports this claim, with chloride levels averaging 8 – 10 times that found in most Northern Michigan water bodies. A portion of US 31, along with residential development, contributes to a ditch system along Pickerel Lake Road. A culvert then transmits flow to an outfall on the southeast side of Spring Lake. The only detention basin in this area is beside the parking lot of the local hardware store, allowing runoff from 2.25 acres of impervious surface to infiltrate to groundwater, filtering out pollutants in the process. The north side of Spring and Mud Lakes, along M-119, contributes less pollution to the Lakes due to wetland buffers between development and surface water.

Wolverine

While Wolverine has relatively low-density development, steep slopes and close proximity to the Sturgeon River create the potential for stormwater pollution. East of Straits Highway, very little stormwater management infrastructure exists. The largest drainage basin encompasses the majority of Wolverine, draining from south to north along Spruce Street and Straits Highway. This system then merges with a presumably spring fed ditch, flows under Straits Highway, and enters a linear bio-swale between the highway and old railroad grade. This bio-swale is extremely long and likely neutralizes most pollution that enters. The South Side of town contains two basins that outlet to the Sturgeon River's West Branch. The largest, composed of the

Wolverine School and south portion of downtown, drains to ditches along straits highways until a culvert carries water under the highway to a riverside outfall.

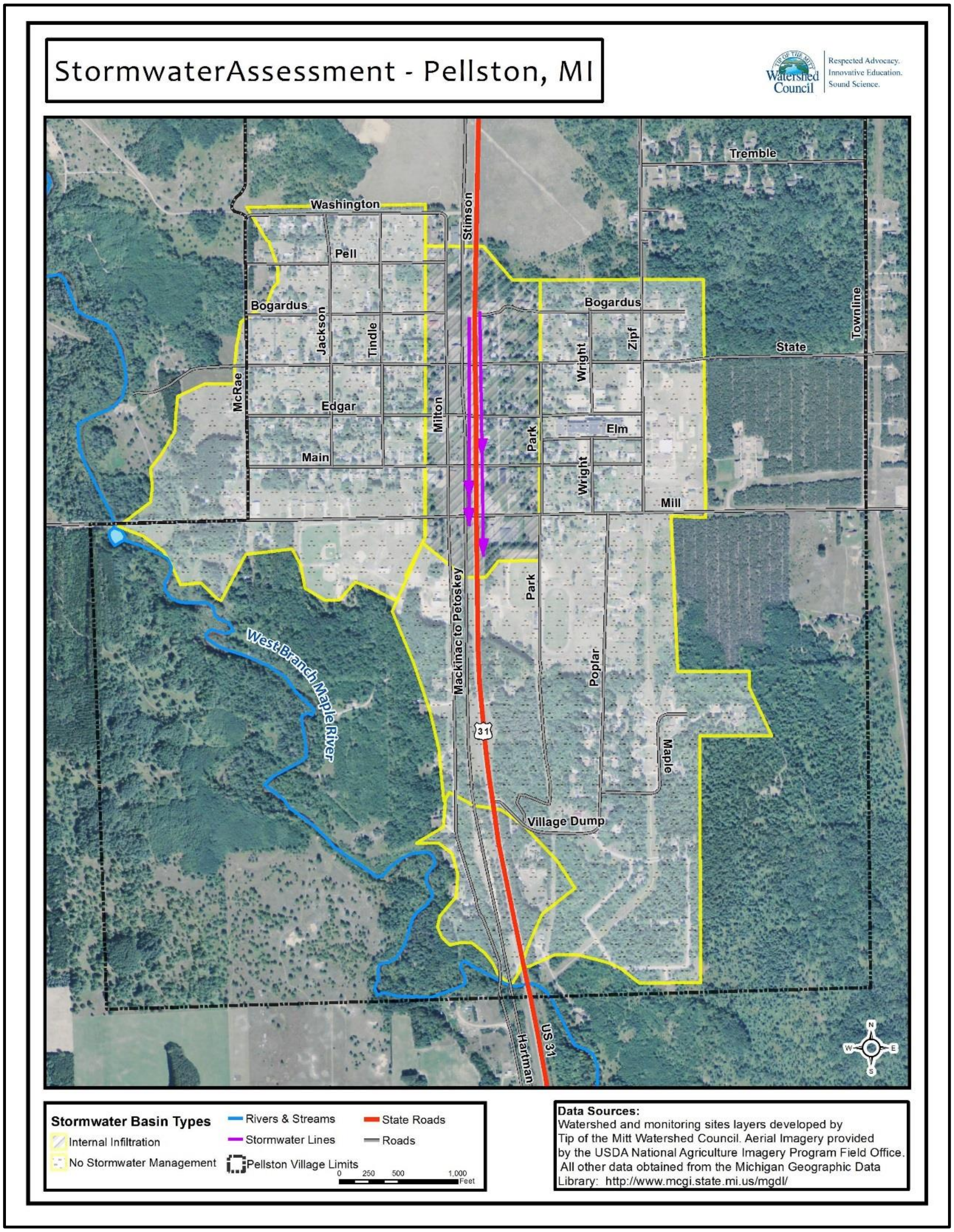


Figure 77: Stormwater Assessment- Pellston

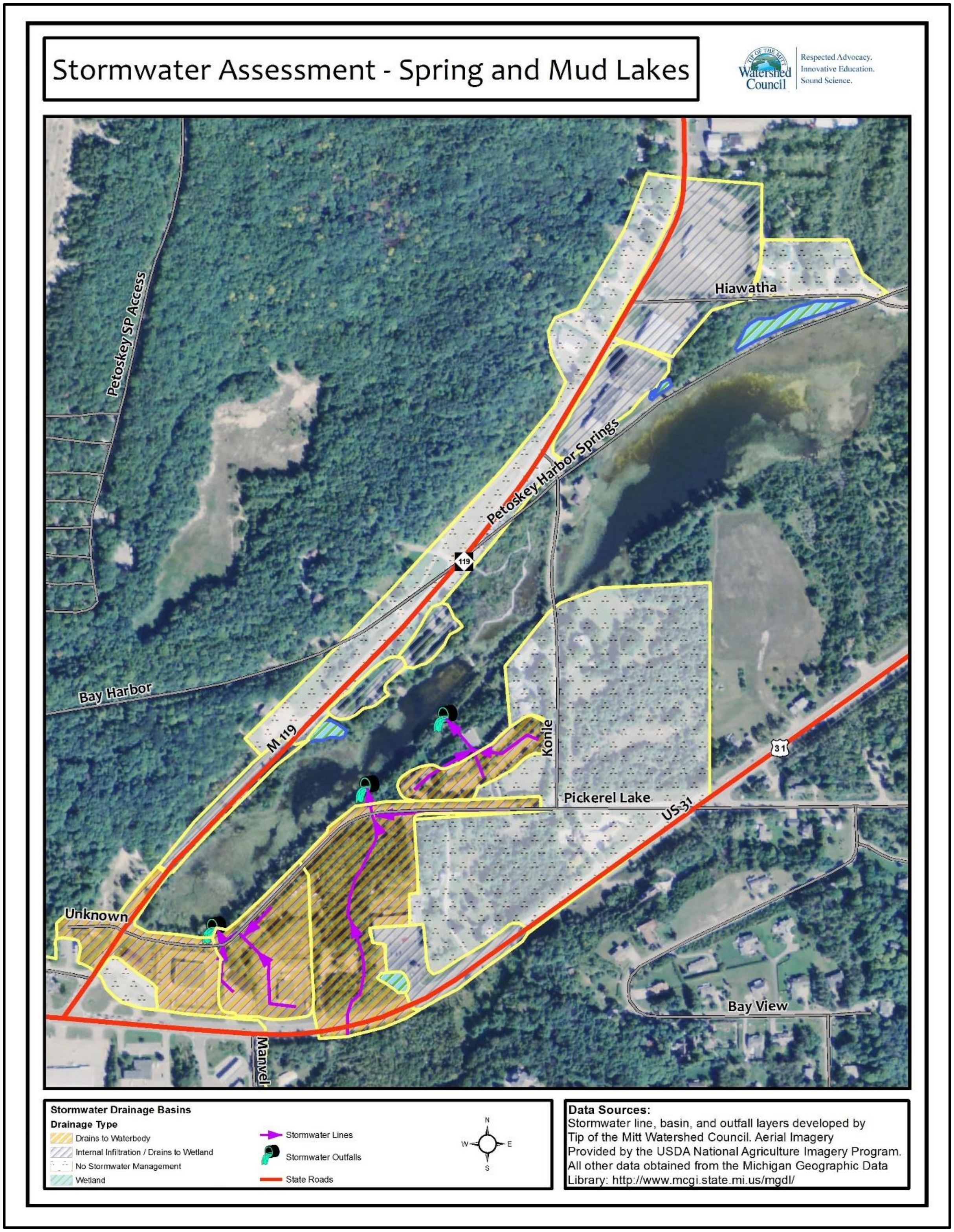


Figure 78: Stormwater Assessment-Spring and Mud Lakes

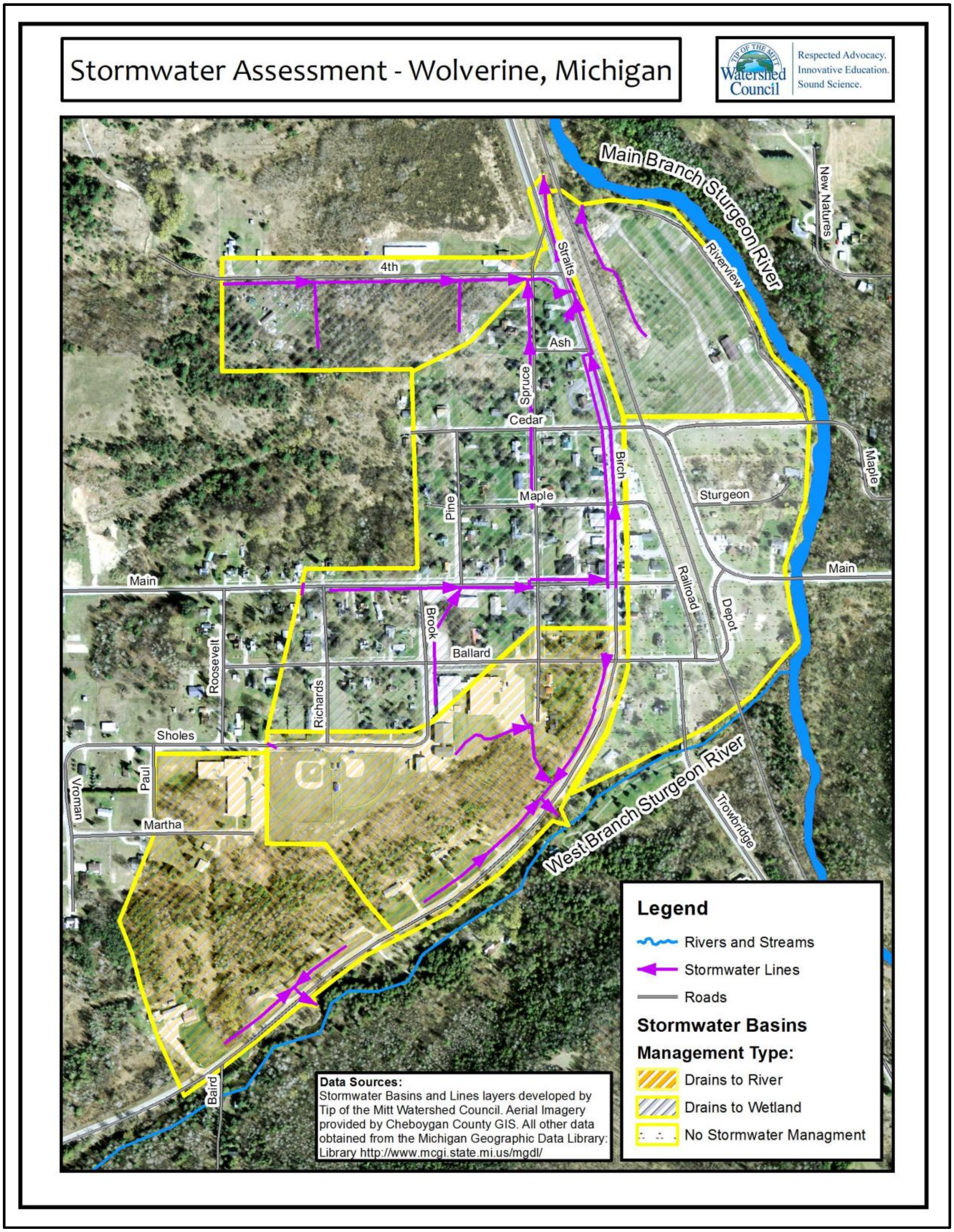


Figure 79: Stormwater Assessment-Wolverine

Vanderbilt

Most of Vanderbilt has no stormwater management. The more densely developed city center does have curb and gutter stormwater infrastructure. These drain to pipes that carry stormwater to the outskirts of town, discharging into grassy swales where it infiltrates and does not reach any surface water.

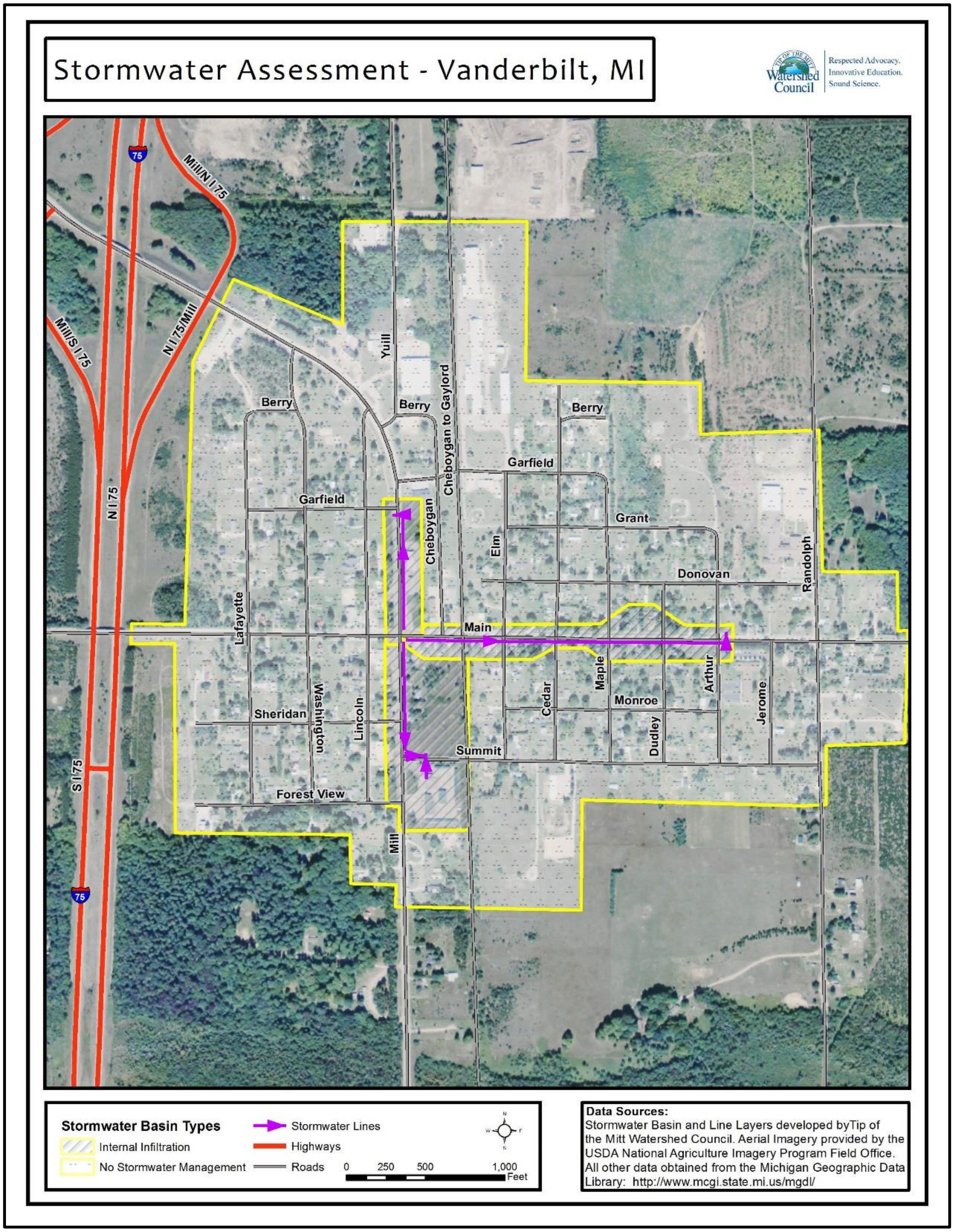


Figure 80: Stormwater Assessment-Vanderbilt

Table 19: Pollutant loading by urban area

Urban Area	Phosphorus Load (lbs/yr)	Nitrogen Load (lbs/yr)	Lead Load (lbs/yr)	Copper Load (lbs/yr)	Sediment Load (lbs/yr)
Spring Lake	16	124	3	<1	3375
Alanson	96	737	19	4	20,095
Indian River	37	290	7	2	7,911
Vanderbilt	0*	0*	0*	0*	0*
Wolverine	29	224	6	1	6,116
N. Gaylord	66	508	13	2.82	13856
Pellston	0*	0*	0*	0*	0*

Shoreline Surveys

Background

Shoreline surveys are an important lake management tool used extensively on lakes in the Northern Lower Peninsula of Michigan. These surveys involve assessing shoreline properties to document conditions or activities that have the potential to affect water quality and the lake ecosystem. Shoreline surveys commonly include an assessment of: *Cladophora* algae growth as a nutrient pollution indicator, erosion, alterations (e.g., seawalls), greenbelts (i.e., shoreline vegetation), emergent aquatic plants, wetlands, and tributary inlets and outlets. Survey results provide the means to carry out follow-up actions that address problems in shoreline areas. Through actions such as on-site consultations, problems in shoreline areas that threaten the water quality can be identified and corrected. These solutions are often simple and low cost, such as regular septic system maintenance, shoreline plantings, proper lawn care practices, and low impact development along the shoreline. Problems in shoreline areas can be prevented by promoting education and awareness of the survey and ecologically friendly approaches to shoreline property management. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends in near-shore nutrient inputs, greenbelts, erosion, and shoreline alterations associated with land-use changes, and for monitoring and assessing the success of remedial actions.

During late May and early June of both 2014 and 2015, Tip of the Mitt Watershed Council completed comprehensive shoreline surveys for each of the following Lakes: Wildwood, Silver, Lance, Huffman, Round, and Douglas Lakes. Data for each Lake is summarized in (Table 20).

Shoreline Development Impacts

Lake shorelines are the critical interface between land and water, where human activity has the greatest potential for degrading water quality. Developing shoreline properties for residential, commercial, or other uses invariably has negative impacts on the lake ecosystem. During the development process, the natural landscape is altered in a variety of ways: vegetation is removed, the terrain is graded, utilities are installed, structures are built, and areas are paved. These changes to the landscape and subsequent human activity in the shoreline area have consequences on the aquatic ecosystem. Nutrients from wastes, contaminants from cars and roads, and eroded soils are among some of the pollutants that reach and negatively impact the lake following shoreline development.

Nutrient pollution can create a recreational nuisance, adversely impact aquatic ecosystems, and lead to conditions that pose a danger to human health. Although nutrients are necessary to sustain a healthy aquatic ecosystem, excess can result in nuisance and potentially harmful algal and aquatic plant growth. Excessive aquatic macrophyte growth (i.e., vascular aquatic plants) and heavy algal blooms that form mats and scum at the lake's surface can become a recreational nuisance. Algal blooms also pose a public health risk as some species produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Furthermore, excess algal and aquatic plant growth can degrade water quality by depleting the ecosystem's dissolved oxygen stores. Decomposition of dead algae and plant material reduces dissolved oxygen supplies due to the aerobic activity of decomposers, which is particularly problematic in the deeper waters of stratified lakes. The problem becomes particularly acute during nighttime respiration, when plants compete with other organisms for a limited oxygen supply.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from riparian (shoreline) areas, and atmospheric deposition. Springs, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter and wetland seepages may discharge nutrients at certain times of the year. Cultural sources include septic and sewer systems, fertilizer application, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural practices, soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, some cultural sources (e.g., malfunctioning septic systems and animal wastes) pose a potential health risk due to exposure to bacteria and viruses.

Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators (a.k.a., bio-indicators). Chemical analyses of water samples can be effective, though costlier and more labor intensive than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituent concentrations can be measured, such as chloride, which are related to human activity and often elevated in areas impacted by malfunctioning septic or sewer systems. Physical measurements are primarily used to detect leachate from these systems, which can cause localized increases in water temperature and conductivity (i.e., the water's ability to conduct an electric current). Biologically, nutrient pollution can be detected along the lakeshore by noting the presence of *Cladophora* algae.

Cladophora is a branched, filamentous green algal species that occurs naturally in small amounts in Northern Michigan lakes. Its occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. *Cladophora* is found most commonly in the wave splash zone and shallow shoreline areas of lakes and can also be found in streams. It grows best on stable substrates such as rocks and logs, though artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures of 50 to 70 degrees Fahrenheit. Consequently, the optimal time for its growth and thus, detection, in Northern Michigan lakes is generally during the months of May, June, September, and October.

The nutrient requirements for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in the lakes of Northern Michigan. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. Documenting the size and density of *Cladophora* helps interpret causal factors on an individual basis. However, the description has limited value when making year-to-year comparisons at a single location or estimating the relative amount of shoreline nutrient inputs because growth features are greatly influenced by current patterns, shoreline topography, size, distribution of substrate, and the amount of wave action on the shoreline. Rather, the presence of any significant growth at a single site over several years is the most indicative of elevated nutrient concentrations in shoreline areas. It can reveal the existence of chronic nutrient loading problems, help interpret the cause of the problems, and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient inputs due to changes in land use or land management practices.

Erosion along the shoreline has the potential to degrade a lake's water quality. Stormwater runoff through eroded areas and wave action along the shoreline contribute sediments to the lake, which negatively impacts the lake ecosystem. Sediments clog the gills of fish, aquatic insects, and other aquatic organisms. Excessive sediments smother fish spawning beds and fill interstitial spaces that provide habitat for a variety of aquatic organisms. While moving through the water column, sediments absorb sunlight energy and increase water temperatures. In addition, nutrients adhere to sediments that wash in from eroded areas.

Shoreline greenbelts are essential for maintaining a healthy aquatic ecosystem. A greenbelt consisting of a variety of native woody and herbaceous plant species provides habitat for near-shore aquatic organisms as well as terrestrial animals. Greenbelts naturally function to control erosion by stabilizing the shoreline with plant root structures that protect against wave action and ice. The canopy of the greenbelt provides shade to near-shore areas, which helps to maintain cooler water temperatures and higher dissolved oxygen levels. In addition, greenbelts provide a mechanism to reduce overland surface flow and absorb pollutants carried by stormwater from rain events and snowmelt.

Tributaries have great potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake from its watershed. Inlet streams may provide exceptionally high quality waters that benefit the lake ecosystem, but conversely have the potential to deliver polluted waters that degrade the lake's water quality. Outlet streams flush water out of the lake, providing the means to remove contaminants that have accumulated in the lake ecosystem. With regards to shore surveys, noting the location of inlet tributaries is beneficial when evaluating shoreline algae conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to heavier *Cladophora* and other algae growth in nearby shoreline areas.

Responsible, low-impact shoreline property development, and best management practices are paramount for protecting water quality. Maintaining a healthy greenbelt, regular septic tank pumping, treating stormwater with rain gardens, correcting erosion sites, and eliminating fertilizer, herbicide, and pesticide application are among many low-cost best management practices that minimize the impact of shoreline properties on lake water quality. Living in harmony with the lake and practicing responsible stewardship are vitally important for sustaining a healthy and thriving lake ecosystem.

Table 20: Averaged results for shore survey inventories (2006-2015)

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Burt Lake	2009	47%	29%	4%	36%	46%
Crooked Lake	2012	29%	26%	14%	51%	65%
Douglas Lake	2015	27%	6%	17%	53%	60%
Huffman Lake	2015	14%	0%	7%	57%	70%
Lance Lake	2014	19%	0%	12%	35%	31%
Larks Lake	2006	4%	0%	ND	12%	29%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Silver Lake	2014	3%	0%	70%	53%	65%
Wildwood Lake	2014	5%	0%	22%	45%	50%
AVERAGE	NA	20%	9%	21%	44%	52%

**Percentages are in relation to number of parcels on the lake shore, except for "heavy algae," which is the percent of only parcels that had Cladophora growth. Erosion is the percentage of parcels with moderate to severe erosion and poor greenbelts include those in the poor or very poor categories. ND=no data.*

Burt Lake Direct Drainage

Burt Lake (2009)

During the summer of 2009, the Tip of the Mitt Watershed Council conducted a comprehensive shoreline survey on Burt Lake to document conditions that have the potential to impact water quality. Funding for this project was provided by the Burt Lake Preservation Association (BLPA). This survey was performed because shoreline property is the first and most important line of defense for protecting the lake ecosystem.

The 2009 survey examined nutrient pollution, greenbelt health, shoreline alterations and shoreline erosion at all 1123 properties on Burt Lake and found that shoreline property management is undoubtedly impacting the Lake ecosystem and water quality. Some sign of nutrient pollution was noted at over half of shoreline properties; 36% had greenbelts in poor condition; 46% had altered shorelines; and erosion was present at 6%. **Relative to other lakes in Northern Michigan, Burt Lake had a high percentage of shoreline properties with signs of nutrient pollution and a moderate number of properties with poor greenbelts and altered shorelines.** Properties with strong signs of nutrient pollution and those with poor greenbelts were scattered throughout the Lake, but also concentrated in certain locations.

There was noted improvement in greenbelt health since the last shore survey performed in 2001. The 2001 survey focused on identifying locations of *Cladophora* growth and other shoreline features. Between 2001 and 2009 there was a 23% increase in the number of properties with greenbelts that rated good or excellent and a 20% decrease in greenbelts rated poor.

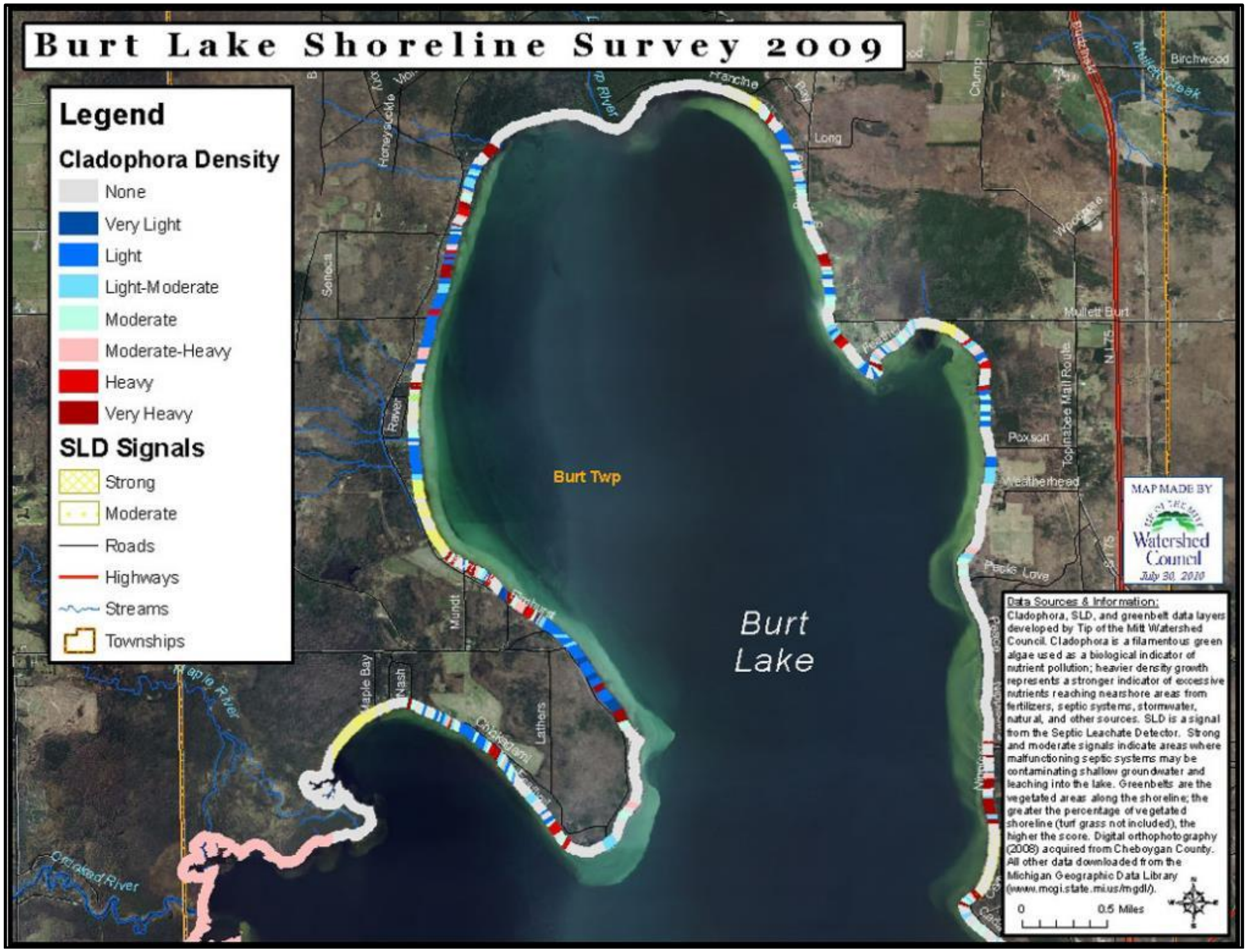


Figure 81: Burt Lake shore survey (north/*Cladophora*)(2009)

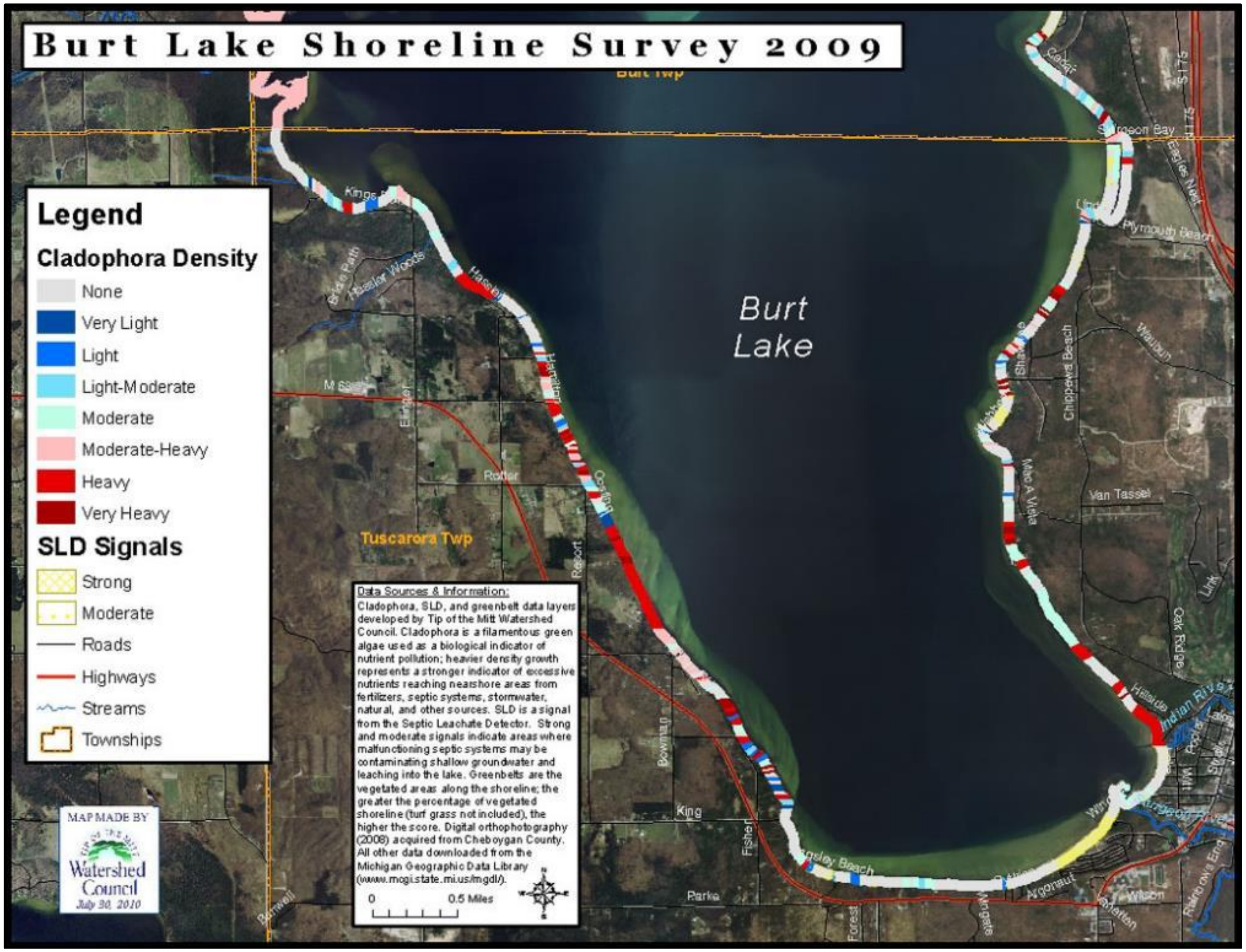


Figure 82: Burt Lake shore survey (south/*Cladophora*) (2009)

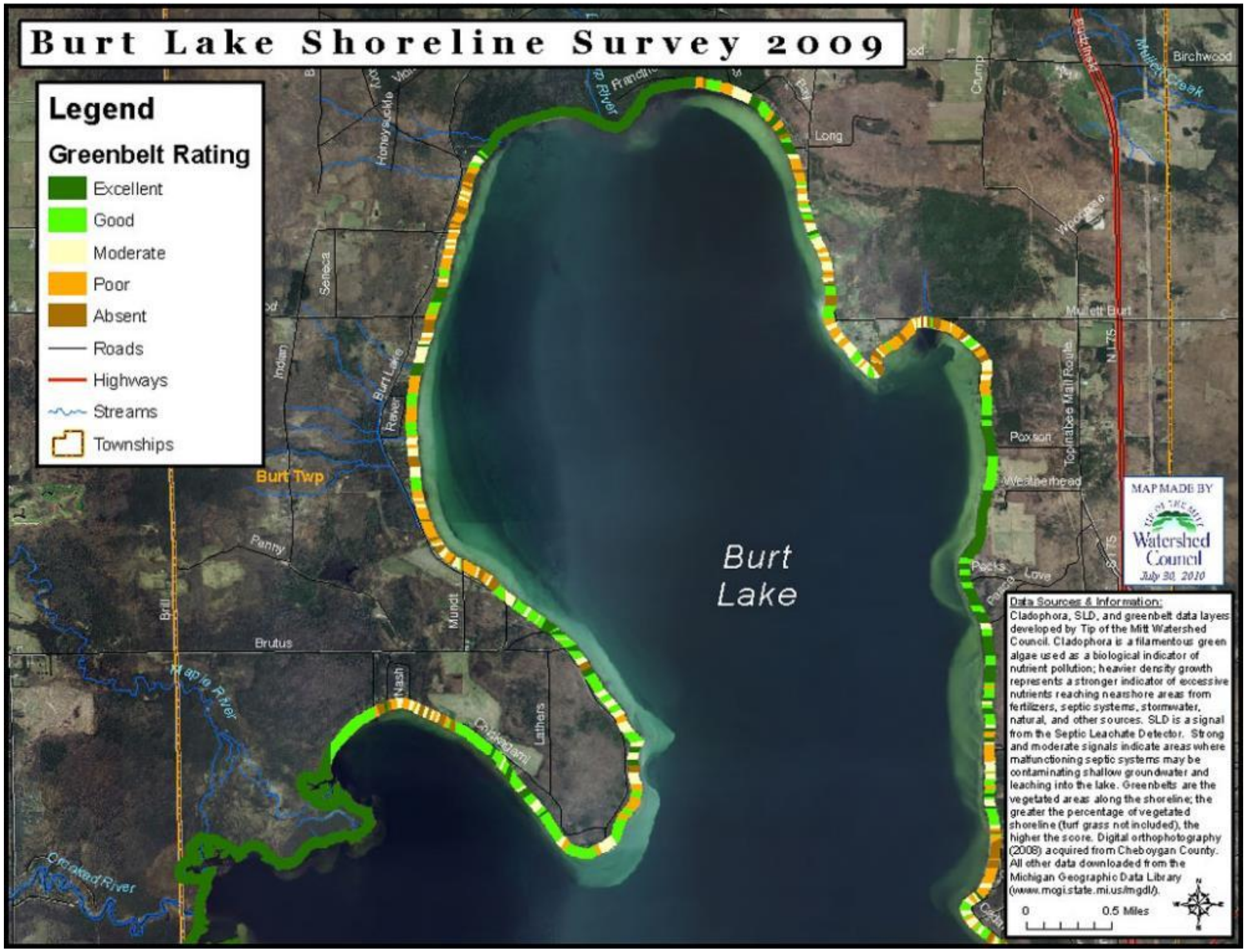


Figure 83: Burt Lake shore survey (north/greenbelt) (2009)

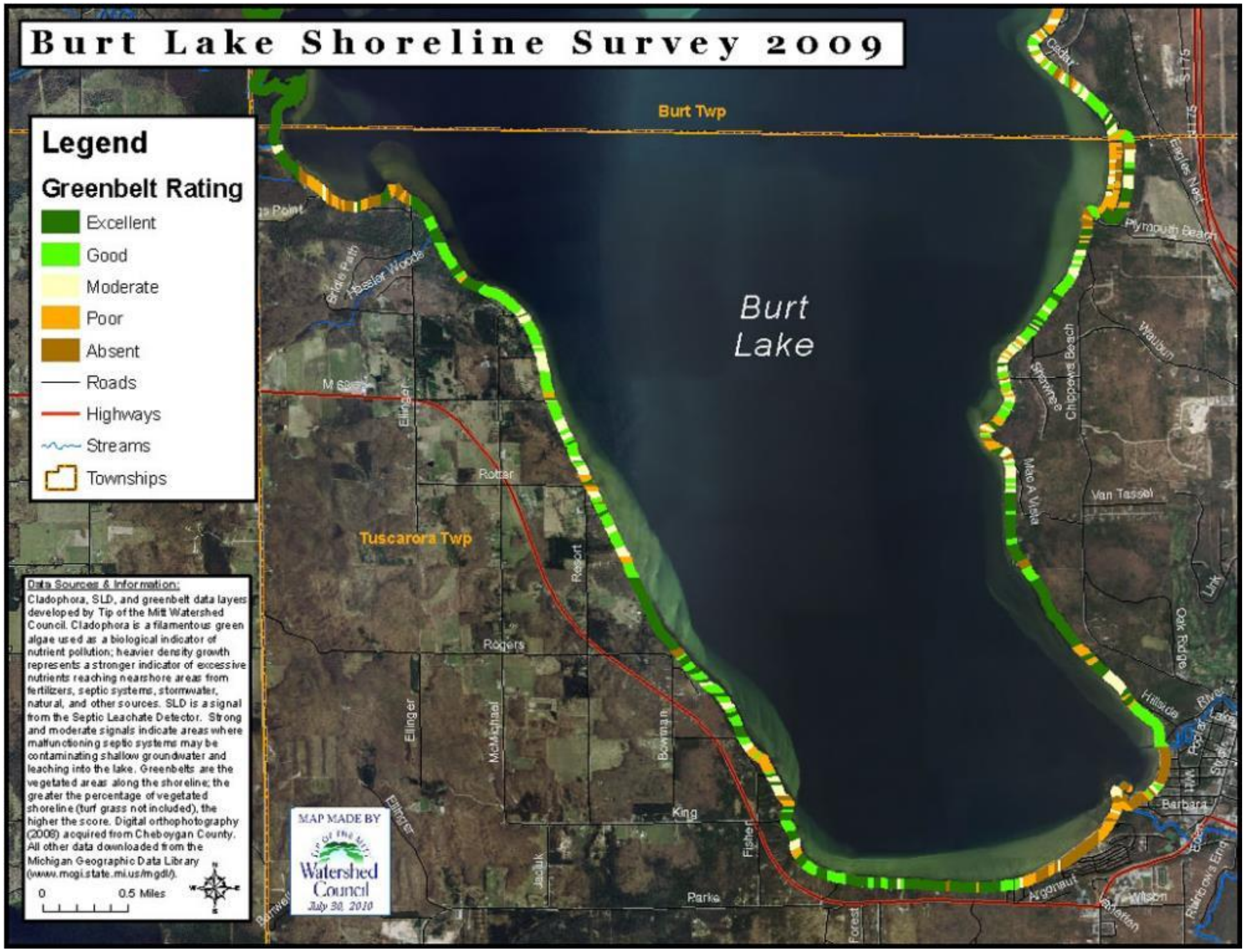


Figure 84: Burt Lake shore survey (south/greenbelt)(2009)

Maple River Watershed

Douglas Lake (2015)

Prior shoreline surveys on Douglas Lake were performed in 1988 and 2002 by Tip of the Mitt Watershed Council. All residential shoreline areas were surveyed in both of the earlier surveys. The 1988 survey was limited to nutrient pollution assessments, while the 2002 survey included nutrient pollution, shoreline erosion, greenbelt status, and shoreline alterations.

Results from the 2002 survey showed *Cladophora* was documented at 51 shoreline properties (14.7%), of which six exhibited heavy-density growth and 12 had moderate-density growth (TOMWC 2002). Erosion was documented at 108 properties (31%), but severity information was not included. Over 70% of greenbelts were found to be in poor condition, with approximately 13% in pristine condition. Alterations were found at 40% of properties, of which 67% were riprap, 31% seawalls, and the remaining 2% a mix of riprap and seawall.

The most recent survey (May/June 2015) documented shoreline conditions at 346 properties on Douglas Lake. Approximately 83% (288) of shoreline properties were considered to be developed. The length of shoreline per parcel varied from less than 20 feet to over 6000 feet.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline at 211 properties (61%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 95 properties, representing 27% of the total or 33% of properties with suitable habitat (Table 20). At properties where *Cladophora* growth was observed, approximately 47% were classified as light or very light growth and six properties had heavy or very heavy growth.

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Approximately 32% of greenbelts were found to be in good or excellent condition. Conversely, 53% of shoreline property greenbelts rated in the poor or very poor categories (Table 20).

Some form of shoreline alteration was noted at 207 shoreline properties (60%) on Douglas Lake (Table 20). Riprap accounted for 59% of shoreline alterations, while seawalls, including seawalls combined with riprap or other structures, accounted for 33%. Beach sand, whether from fill or vegetation and topsoil removal to expose underlying sand, was documented at 17 properties.

Erosion was noted at 131 properties (38%) on the Douglas Lake shoreline. Of these, only 11 properties were found to be experiencing severe erosion, while moderate erosion was documented at 47. The remainder (56%) were classified as minor.

Tributary streams were documented at seven properties. The actual number varies from this total because tributaries are sometimes missed and those located at property borders are sometimes tallied for both properties.

Spatial patterns in the occurrence of *Cladophora* growths, erosion, and poor greenbelts were noticeable. Properties with moderate to heavy *Cladophora* growth were concentrated primarily south of Van Rd on the west shoreline, with a second cluster occurring at Bentley Point on the north shore. Properties with moderate to severe shoreline erosion were found in various locations throughout the Lake, with clusters at Pells Island and adjacent areas on the south shore, as well as in the northwest corner of the Lake. Groupings of properties with shoreline alteration and poor greenbelts corresponded with residential shorelines in the west half of the Lake. Based on the property clusters described above, a map was developed highlighting the degraded shoreline areas (Figure 85).

Relative to shore surveys conducted on other lakes in the Burt Lake Watershed, **Douglas Lake was above the average in terms of the percentage of properties with *Cladophora* growth and heavy *Cladophora* growth** (Table 20). *Cladophora* found on the west shore could be the result of anthropogenic sources of nutrient pollution, such as fertilizers, runoff from impervious surfaces, and septic system leachate in shoreline residential areas. However, it could also be due to natural factors, in particular, the inlet tributary near the intersection of Van and Silver Strand Roads. In Northern Michigan, streams typically have higher nutrient concentrations than lakes, which results in heavier *Cladophora* growth in shoreline areas near the inlet. On-site assessments by trained personnel can help determine if the algae growth is the result of human-caused nutrient pollution. Once the source of nutrient enrichment has been identified, actions can be taken to address the problem.

The percentage of properties with poor greenbelts on Douglas Lake (53%) was above the average for lakes in the Burt Lake Watershed (Table 20). Lakeshore vegetation removal and the consequent loss of nearshore habitat and food sources impacts aquatic fauna ranging from minute crustaceans to top predator fish. Furthermore, the lack of vegetation leads to greater amounts of shoreline erosion and less filtration of pollutants. Although the percentage of properties with poor greenbelts was high, nearly 20% received a perfect score, indicating exemplary greenbelt health. Furthermore, several large properties owned by the University of Michigan Biological Station were among those receiving perfect scores, which account for approximately 40% of the Douglas Lake shoreline (6.3 miles). Properties such as these, with healthy, intact greenbelts, provide a model for improvement for other shoreline properties. Improvements in the quality of greenbelts throughout the shoreline will invariably have positive impacts on the Lake's water quality and ecosystem in general.

Shoreline erosion on Douglas Lake was below the average for lakes in the Burt Lake Watershed (Table 20). The erosion on Pells Island occurred primarily on the east side, which is exposed to wave action from a fetch of up to 2.3 miles. Therefore, this erosion is primarily the result of natural physical forces. Many property owners on the Island have hardened their shorelines with seawalls and riprap to reduce erosion. It is important that they maintain and enhance their greenbelts, and leave fallen trees in the water, to help reduce erosion.

The erosion documented in other areas of the Lake consisted of two primary types: erosion occurring under shallow-rooted turf grass with no natural vegetation buffer and eroding beach sand. Regardless of the cause, corrective actions to address existing erosion, preferably using bioengineering techniques, as well as preventative measures, such as improving greenbelts, will benefit the Douglas Lake ecosystem.

The percentage of properties with shoreline alterations on Douglas Lake was above average for lakes in the Burt Lake Watershed (Table 20). Most shoreline alterations (60%) consisted of small riprap, which is one of the least damaging types in regards to lake ecosystem health. However, over 30% of noted alterations were seawalls or seawalls mixed with other alteration types, such as riprap or beach sand. Seawalls are now frowned upon by water resource managers due to negative impacts that range from near-shore habitat loss to ice-induced erosion in neighboring shoreline areas. Reducing the length of altered shoreline, particularly in terms of seawalls, will improve the water quality and bolster the ecosystem of Douglas Lake.

Comparisons with the shoreline survey conducted on Douglas Lake in 2002 showed largely negative changes in shoreline conditions and associated property management. *Cladophora* occurrence increased by 12%; the majority of this increase occurring in the light and moderate density categories. There was little change in greenbelt conditions over time in terms of broad categories of poor, moderate, and good (grouping the top two and bottom two categories). Although the percentage of greenbelts rated as very poor decreased considerably since 2002, assessment methods varied between the two surveys. The percentage of shoreline properties with erosion increased by 7% over the 14-year period and alterations increased by 20%. Comparisons were not made with the survey conducted in 1988 because different parameters were assessed.

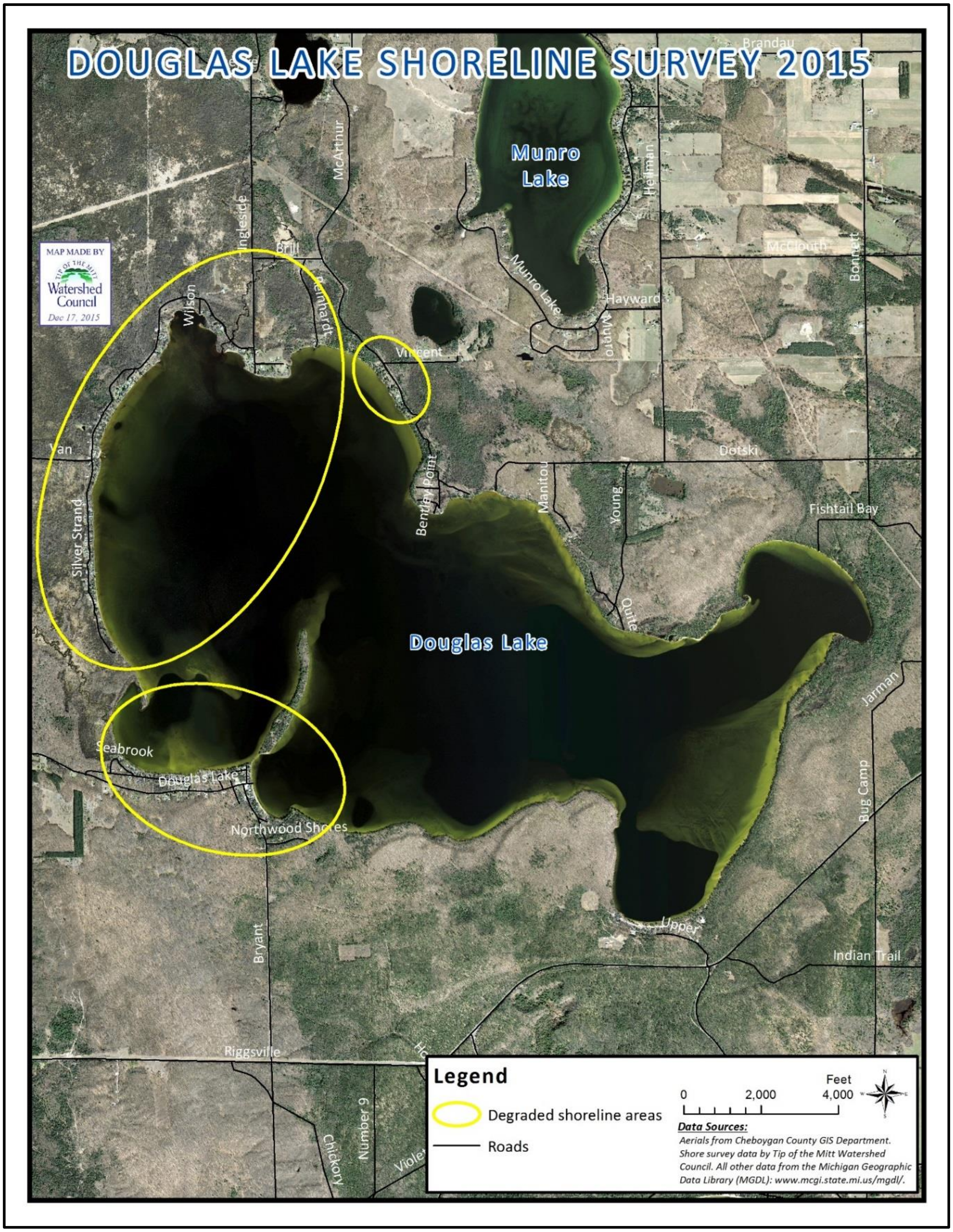


Figure 85: Douglas Lake shore survey results (2015)

Larks Lake (2006)

The current condition of greenbelts, or shoreline vegetation, was assessed and documented during the shoreline survey performed by Tip of the Mitt Watershed Council during the summer of 2006.

Greenbelt status was documented for 83 property parcels. The number of parcels is approximate because survey observations were made from watercraft and exact property boundaries were not always evident. 54 property parcels are developed lots and 29 are considered undeveloped

Of the 83 parcels surveyed, 53 parcels (64%) had a greenbelt that extended 75% or greater of the length of the shoreline. Of the developed parcels, only 25 parcels (30%) had greenbelts. 20% (17 parcels) had a greenbelt 25-75% the length of the shoreline; 4% (3 parcels) had a greenbelt 10-25% the length of the shoreline; and 5% (4 parcels) had a greenbelt less than 10% of the shoreline. Six of the 83 parcels (7%) were documented as having no shoreline greenbelt. All parcels documented as having no shoreline greenbelt were developed property parcels.

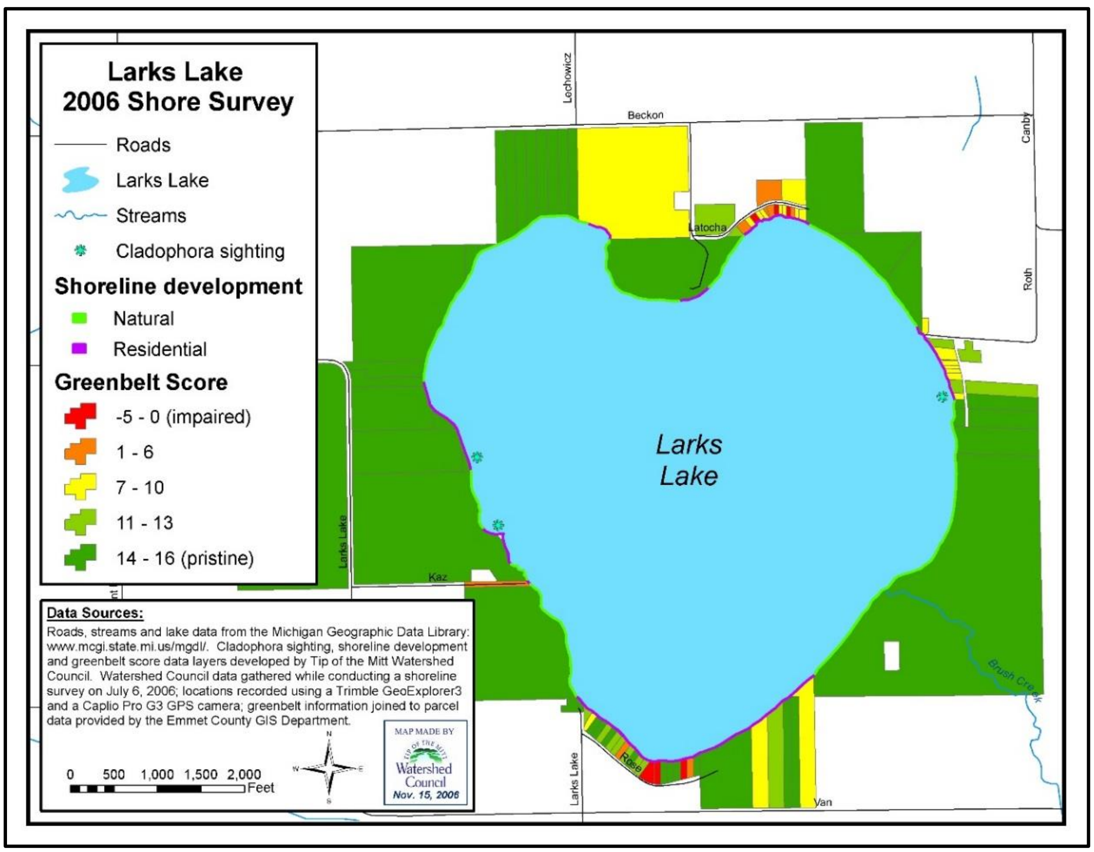


Figure 86: Larks Lake Shore Survey (2006)

Crooked River Watershed

Crooked and Pickerel Lakes (2012)

During the late spring of 2012, the Tip of the Mitt Watershed Council conducted a comprehensive shoreline survey on Crooked and Pickerel Lakes to assess such shoreline conditions.

Survey results indicate that human activity along the Crooked and Pickerel Lakes shoreline is likely impacting the Lake ecosystem and water quality. *Cladophora* was noted at nearly one third of shoreline properties, of which 30% consisted of heavy growth (i.e., a strong indication of nutrient pollution). Over 50% of greenbelts on shoreline properties were found to be in poor condition, though 36% were in excellent condition. Moderate to severe erosion was documented at 14% of properties and approximately 65% had altered shorelines. **Relative to other lakes in the region, Crooked and Pickerel Lakes had a high percentage of properties with heavy *Cladophora* algae growth, poor greenbelts, erosion, and altered shorelines.**

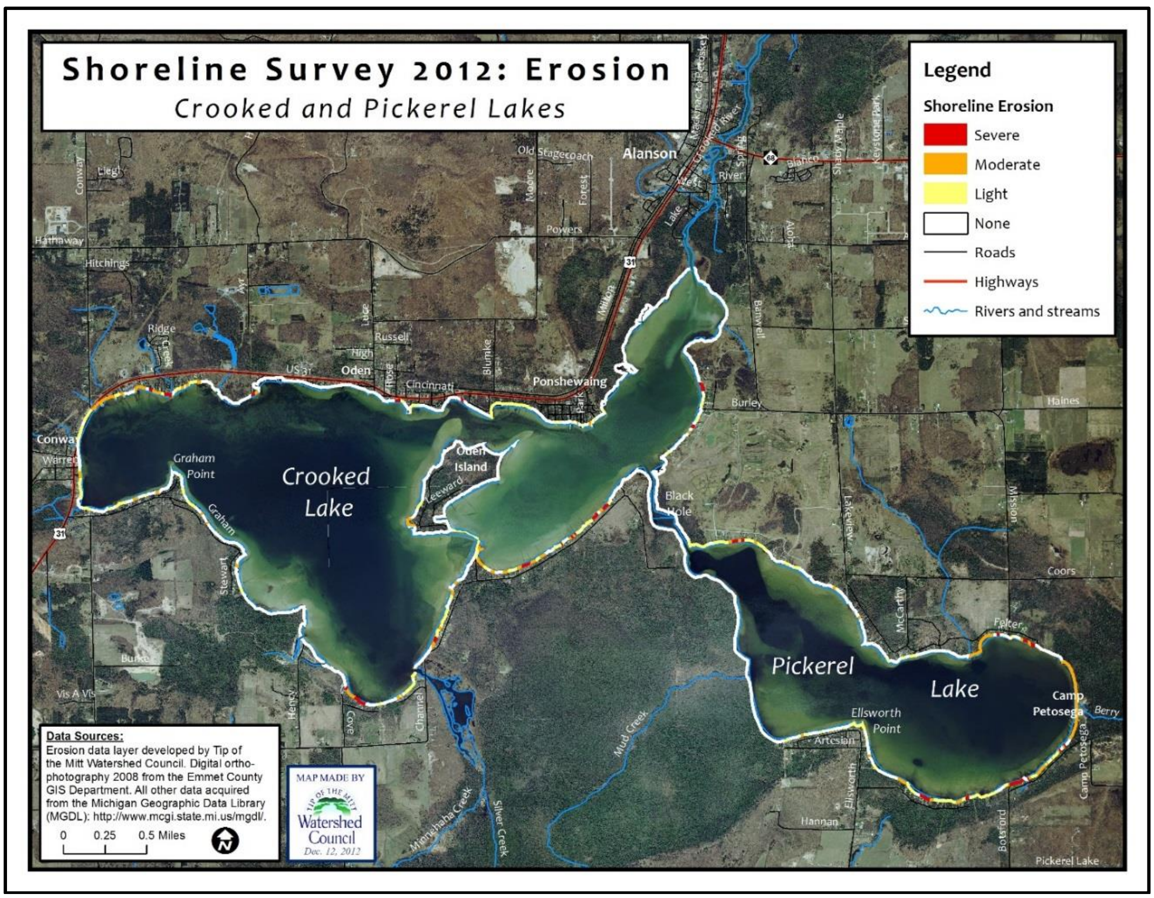


Figure 87: Crooked and Pickerel Lakes shore survey: erosion (2012)

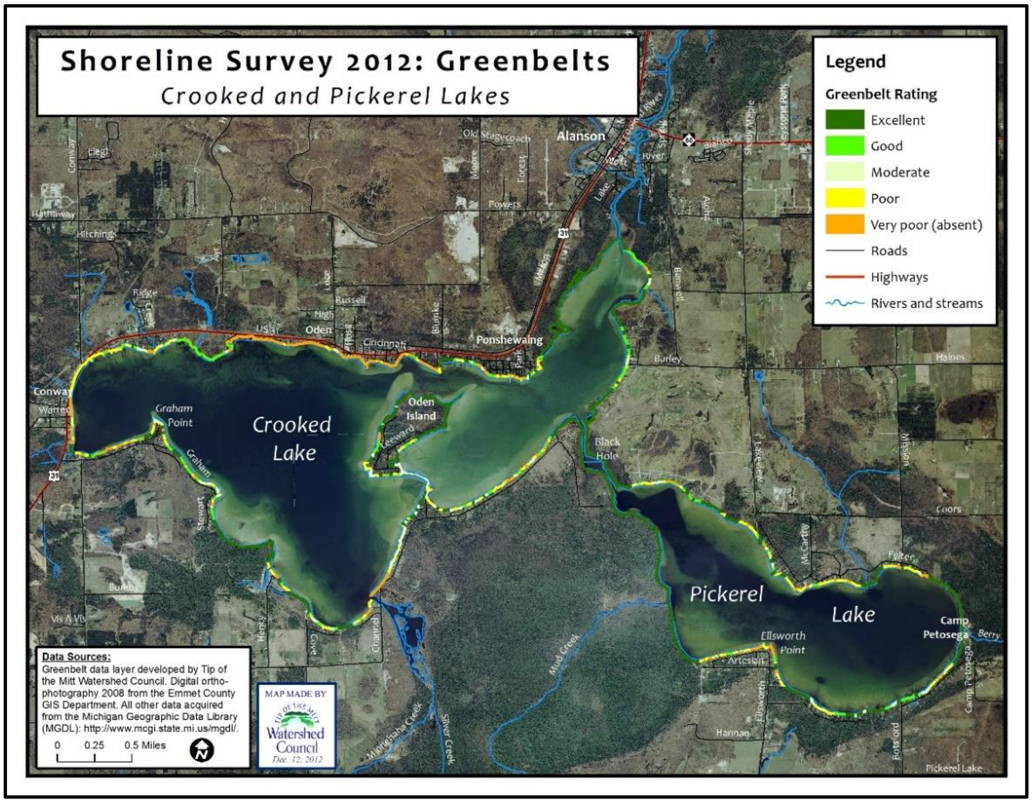


Figure 88: Crooked and Pickerel Lakes shore survey: greenbelts (2012)

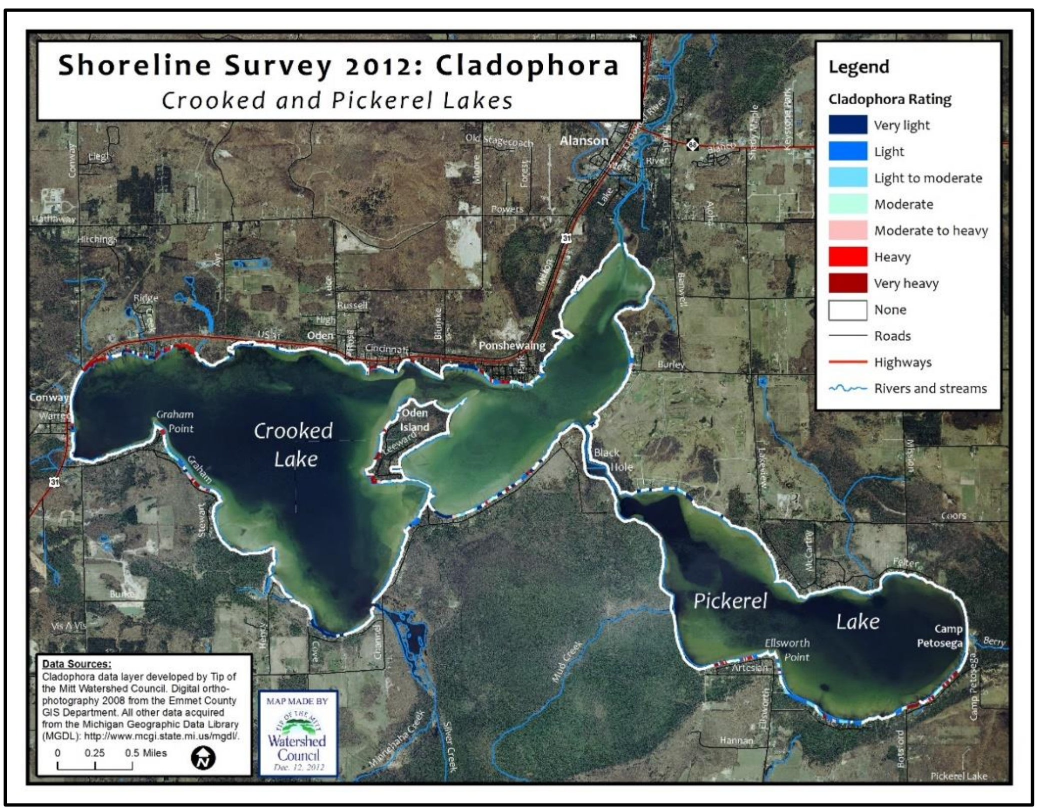


Figure 89: Crooked and Pickerel Lakes shore survey: *Cladophora* (2012)

Round Lake (2014)

This survey documented shoreline conditions at 71 properties on Round Lake. Approximately 72% (51) of shoreline properties on Round Lake were considered to be developed. The length of shoreline per parcel varied from less than 20 feet to over 2300 feet.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline at 40 properties (56%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 15 properties, representing 21% of the total or 38% of properties with suitable habitat (Table 20). At properties where *Cladophora* growth was observed, approximately 87% were classified as light or very light growth and no properties had heavy or very heavy growth.

Greenbelt scores on Round Lake ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Approximately 41% of greenbelts were found to be in good or excellent condition. Conversely, 44% of shoreline property greenbelts rated in the poor or very poor categories (Table 20).

Some form of shoreline alteration was noted at 31 shoreline properties (44%) on Round Lake. Riprap accounted for 61% of shoreline alterations, while seawalls, including seawalls combined with riprap or other structures, accounted for 23%. Beach sand, whether from fill or vegetation and topsoil removal to expose underlying sand, was documented at just four properties.

Erosion was noted at 30 properties (42%) on the Round Lake shoreline. Over half (57%) of shoreline properties with erosion were classified as moderate in terms of severity, while two properties were experiencing severe erosion. Minor erosion was documented at 37% of properties with erosion.

Tributary streams were documented at 11 properties. The actual number could be higher or lower because tributaries are sometimes missed during the survey and those located between land parcels can mistakenly be tallied for both properties.

All properties with observed *Cladophora* growth occurred on the northern shore of the Lake, with the heaviest growth occurring to the west of the MDNR boat launch. Clusters of properties with moderate to severe shoreline erosion were found in the three developed lakeshore areas, toward the middle of the north, west, and southeast shorelines. Groupings of properties with shoreline alteration and poor greenbelts corresponded with those of erosion sites.

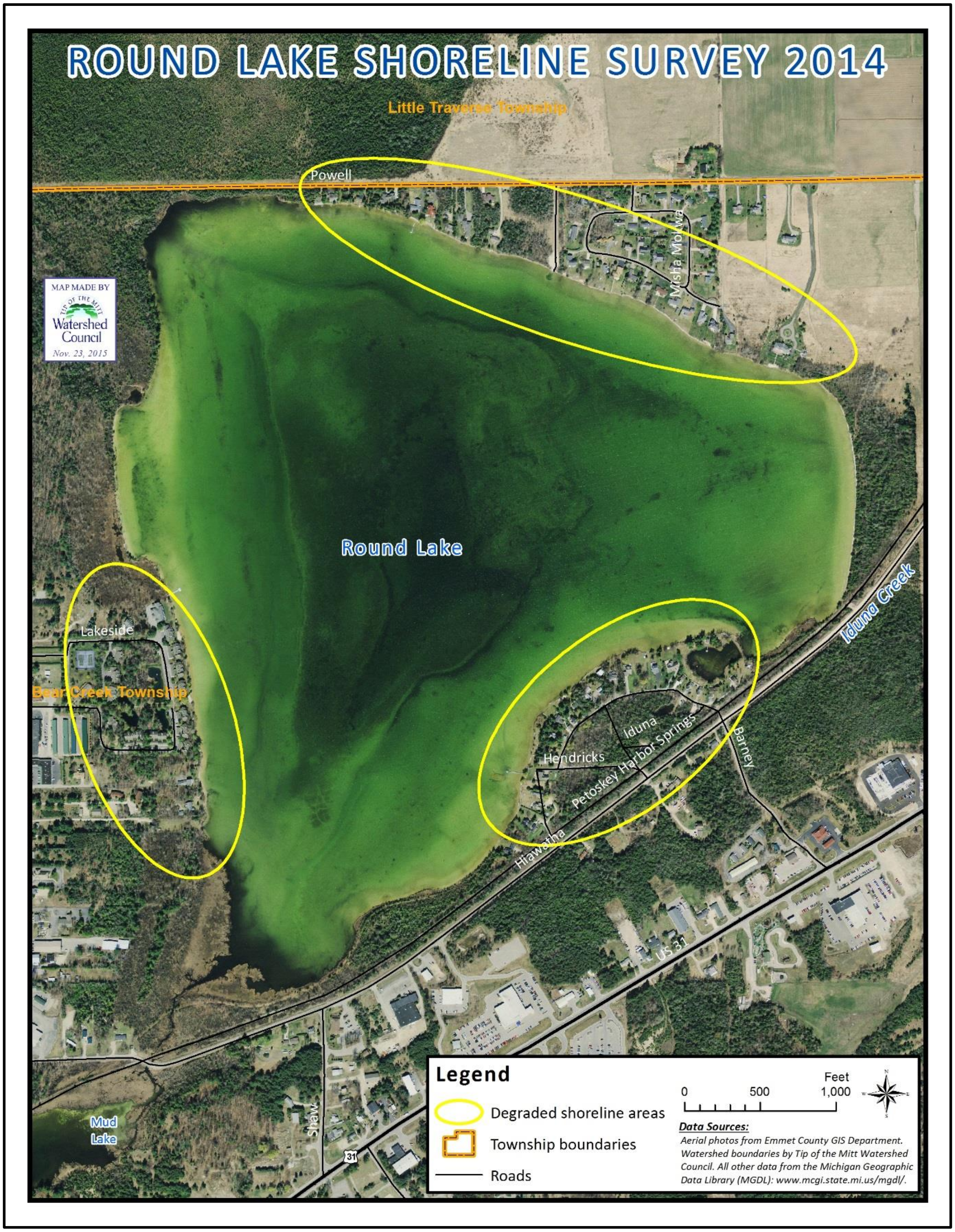


Figure 90: Round Lake shore survey (2014)

Sturgeon River Watershed

Huffman Lake (2015)

A prior shoreline survey, sponsored by the Huffman Lake Property Owners Association, was conducted by Tip of the Mitt Watershed Council on Huffman Lake in 2006. All residential shoreline areas were surveyed for nutrient pollution and shoreline alterations. Survey results showed moderate to heavy-density *Cladophora* growth at 24 shoreline properties and strong septic leachate detector readings at another six properties. Nutrient pollution indicators were concentrated in four Lake areas, including embayments in the northeast and southeast corners, the northern part of the west shoreline, and the western side of the southern shoreline. Shoreline alterations were noted at 76% of properties, over 90% of which consisted of riprap. Follow-up actions to identify and address specific nutrient pollution sources was not carried out.

This survey documented shoreline conditions at 70 properties on Huffman Lake. Approximately 52 shoreline properties (74%) were considered to be developed. The length of shoreline per parcel varied from less than 20 feet to over 1000 feet.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline at 65 properties (93%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 10 properties, representing 14% of the total or 15% of properties with suitable habitat (Table 20). At properties where *Cladophora* growths were observed, approximately 70% were classified as light or very light growth and six properties had heavy or very heavy growth.

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Approximately 21% of greenbelts were found to be in good or excellent condition. Conversely, 57% of shoreline property greenbelts rated in the poor or very poor categories (Table 20).

Shoreline alterations were noted at 49 shoreline properties (70%) on Huffman Lake (Table 20).

Riprap accounted for 80% of shoreline alterations, while 16% had seawalls, including seawalls combined with riprap or other structures. Beach sand, whether from fill or vegetation and topsoil removal to expose underlying sand, was documented at four properties.

Erosion was noted at 39 properties (56%) on Huffman Lake, but only 7% was classified as moderate in terms of severity. No severe erosion was found on the shoreline (Table 20).

Spatial patterns in the occurrence of *Cladophora* growth, erosion, and poor greenbelts were noticeable (Figure 91). *Cladophora* growth was observed at properties throughout the Lake, with the densest growth occurring along the south shore. Properties with moderate shoreline erosion were found in isolated clusters along the northwest and southeast shores. Shoreline alterations and poor greenbelts were found at residential shorelines throughout the Lake. Poor shoreline health occurred in the densest residential areas.

Results from the 2015 survey indicate that poor greenbelts, and shoreline alterations pose the greatest threats to the water quality and nearshore health of Huffman Lake.

Relative to shore surveys conducted in the Burt Lake Watershed, Huffman Lake was well below the average in terms of the percentage of properties with *Cladophora* growth and heavy *Cladophora* growth. Moderate-density growth was found at just two locations, which coincide with the 2006 survey. The tributary stream entering the Lake in the northern end of the west shoreline is probably the source of nutrients contributing to *Cladophora* growth in that area. The moderate-density growth in the northeast corner of the Lake, however, may be the result of nutrient pollution from human sources. On-site assessments by trained personnel can help determine if the algae growth is the result of human-caused nutrient pollution. Once the source of nutrient enrichment has been identified, actions can be taken to address the problem.

The percentage of properties with poor greenbelts on Huffman Lake (57%) was above the average for lakes in this region. Lakeshore vegetation removal and the consequent loss of nearshore habitat and food sources impacts aquatic fauna ranging from minute crustaceans to top predator fish. Furthermore, the lack of vegetation leads to greater amounts of shoreline erosion and less filtration of pollutants. Although the percentage of properties with poor greenbelts was high, large parcels along the western half of the south shore that makes up approximately 20% of the Lake shoreline received good or excellent greenbelt ratings. Properties such as these, with healthy, intact greenbelts, provide a model for improvement for other shoreline properties. Improvements in the quality of greenbelts throughout the shoreline will invariably have positive impacts on the Lake's water quality and ecosystem in general.

Shoreline erosion on Huffman Lake was well below average for lakes in this region. Moderate erosion was found at locations on the north and south shores in developed shoreline areas. The properties with moderate erosion also had poor greenbelts, indicating a relationship between the two. Corrective actions to address existing erosion, preferably using bioengineering techniques, as well as preventative measures, such as improving greenbelts, will benefit the Huffman Lake ecosystem.

The percentage of properties with shoreline alterations on Huffman Lake was above average (Table 20). Most shoreline alterations (87%) consisted of riprap, which is one of the least damaging types in regards to lake ecosystem health. However, the majority of the remaining alterations (10%) were seawalls or seawalls mixed with other alteration types, such as riprap or beach sand. Seawalls are now frowned upon by water resource managers due to negative impacts that range from near-shore habitat loss to ice-induced erosion in neighboring shoreline areas. Reducing the length of altered shoreline, particularly in terms of seawalls, will improve the water quality and bolster the ecosystem of Huffman Lake.

Comparisons with the shoreline survey conducted on Huffman Lake in 2006 showed positive changes in shoreline conditions. *Cladophora* occurrence decreased by 45%, the majority of this decrease occurring in the moderate and heavy density categories. The percentage of properties with shoreline alterations was roughly equivalent between surveys. Greenbelt status and shoreline erosion were not documented in the 2006 survey.

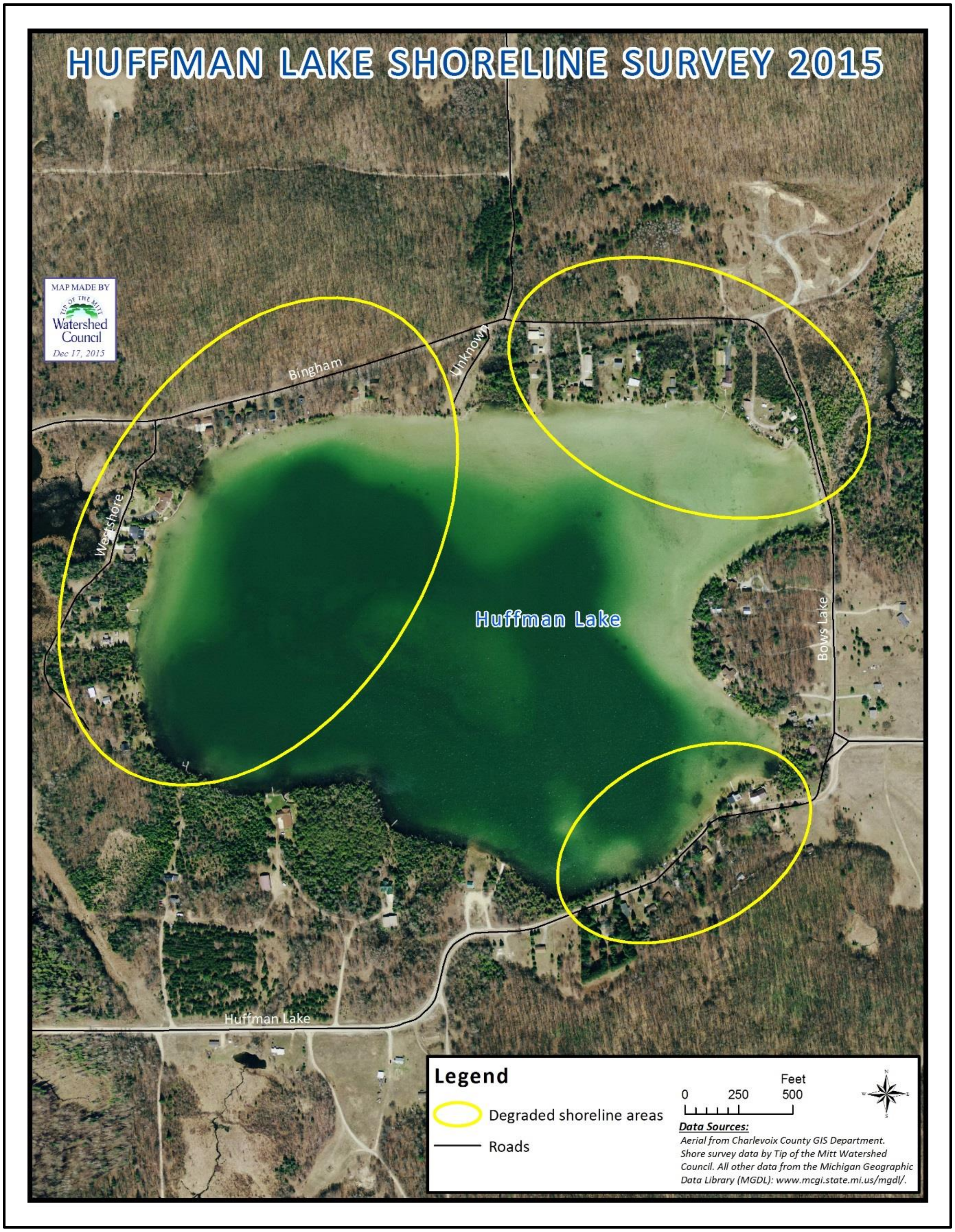


Figure 91: Huffman Lake shore survey results (2015)

Lance Lake (2014)

This survey documented shoreline conditions at 26 properties on Lance Lake. **Approximately 77% (20) of shoreline properties on Lance Lake were considered to be developed.** The length of shoreline per parcel varied from less than 20 feet to over 900 feet.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 18 properties (69%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at five properties, representing 19% of the total or 28% of properties with suitable habitat (Table 20). *Cladophora* density classification for 80% of properties was light or very light. No heavy-density growth was documented during the survey.

Greenbelt scores on Lance Lake ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Over a third of greenbelts (38%) were found to be in good or excellent condition. However, over a third of shoreline property greenbelts (35%) rated in the poor or very poor categories (Table 20).

Some form of shoreline alteration was noted at eight shoreline properties (31%) on Lance Lake (Table 20). Riprap accounted for 25% of shoreline alternations, while seawalls, including seawalls combined with riprap or other structures, accounted for 75% of shoreline alterations. Beach sand, whether from fill or vegetation and topsoil removal to expose underlying sand, was documented at just one property.

Erosion was noted at three properties (12%)(Table 20). In terms of severity, two of these were classified as moderate while the other had moderate to severe erosion.

Tributary streams were documented at one property. This stream was determined to be the inlet from the Wildwood Lake impoundment.

There were no clear spatial patterns or relationships among the various survey parameters (Figure 92). Properties with poor greenbelts, shoreline erosion, and *Cladophora* growth occurred in the developed southern half of the Lake. There were two properties at the northern tip with compromised greenbelts.

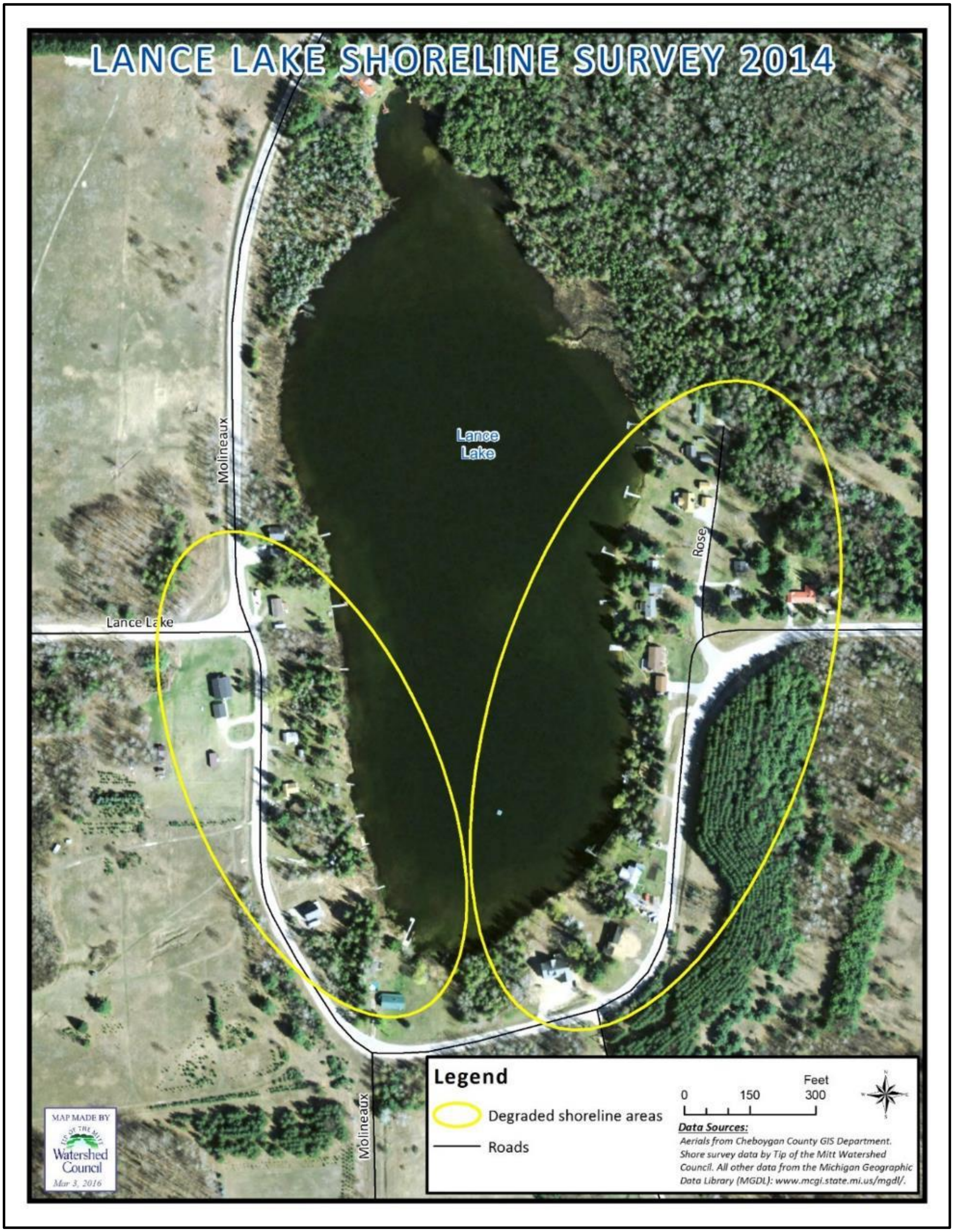


Figure 92: Lance Lake shore survey results (2014)

Silver Lake (2014)

This survey documented shoreline conditions at 71 properties on Silver Lake. **Approximately 86% (61) of shoreline properties on Silver Lake were considered to be developed.** The length of shoreline for individual parcels varied from less than 25 feet to over 650 feet.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 32 properties (45%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at just two properties. Both were classified as light growth.

Greenbelt scores for Silver Lake properties ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). The greenbelts at over half of shoreline properties rated in the poor or very poor categories (Table 20). However, 27% of greenbelts were found to be in good or excellent condition.

Some form of shoreline alteration was noted at 46 shoreline properties (65%) on Silver Lake (Table 20). Riprap accounted for 4% of shoreline alternations, while seawalls, including seawalls combined with riprap or other structures, accounted for 67% of shoreline alterations. Beach sand, whether from fill or vegetation and topsoil removal to expose underlying sand, was documented at 18 properties (25%).

Shoreline erosion was noted at 30 properties (42%) on Silver Lake (Table 20). While only five properties (17%) had severe erosion, over half (53%) were classified as moderate. No tributaries were documented during the survey.

There were no clear spatial patterns or relationships among the various survey parameters. The most severe shoreline erosion occurred on the east shore. Poor greenbelts were distributed throughout much of the Lake, except in the southwest corner (Figure 93).

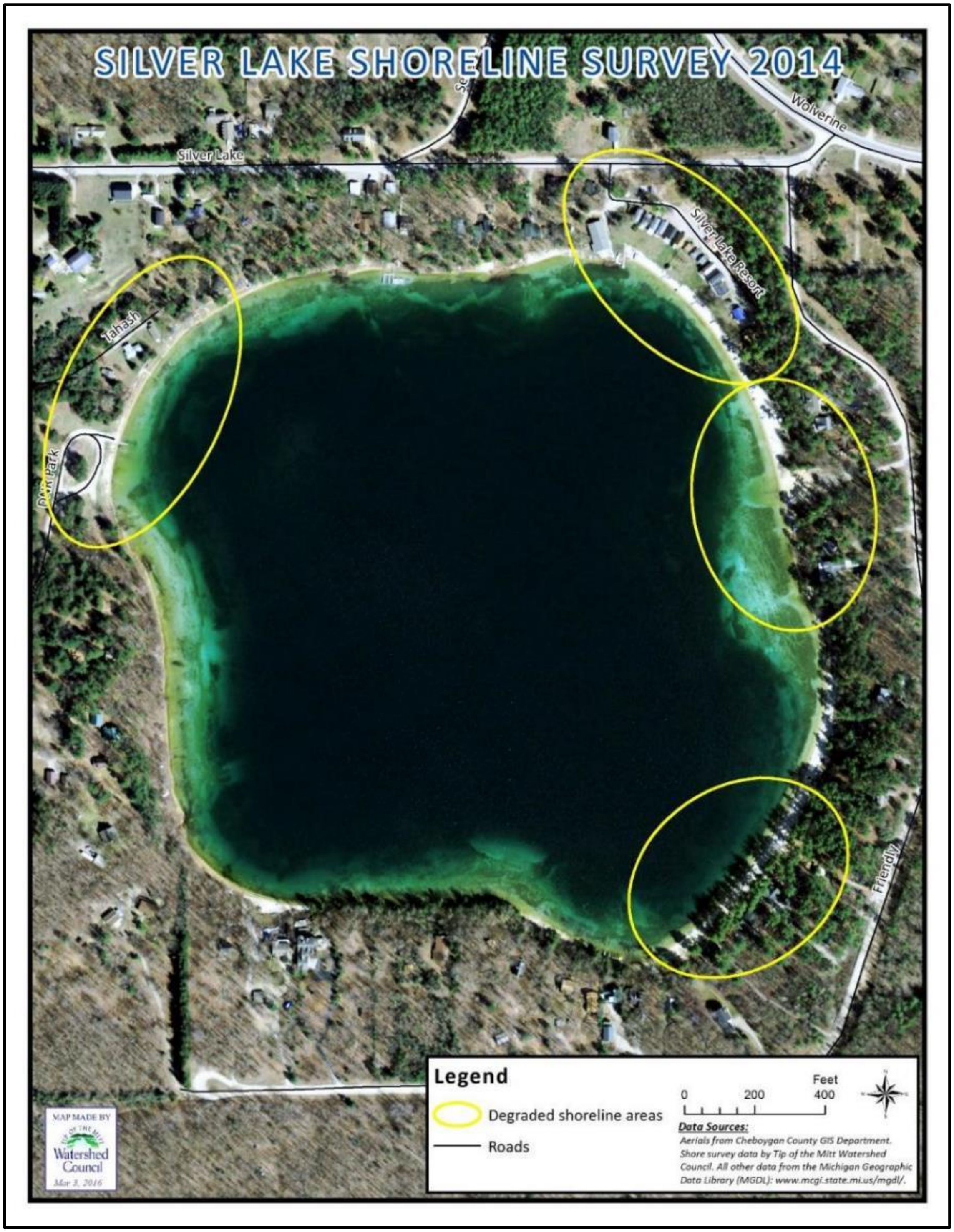


Figure 93: Silver Lake shore survey results (2014)

Wildwood Lake (2014)

This survey documented shoreline conditions at 237 properties on Wildwood Lake. **Approximately 62% (147) of shoreline properties on Wildwood Lake were considered**

to be developed. The length of shoreline per parcel varied from less than 20 feet to over 2000 feet.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 101 properties (43%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 11 properties, representing 5% of the total or 11% of properties with suitable habitat (Table 20). All properties where *Cladophora* growth was observed were classified as light or very light.

Greenbelt scores on Wildwood Lake ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Approximately 45% of shoreline property greenbelts rated in the poor or very poor categories (Table 20). Conversely, 41% of greenbelts were found to be in good or excellent condition.

Some form of shoreline alteration was noted at 118 shoreline properties (50%) on Wildwood Lake (Table 20). Riprap accounted for 48% of shoreline alterations, while seawalls, including seawalls combined with riprap or other structures, accounted for 36% of shoreline alterations. Beach sand, whether from fill or vegetation and topsoil removal to expose underlying sand, was documented at 46 properties.

Erosion was noted at 105 properties (44%). Over a third (38%) of shoreline properties with erosion were classified as moderate in terms of severity, while 11 properties were experiencing severe erosion. Minor erosion was documented at over half (51%) of properties with erosion.

Tributary streams were documented at only one property on the south shore of the Lake. The actual number could be higher because tributaries are sometimes missed during the survey.

Properties with poor greenbelts and shoreline erosion were interspersed throughout with no clear spatial patterns or relationships. However, a cluster of properties with excellent greenbelts was documented in the northeast corner of the Lake. Properties where *Cladophora* growth was observed occurred on the large island and south shore of the Lake.

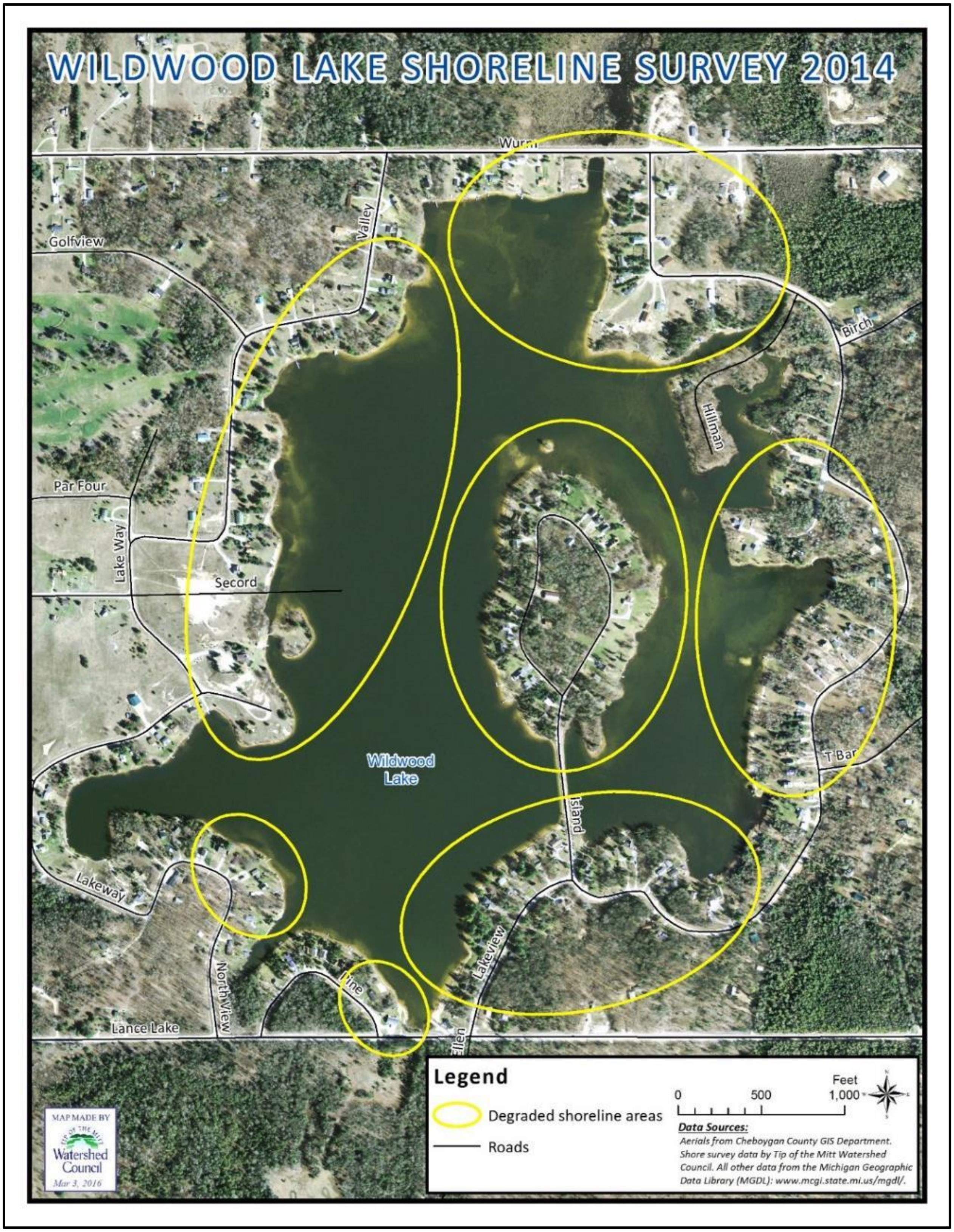


Figure 94: Wildwood Lake shore survey results (2014)

Road/Stream Crossing Inventories

Road/stream crossings (RSX) that are improperly designed or installed, structurally failing, or no longer accommodate current stream conditions can impact stream health. They can affect stream hydrology, prevent fish and other aquatic organisms from accessing up-and downstream reaches, increase water temperatures, and are sources of nutrients, sediments, bacteria, heavy metals, and other nonpoint source pollutants. In Northern Michigan, sediments pose the greatest threat to rivers and streams. Sedimentation can adversely impact fish and aquatic organisms by degrading their habitat and reducing water quality.

Road/stream crossing (RSX) inventories serve as a useful watershed management tool. They help to identify sediment pollution entering surface waters from poorly designed, maintained, or aging infrastructure; fish passage barriers due to perched culverts or velocity barriers; and altered stream hydrology due to inadequately designed or installed crossings. Therefore, identifying failing or deficient RSXs is critical to resource management. Regular inventorying of RSXs allows road commissions and resource managers to note change in stream and structure conditions over time. Furthermore, by applying the Great Lakes Road/Stream Crossing protocol, RSXs can be ranked as minor, moderate, or severe as a means of prioritizing them for improvements or replacement.

During 2014 and 2015, 168 RSXs were inventoried throughout the Burt Lake Watershed. The inventory included utilizing the Great Lakes Road/Stream Crossing protocol and corresponding field form (Appendix C). Additional information collected includes photographs of the site, a site sketch, whether it is considered a priority site, whether a future visit is recommended, and if any invasive species were observed at the site. All data collected during the inventory was then entered into the Great Lakes Road/Stream Crossing Inventory Access database. The database includes formulas built into each record as a means to rank each site with respect to the erosion and fish passage, and calculates a severity rating (minor, moderate, and severe).

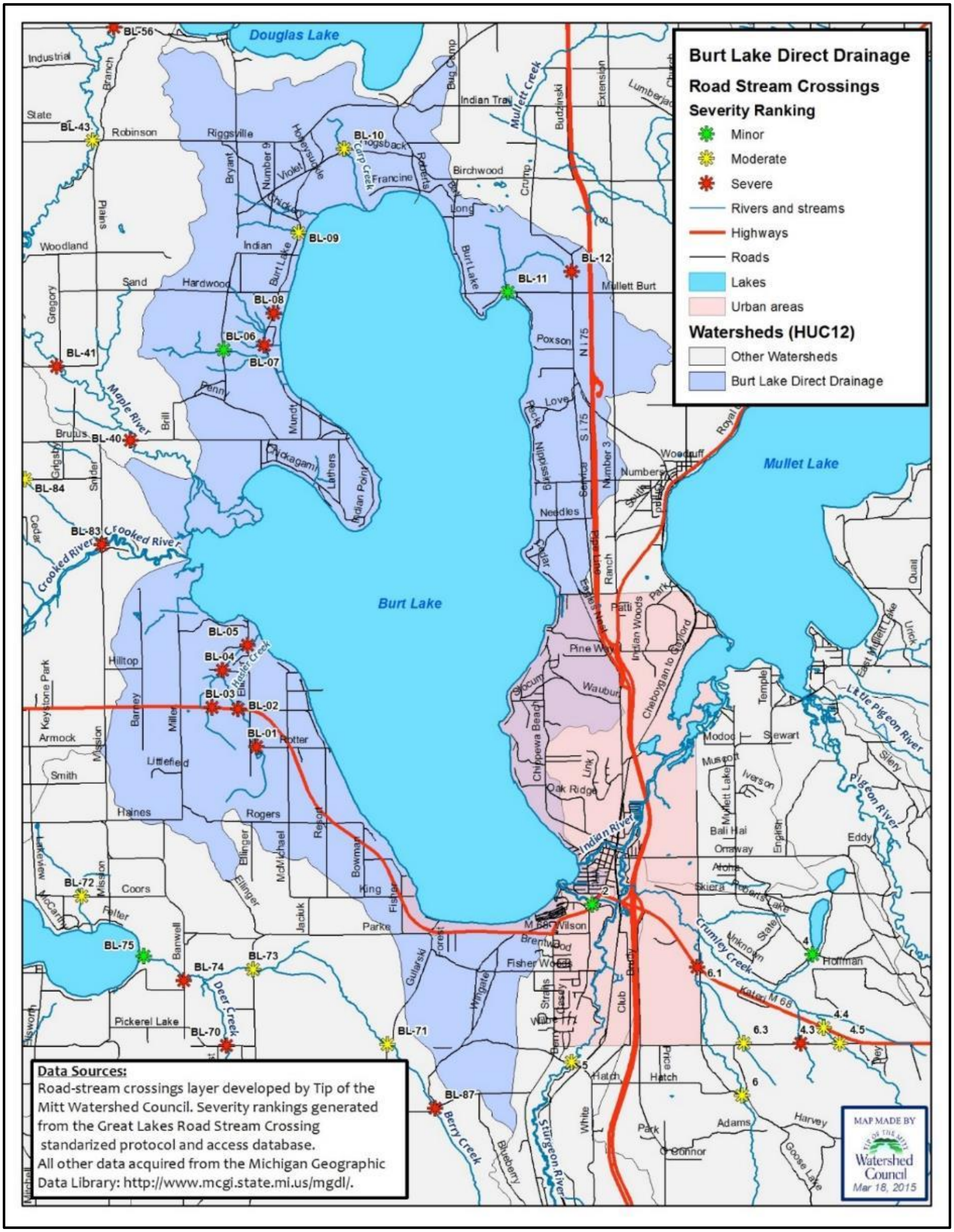


Figure 95: Burt Lake Direct Drainage road/stream crossing inventory

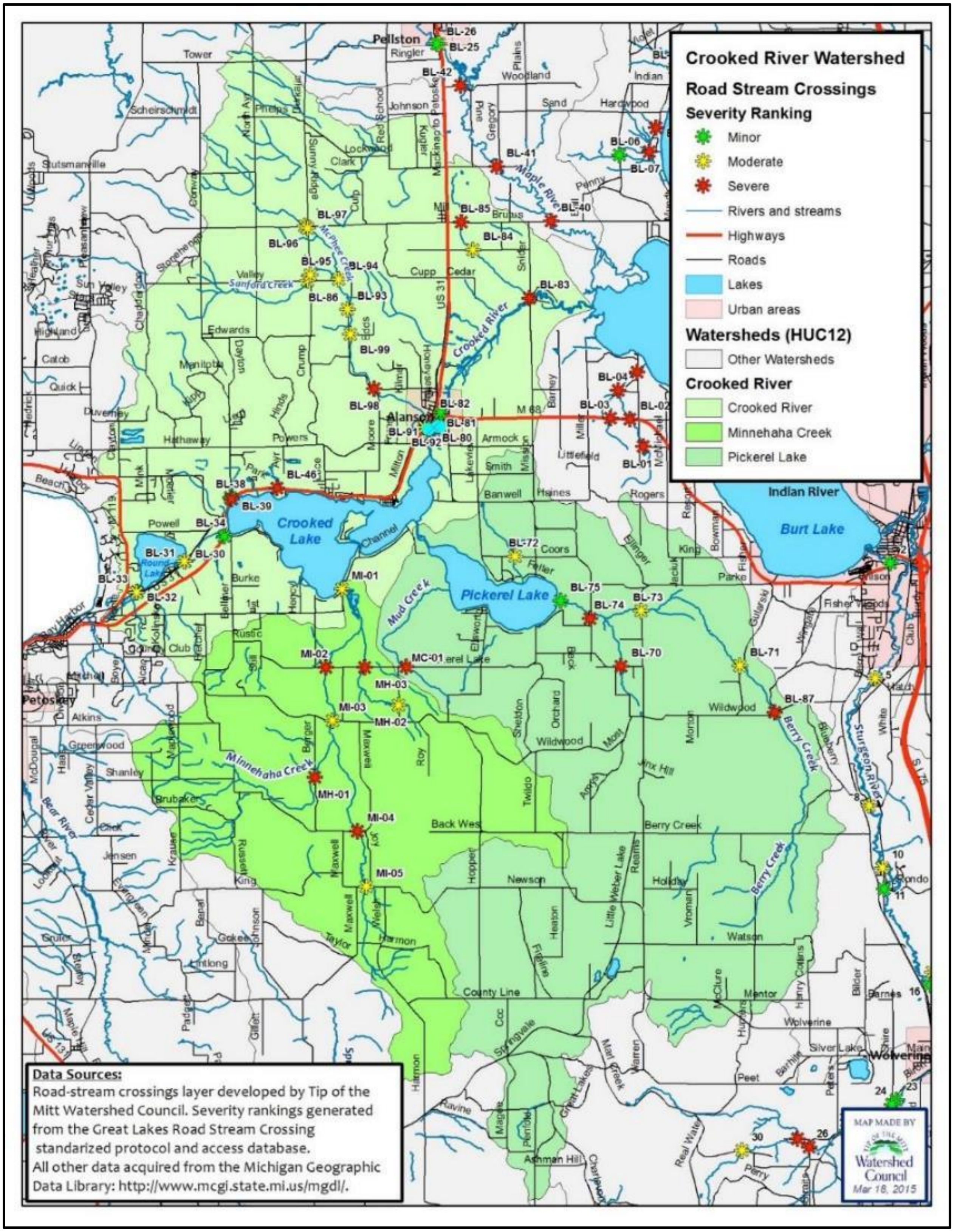


Figure 96: Crooked River Watershed road/stream crossing inventory

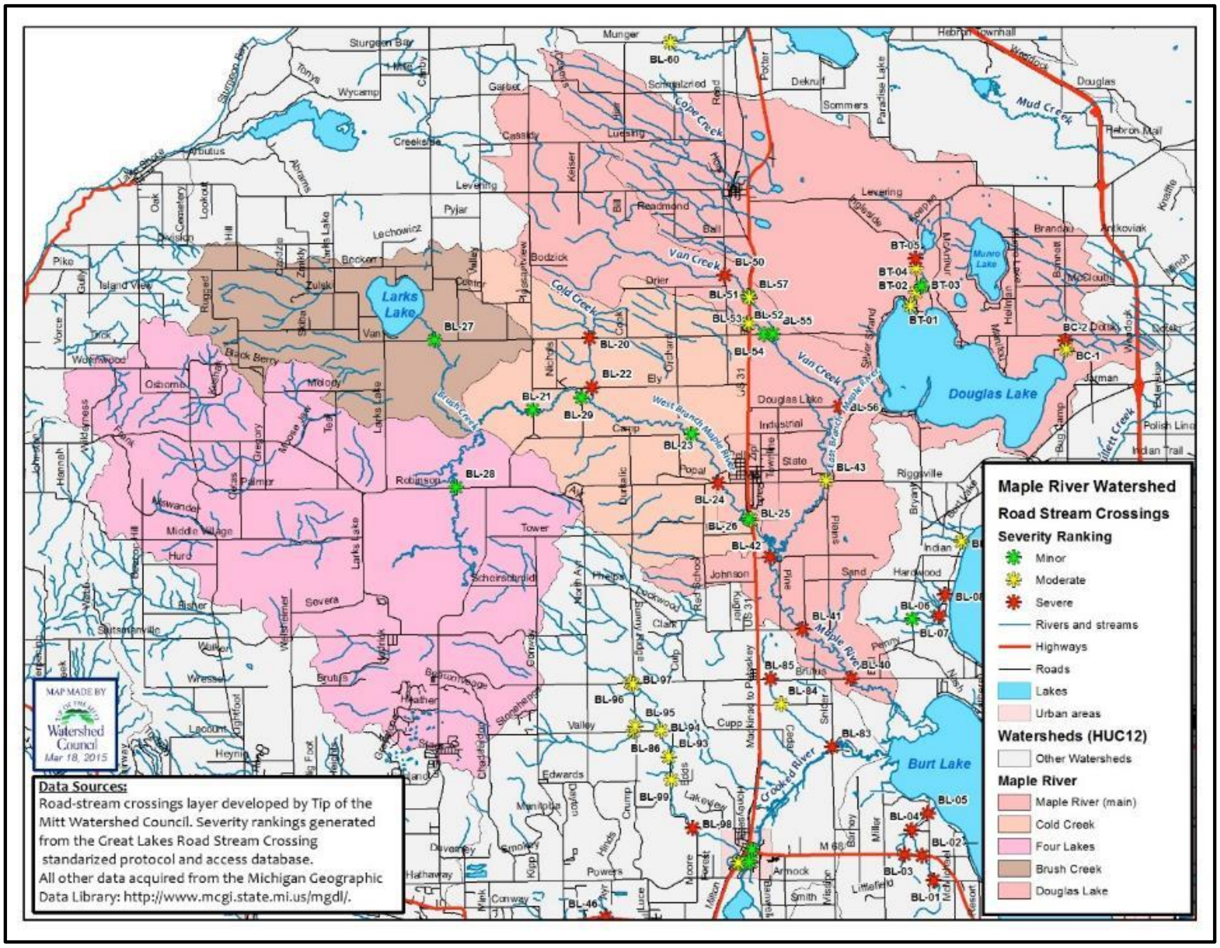


Figure 97: Maple River Watershed road/stream crossing inventory

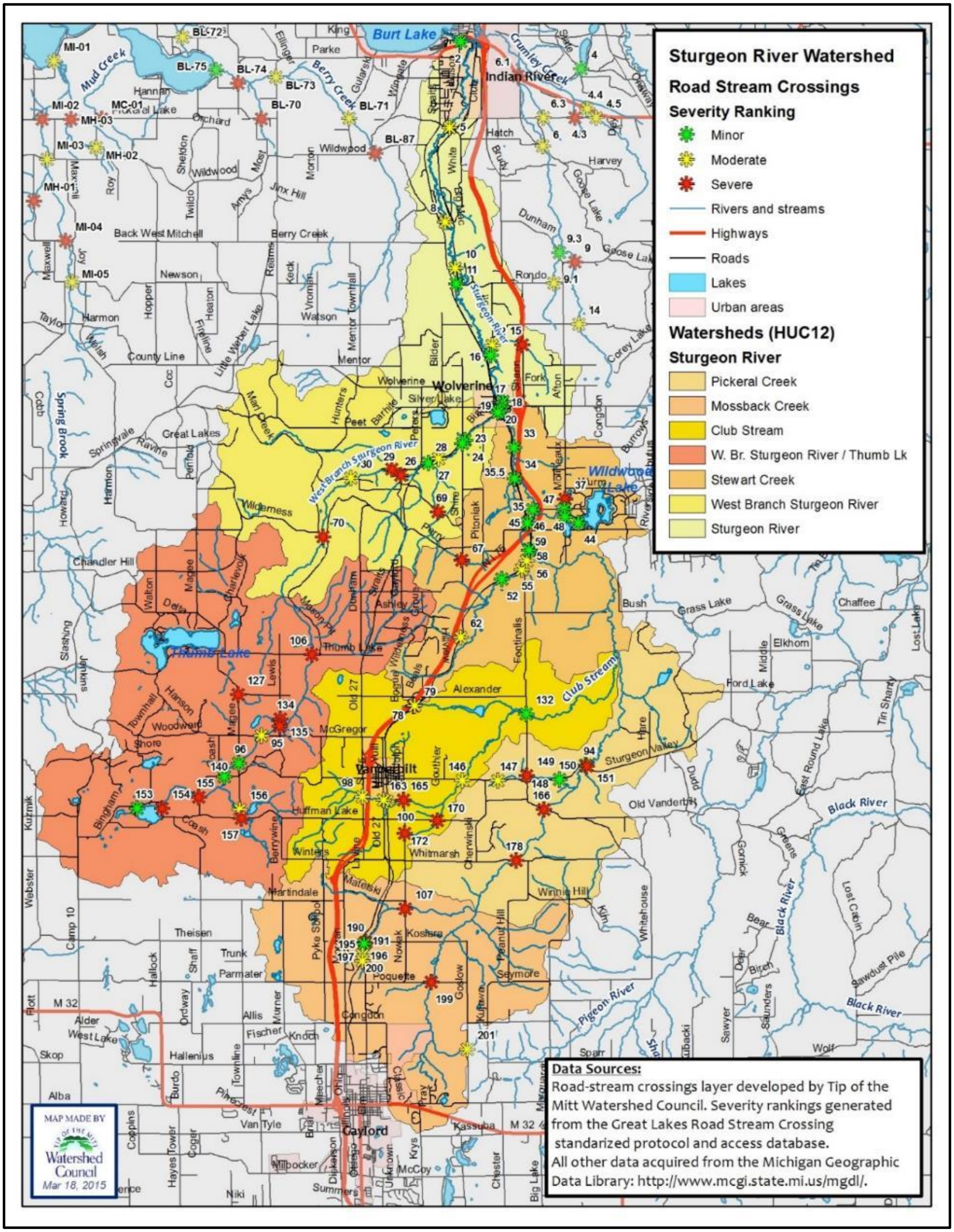


Figure 98: Sturgeon River Watershed road/stream crossing inventory

Of the 168 inventoried, 62 ranked as severe. Nearly half of those RSXs are within the Sturgeon River Subwatershed (Table 21)(Figure 99).

Table 21: Road/Stream crossing severity ranking by subwatershed

	Road/Stream Crossing Severity Ranking		
Subwatershed	Severe	Moderate	Minor
Burt Lake Direct Drainage	9	2	2
Crooked River	15	19	7
Maple River	9	8	11
Sturgeon River	29	27	30
All Subwatersheds	62	56	50

Similarly, of the 168 inventoried, 50 were determined to be a barrier to most aquatic species at most flows. Of those, nearly half were within the Sturgeon River Subwatershed (Table 22)(Figure 100).

Table 22: Fish passage scores by subwatershed

Subwatershed	Fish Passage Scores			
	0	0.5	0.9	1
Burt Lake Direct Drainage	7	2	4	0
Crooked River	13	12	13	3
Maple River	7	6	15	0
Sturgeon River	23	19	13	31
Total	50	39	45	34

Scores: 1=not a barrier; .9=barrier at high flows; .5= some species and life stages cannot pass at most flows; 0= most species and life stages cannot pass at most flows.

Pollutant loading estimates for sediment were calculated applying the formulas that accompany the Great Lakes Road/Stream Crossing Inventory. Pollutant loading estimates for phosphorus and nitrogen was determined by applying an overall phosphorus concentration of 0.0005 lbP/lb of soil and a nitrogen concentration of 0.001 lbN/lb of soil. Soil texture is determined and a correction factor is used to better estimate nutrient holding capacity of the soil. Sand is the dominant soil texture for the Burt Lake Watershed, thus a correction factor of 0.85 was used.

Table 23: Road/stream crossing: pollutant loading by subwatershed

Subwatershed	Sediment Tons/year	Phosphorus lbs/year	Nitrogen lbs/year
Burt Lake Direct Drainage	24	20	41
Crooked River	13	11	22
Maple River	15	13	26
Sturgeon River	140	119	238
Total	192	163	327

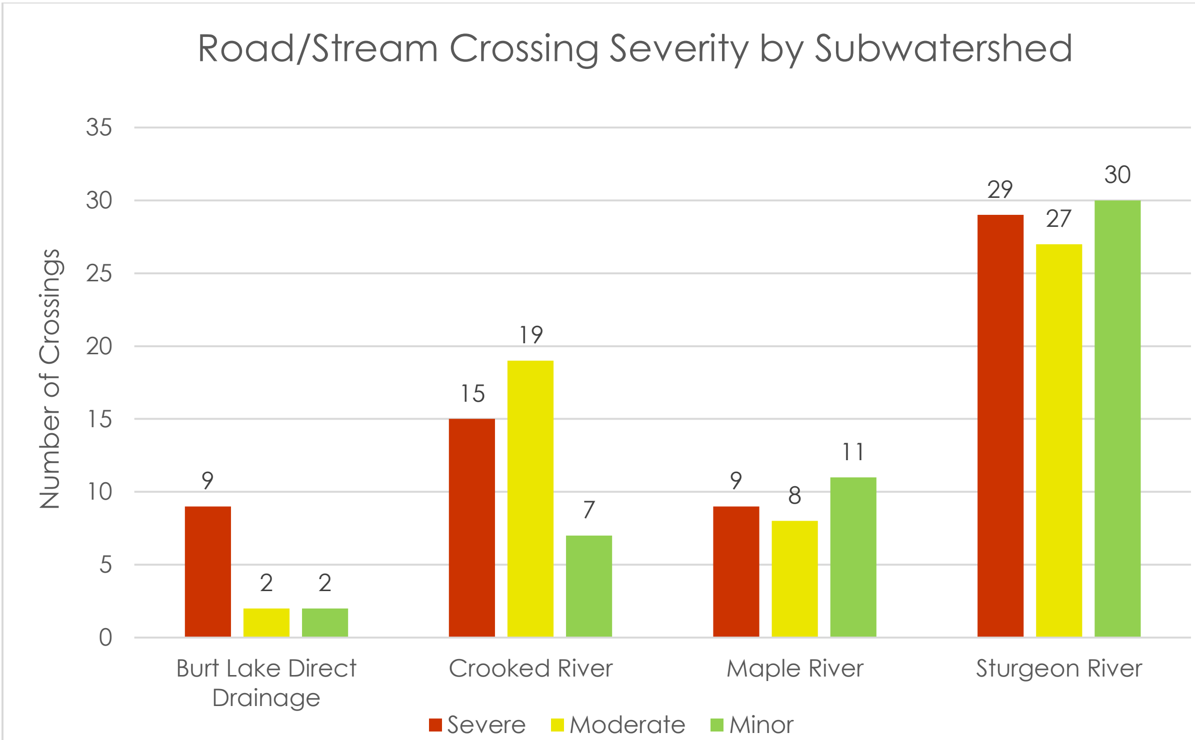


Figure 99: Road/stream crossing severity by subwatershed

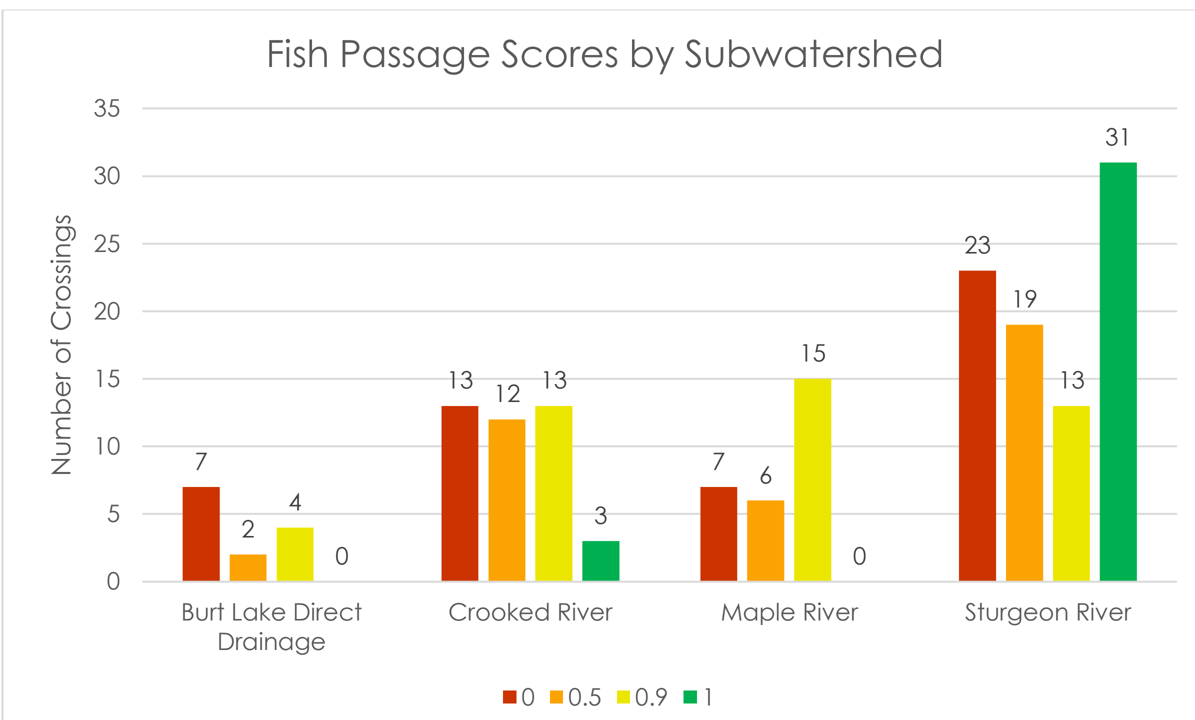


Figure 100: Fish passage scores by subwatershed


Figure 101: Minnehaha Creek at Maxwell Road (TOMWC)

Agricultural Inventory

The Burt Lake Watershed has 33,644 acres of agricultural landcover, representing 9.07% of the total Watershed area (Table 24). Of the agricultural landcover, 28,970 acres (86.11%) is cropland while 4,674 acres (13.89%) is pasture or hay (Table 25). Common agricultural activities include producing corn, cows, horses, hay, grapes, maple trees, wheat, ornamental trees, and small-scale apiaries. In 1985, the Watershed had 30,742 acres of agricultural landcover representing 8.28% of the total Watershed area (Table 26). Between 1985 and 2010, agricultural landcover increased by 2,902 acres (0.78%)(Table 27).

Table 24: Agricultural lands by subwatershed IN 2010 (NOAA 2010)

Subwatershed Name	Size (acres)	Agriculture (acres)	Agriculture (%)
Burt Lake Direct Drainage	40,753	1,982	5
Crooked River Watershed	97,343	9,437	10
Maple River Watershed	107,061	13,184	12
Sturgeon River Watershed	125,974	9,041	7
Burt Lake Watershed	371,131	33,644	9

Table 25: Cropland and pasture/hay by subwatershed (NOAA 2010)

Subwatershed Name	Cropland (acres)	Cropland (%)*	Pasture / Hay (acres)	Pasture / Hay (%)*
Burt Lake Direct Drainage	1,723	86.93%	259	13
Crooked River Watershed	8,127	86.11%	1,310	14
Maple River Watershed	10,968	83.19%	2,216	17
Sturgeon River Watershed	8,152	90.17%	889	10
Burt Lake Watershed	28,970	86.11%	4,674	13.89%

*As a percentage of total agricultural land.

Table 26: Agricultural lands by subwatershed in 1985 (NOAA 1985)

Subwatershed Name	Size (acres)	Agriculture (acres)	Agriculture (%)
Burt Lake Immediate Watershed	40,753	1,700	4
Crooked River Watershed	97,343	7,855	8
Maple River Watershed	107,061	12,405	12
Sturgeon River Watershed	125,974	8,782	7
Burt Lake Watershed	371,131	30,742	8

Table 27: Agricultural landcover change by subwatershed 1985-2010 (NOAA)

Subwatershed Name	Agriculture Change 1985-2010 (acres)	Agriculture Change 1985-2010 (%)*
Burt Lake Immediate Watershed	282	1
Crooked River Watershed	1,582	2
Maple River Watershed	780	1
Sturgeon River Watershed	259	<1
Burt Lake Watershed	2,903	1

*As a percentage of subwatershed agricultural landcover acreage.

Seven farms in the Burt Lake Watershed are verified by the Michigan Agriculture Environmental Assurance Program (MAEAP). MAEAP is a voluntary program that ensures farms are engaging in pollution prevention practices that are cost-effective, pollution minimizing, and complying with environmental regulations. The MAEAP program promotes scientific farming standards designed to protect natural resources, including minimizing fertilizer use and safe storage of fuel and chemicals.

Table 28: MAEAP certified farms

Subwatershed Name	# MAEAP Farms
Burt Lake Immediate Watershed	0
Crooked River Watershed	4
Maple River Watershed	0
Sturgeon River Watershed	3
Total	7

Agricultural pollutant loads can be found in Table 14, Table 15, Table 16, Table 17, and Table 18.

Burt Lake Direct Drainage

The Burt Lake Direct Drainage has 1,982 acres of agricultural landcover, representing 4.86% of the total drainage area. Of the agricultural landcover, 1,723 acres (86.93%) is cropland while 259 acres (13.07%) is pasture or hay. The majority of agriculture activity is in the southwest corner of the Watershed by Hasler Creek and Poverty Bay (Figure 102). Common agricultural activities include growing corn, cows, and horses. In 1985, the drainage had 1,700 acres of agricultural landcover representing 4.17% of the total area. Between 1985 and 2010, agriculture increased 282 acres (0.69%).

The inventory visited six farms in the southwest corner of the drainage. Of these farms, four are determined to have a very low water resource impact, one a moderate impact, and one a high impact. The high impact farm is located near Poverty Bay due to steep slopes, erosion, proximity to water bodies, and an incomplete riparian buffer. Three of the inventoried farms had cow pasture near creeks; however, each farm had a 30’ to 100’ riparian buffer. No farms are MAEAP verified.

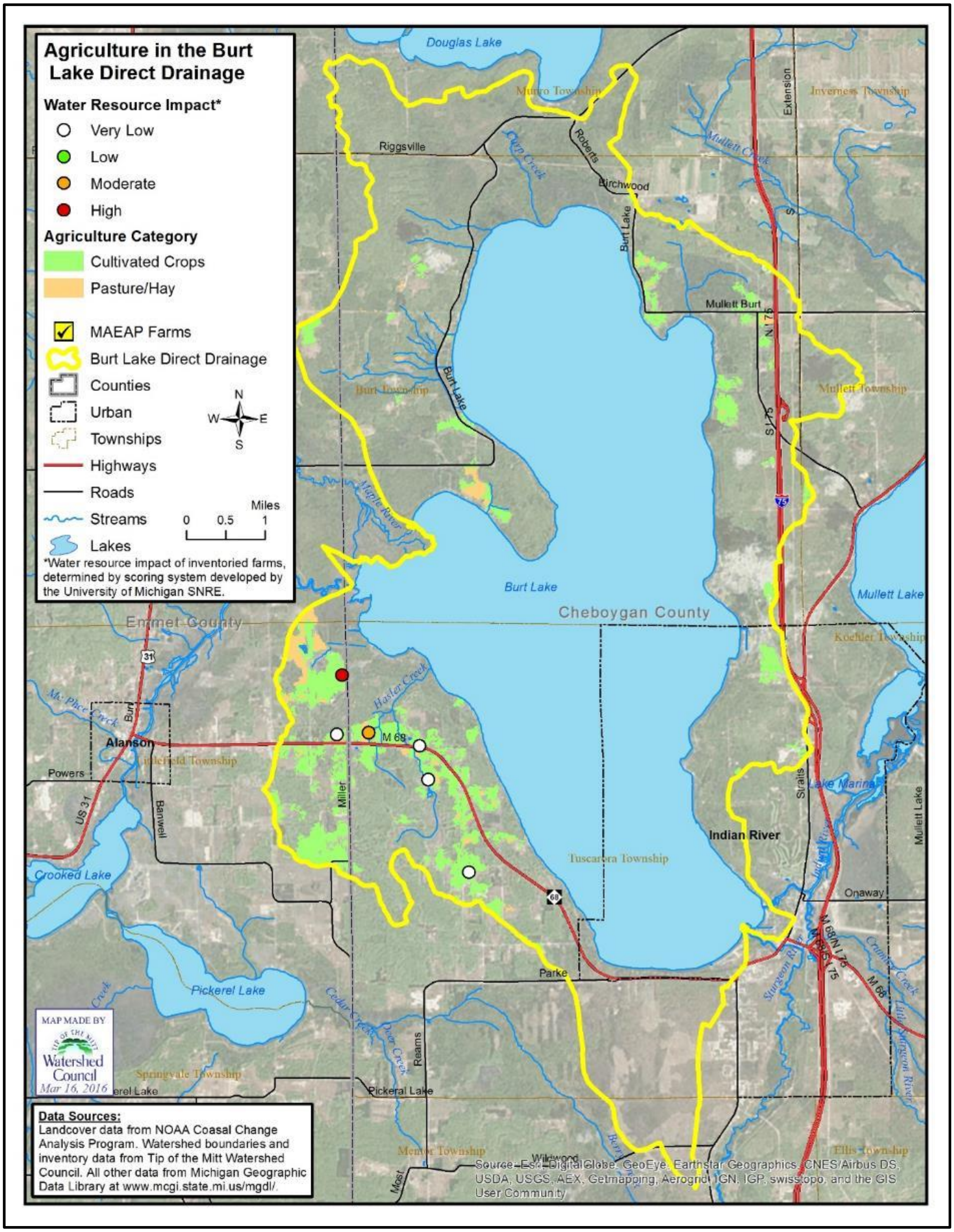


Figure 102: Agriculture in the Burt Lake Direct Drainage

Crooked River Watershed

The Crooked River Watershed has 9,437 acres of agricultural landcover, representing 9.70% of the total drainage area. Of the agricultural landcover, 8,127 acres (86.11%) is cropland while 1,310 acres (13.89%) is pasture or hay. The areas with densest agriculture activity are southeast of Alanson in between Pickerel Lake and M68 Littlefield Township surrounding East Mitchell and Atkins Rds. by Minnehaha Creek at the mid-western side of the Watershed in Bear Creek Township, and along Maxwell Rd. by Minnehaha Creek at the southwestern side of the Watershed in Springvale Township (Figure 103). Common agricultural activities include growing hay, cows, grapes, horses, corn, and maple trees. In 1985, the Watershed had 7,855 acres of agricultural landcover, representing 8.07% of the total area. Between 1985 and 2010, agricultural landcover increased by 1,582 acres (1.63%). This is the largest percent increase of the major Subwatersheds of Burt Lake, with the most increase in the southwest portion of the Watershed near Minnehaha Creek.

The field inventory visited 24 farms throughout the Watershed. Two farms were visited near McPhee Creek, five southeast of Alanson, fourteen in the Midwest to southwest portion of the Watershed, and three near the southern end of the Watershed. Of these farms, nine were determined to have a very low water resource impact, six a low impact, three a moderate impact, and six a high impact. One farm with a high water resource impact was located along McPhee Creek in northern Littlefield Township. This farm scored high because of steep slopes, livestock access to the Creek, and a lacking riparian buffer. Three farms with a high impact were in the headwaters of the Minnehaha Creek West Branch in western Bear Creek Township. These farms scored high because of steep slopes, severe erosion, incomplete riparian buffers, and livestock access to the Creek (Figure 104). Two farms with a high impact were near Minnehaha Creek in southwestern Springvale Township. One of these farms had severe erosion, an inadequate riparian buffer, and livestock accessing the Creek; the other had steep slopes and a lacking riparian buffer. Five farms in the Watershed are MAEAP verified: one in the north portion of the Watershed near McPhee Creek in southwestern Maple River Township; one southeast of Alanson in northeastern Littlefield Township; one along East Mitchell Rd. in western Bear Creek Township; one along Pickerel Lake Rd. in northern Springvale Township; and one near Weber Lake in southwestern Mentor Township that straddles the border of the Sturgeon River Watershed.

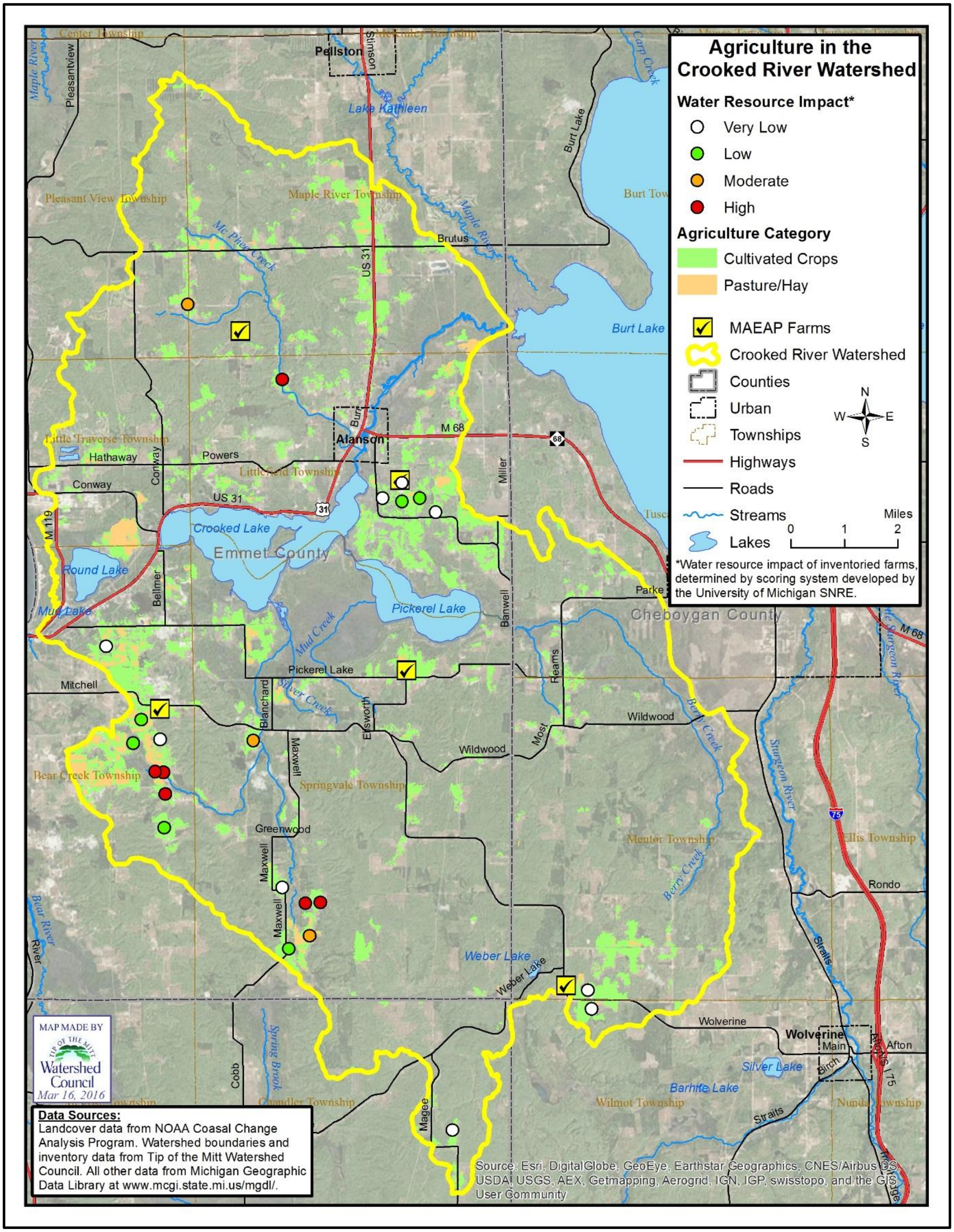


Figure 103: Agriculture in the Crooked River Watershed

Figure 104: Livestock access to stream in Crooked River Watershed

Maple River Watershed

The Maple River Watershed has 13,184 acres of agricultural landcover, representing 12.31% of the total area. This is the highest percentage of agricultural landcover of the major Subwatersheds of Burt Lake. Of the agricultural landcover, 10,968 acres (83.19%) are cropland while 2,216 acres (16.81%) are pasture or hay. The areas with densest agriculture activity are near the Maple River south of Pellston in northeast Maple River Township, near Cold Creek and the Maple River West Branch in McKinley and Center Townships, near Certon Creek at the north end of the Watershed in Carp Lake Township, and east of Munro Lake in northern Munro Township (Figure 105). Common agriculture activities include growing wheat, corn, hay, cows, and horses. In 1985, the Watershed had 12,405 acres of agricultural landcover, representing 11.59% of the total area. Between 1985 and 2010, agricultural landcover increased by 780 acres (0.78%).

The field inventory visited 18 farms throughout the Watershed. Three farms were visited by Lake Kathleen in northern Maple River Township; six sites near Cold Creek and the Maple River West Branch in eastern Center Township; two sites north of Pellston in McKinley Township; four sites near Van Creek mostly in McKinley Township; one site along State Rd. in Friendship Township; and two sites in northern Munro Township by Lancaster and Munro Lakes. Of these farms, nine were determined to have a very low water resource impact; three a low impact; three a moderate impact; and three a high impact. The farms with a high water resource impact were all near the confluence of Cold Creek and the Maple River West Branch. These farms scored high due to cow or vehicle access to creeks, steep slopes, severe erosion, and lacking riparian buffers. No farms in the Watershed are MAEAP verified.

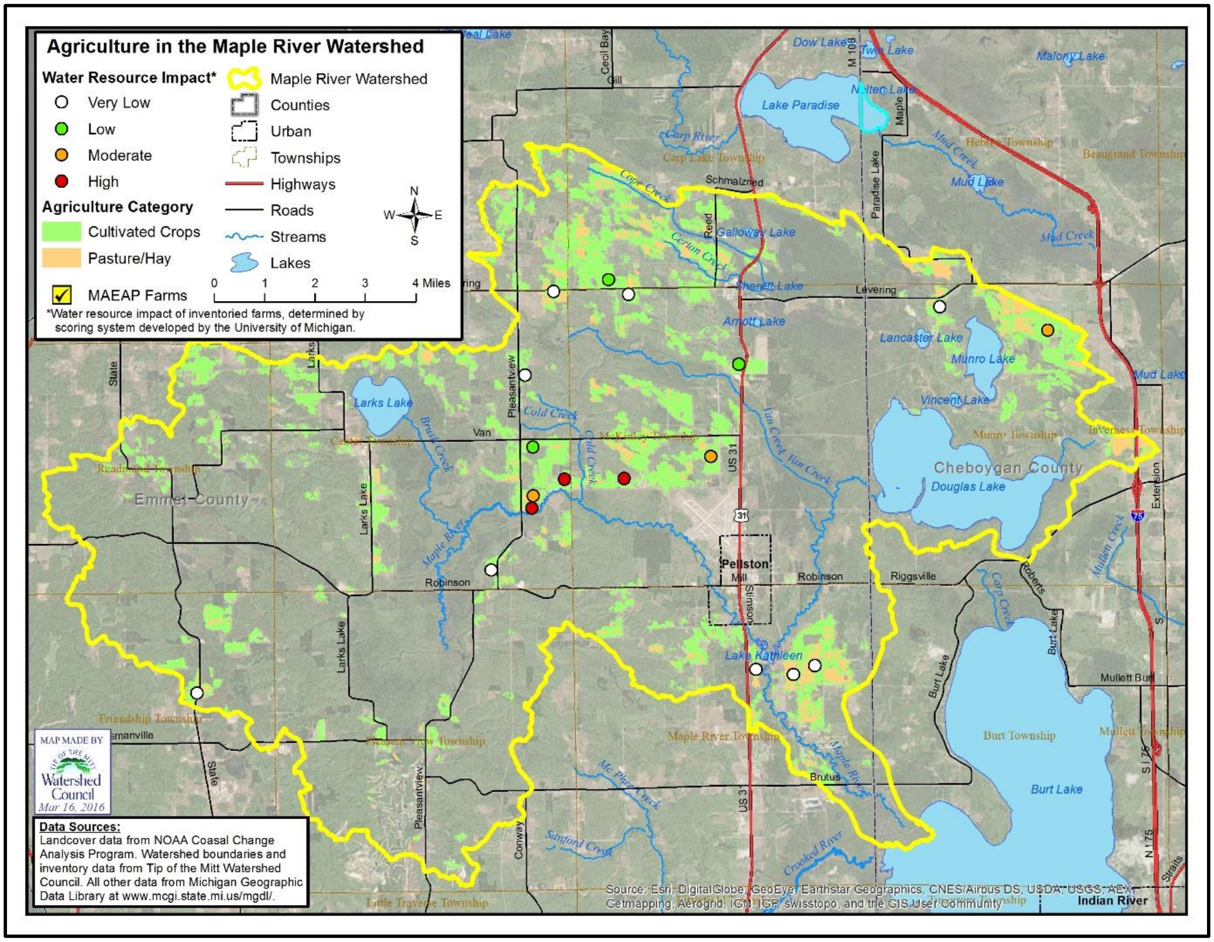


Figure 105: Agriculture in the Maple River Watershed

Sturgeon River Watershed

The Sturgeon River Watershed has 9,041 acres of agricultural landcover, representing 7.18% of the total area. Of the agricultural landcover, 8,152 acres (90.17%) are cropland while 889 acres (9.83%) are pasture or hay. The densest agriculture activity occurs toward the southern end of the Watershed in Livingston Township, near Mossback Creek and the southern reaches of the Sturgeon River. Smaller clusters of agriculture are near Wolverine in western Nunda Township, north of Thumb Lake in southeastern Chandler Township, and west of Huffman Lake in southern Hudson Township (Figure 106). Common agriculture activities include producing corn, hay, horses, cows, ornamental trees, and small-scale apiaries. In 1985, the Watershed had 8,782 acres of agricultural landcover, representing 6.97%

of the total area. Between 1985 and 2010, agricultural landcover increased by 259 acres (0.21%). This is the smallest increase of the major Subwatersheds of Burt Lake.

The field inventory visited eight farms throughout the Watershed. One farm was north of Silver Lake by Wolverine; two farms near the Sturgeon River West Branch in the midwest portion of the Watershed; one farm near Vanderbilt in Corwith Township; and four farms near Mossback Creek in Livingston Township. Of these farms, four were determined to have a very low water resource impact, two a low impact, and two a moderate impact. No sites with a high water resource impact were identified during the field inventory, though two sites near Mossback Creek in Livingston Township have moderate impacts. These two sites have steep slopes but good riparian buffers. Three farms in the Watershed are MAEAP verified: one near Mossback Creek toward the southern end of the Watershed; one by the village of Wolverine; and one straddling the border with the Crooked River Watershed near Weber Lake.

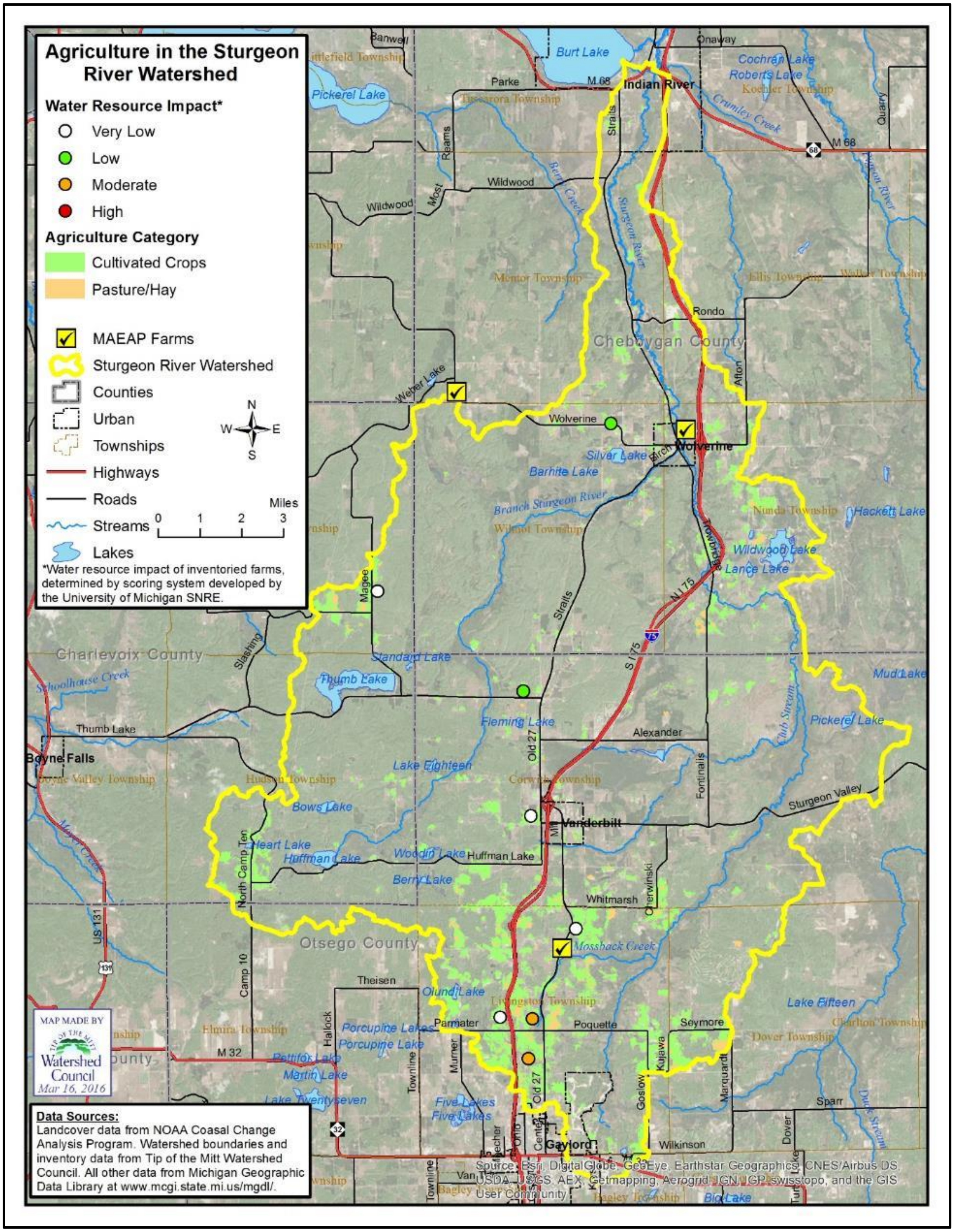


Figure 106: Agriculture in the Sturgeon River Watershed

Forestry Inventory

Forestlands make up the majority of the Burt Lake Watershed. Mixed ownership between State of Michigan and private landowners accounts for the majority of forestlands. Other landholders include the University of Michigan Biological Station, Little Traverse Conservancy, and local government units (Table 29). Forest management under any of the listed entities varies from preservation minded to harvest oriented. Maintenance of unique forest types including old growth, late successional or minimally altered communities is essential for the ecological health of Northern Michigan. However, tree harvest and other extraction-oriented activities are essential to the economic health of Northern Michigan. Applying sustainable and ecologically minded forest management principles to harvest operations can provide a balance between economic gains and ecologic integrity.

Table 29: Forest Ownership within the Burt Lake Watershed

Ownership Type	Acreage	Percentage of Forest
Private	111443	59
State of Michigan	65432	35
University of Michigan (UMBS)	7289	4
Little Traverse Conservancy	3633	2
Other Protected Lands*	425	<1

*Other protected ownership includes local government, other conservancies, and counties.

This forestry inventory aims to identify potential nonpoint pollution sources resulting from forestry practices. Although damage to water resources can vary greatly depending on the situation, the most common issues resulting from forestry activities are surface disturbance and the resultant soil loss and erosion, causing sedimentation of waterways. Some water quality laws aim to reduce the risk of sedimentation and other damage to waterways. In Michigan, Parts 301 and 303 of P.A. 451 protect large streams, rivers, and wetlands from direct ford crossings, filling/ dredging, or damming.

Private Land

Beyond the above regulations, a great deal of discretion is given to the land manager or logging company to implement best management practices (BMPs) and avoid sensitive areas. Stewardship principles and ethics vary amongst landowners, and little has been done to evaluate private landowner attitudes towards minimizing water resource impacts, especially when such efforts would result in a reduced timber harvest. The Natural Resource Conservation Service (NRCS), Michigan Department of Natural Resources (MDNR), and conservation districts offer consultation services for landowners, as well as incentive programs that encourage planned, resource-conscious forest management. Many private companies also offer forestry consultation services and may prepare Forest

Management Plans for government sponsored incentive programs. The five incentive programs available in Michigan are as follows:

1. Forest Stewardship Program – DNR
2. Environmental Quality Incentives Program – NRCS
3. Commercial Forest Program – DNR
4. Qualified Forest Program-Michigan Department of Agriculture and Rural Development (MDARD)
5. American Tree Farm System – American Forest Foundation (AFS)

Watershed Council staff met with NRCS officials to discuss the content of Forest Stewardship Plans and other issues related to forestry practices. The input received during this meeting made clear the efforts of multiple organizations promoting stewardship of private forests. Although plan requirements vary between different programs, they all include measures for water resource protection. Required content includes defining water features and poorly drained soils. Wetland or riparian areas are designated as separate management units. Once this distinction has been made, different management activities are prescribed by the plan developer. For example, a management unit consisting of saturated, mucky soils and small, dense cedar trees would be left uncut for wildlife habitat and aesthetic purposes, considering the low value of timber and risk of water resource damage when harvesting. If harvest must occur, it would need to be done during winter months to avoid rutting, erosion, and associated water resource impacts. Water features are given a buffer in which harvest is limited and selective, if at all. The logistics involved with harvest including equipment access and management of tops/slashing are also addressed. In short, approved Forest Management Plans, when carried out, protect adjacent water resources.

Tax incentives provided by these programs are justified through the public gains of a properly managed forest resource. Economic improvements such as timber quality, properly timed harvest, and use of professional forestry services are facilitated through forest management plans. Improved biological diversity, wildlife viewing, and hunting opportunities on surrounding lands are provided by managing for wildlife habitat. As water quality is protected, all area residents benefit. Landowner education is also an important aspect of forest management plan development. After meeting with a forester, landowners express new appreciation for the natural resources found on their land. They are more likely to implement voluntary BMPs. They also move forward with a working knowledge of their forest resource, and are more likely to avoid the pitfalls associated with "quick and dirty" logging operations that neglect resource protection. Currently, 1078 acres of NRCS forest management plans have been adopted within the Burt Lake Watershed. The MDNR has 78 approved state forest stewardship plans within the Watershed, totaling 15,951 acres.

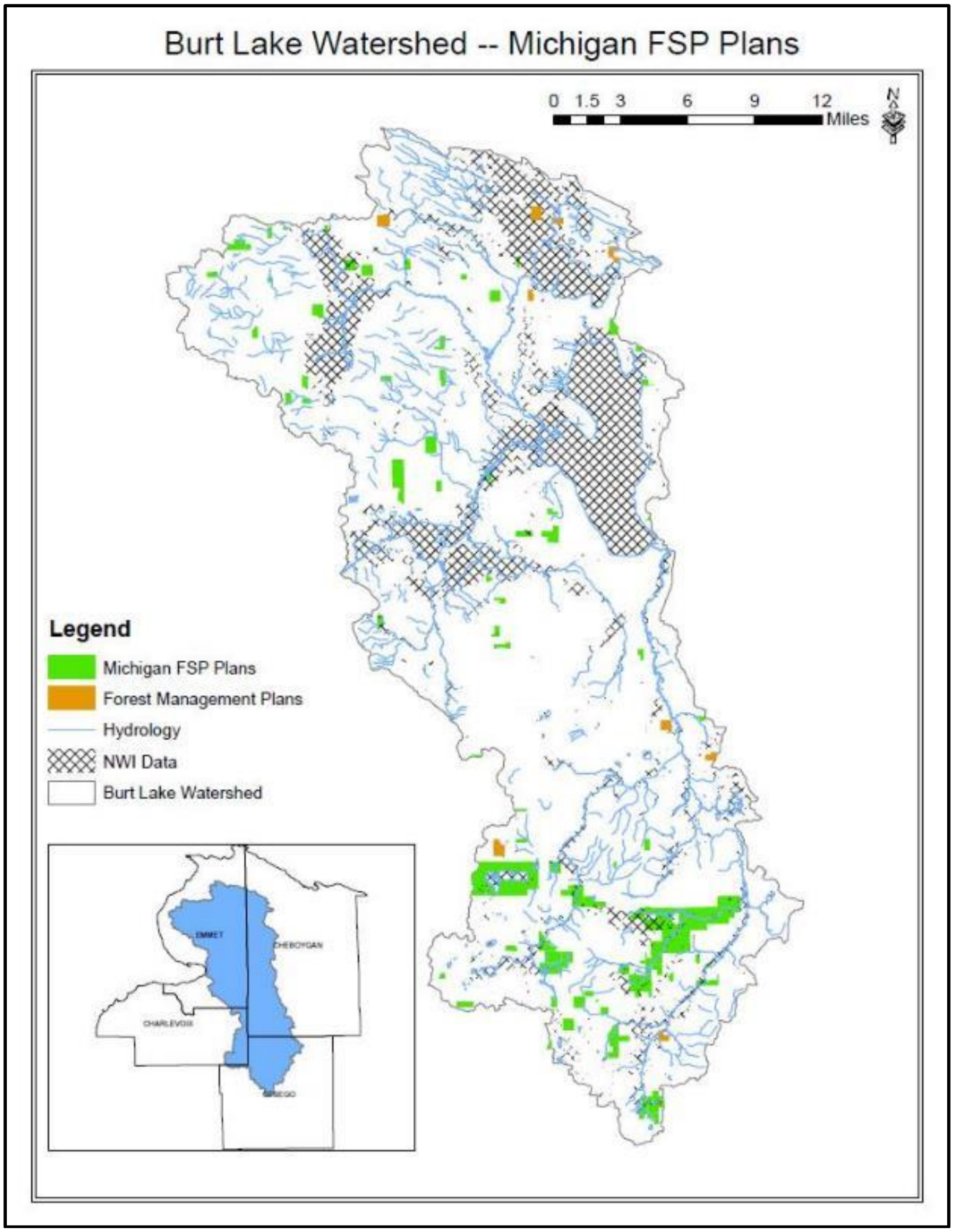


Figure 107: MDNR and NRCS Forest Plans and their proximity to water resources

State Forest

A Meeting with State of Michigan Forest Resources Division officials was conducted as part of the initial information gathering process. The management goals of the MDNR were outlined. Sustainability is paramount in many aspects of their operation, including forest productivity, soil management, and water resources management. Although the state government does little of the actual harvesting, their contracting logging companies are held to these standards through MDNR planning and oversite.

The publication Sustainable Soil and Water Quality Practices on Forest Land serves as a guide for implementation of best management practices (BMPs) and outlines water resource regulations that apply to logging operations. These BMPs are strongly encouraged by the State, and are leveraged through contract negotiation and selection. One such BMP is the designation of Riparian Management Zones (RMZs), also known as buffer strips, filters strips, or streamside management areas or zones. An RMZ occurs on both sides of perennial or intermittent streams and around the perimeter of bodies of open water (e.g. open water wetlands or lakes) where extra precaution is used in carrying out forest management practices including timber-harvesting activities. Michigan's standard RMZ minimum width is 100 feet or 30 meters measured from the top of the bank or the ordinary high water mark of a lake or on each side of a stream.

According to the Sustainable Soil and Water Quality Practices on Forest Land:

One of the purposes of a RMZ is for water quality protection to provide an area of vegetation to interrupt water flow and to trap and filter out suspended sediments, nutrients, chemicals, and other polluting agents before they reach the body of water. An RMZ also provides shade to small streams, thus reducing thermal pollution.

The part of the zone nearest the stream bank can also provide an important contribution to the aquatic food chain. As trees die within the RMZ, all or portions of them may fall over into the adjacent stream. This dead material provides aquatic habitat known as large woody structure (LWS). Naturally occurring LWS in lakes and streams provides essential areas of shaded cover for fish, amphibians and aquatic insects, and can provide important isolated platforms for reptiles and small mammals. In developing a management plan for the RMZ, consider leaving some late successional trees (both coniferous and deciduous) within the RMZ that have the potential to provide LWS to a lake or stream.

Michigan's BMPs do allow for forest management activities within the RMZ. These include equipment operation and timber harvesting. The key is ensuring the water quality protection function of the RMZ is maintained throughout and after the harvesting operation.

Methods

The field component of the forestry inventory involved a Watershed-wide windshield survey, and to a lesser degree, survey on foot. While traveling through any forest land in the Watershed, observations were made when forestry activity was taking place. A survey route line was recorded using a Trimble Juno SB GPS. Specific survey locations were inspected more closely, with pictures taken, and an in-depth assessment of water resource implications was carried out. These survey locations are included on the map and listed below. State forests were targeted due to accessibility, prevalence of harvest, and consistency of management principles. Many special management areas related to water resource protection (as designated by MDNR foresters) were verified in the field. Forestry activities on private land were observed from public road right-of-way whenever possible.

Results

In general, forestry in the Burt Lake Watershed was found to have very little impact on aquatic resources. Many harvest operations are situated in upland areas, where soil nutrient and drainage characteristics yield the highest productivity forests. Lowland areas (which often host rivers, streams, and lakes) are generally less productive than uplands and offer greater logistical challenges to timber harvest. This geographic separation helps to reduce the number of harvest operations that occur adjacent to water bodies, and therefore reduces the risk of aquatic resource impacts. Nevertheless, this distinction does not apply to every water body, as some rivers, lakes, and streams are situated in prime timber producing forests with little wetland buffer. During the survey, no major streams were found to have logging activity immediately adjacent. No fords for logging equipment were found. Infrastructure related to harvest operations was found to be impactful to aquatic resources in some cases. Logging operations in uplands adjacent to water resources posed a risk due to erosion and channel formation, which has the potential to carry sediments to the water body. Road creation in intermittent or ephemeral drainages is the primary example of this type of high-risk activity.

Figure 108: Burt Lake Watershed Forestry Inventory (BL-3)

BL-3 (Figure 108): This haul road, placed in a ravine, has been damaged by severe gully erosion. Although there is no water in the gully most of the season, it is identified as a stream in the State of Michigan's Geographic Framework. This intermittent stream is not connected to a larger waterbody, so aquatic resource impacts here are minimal, but other similar situations could result in resource damage.

Figure 109: Burt Lake Watershed Forestry Inventory (BL-4)

BL-4 (Figure 109): This upland forest stand yields quality hardwood timber. The steep terrain is too steep for logging equipment to traverse. Leaving the forest floor intact on steep slopes helps guard against soil erosion, which could adversely impact a stream 1300 feet to the south.

Figure 110: Burt Lake Watershed Forestry Inventory (BL-5)

Figure 110): This trash dumpsite is located near the Maple River's West Branch. Although logging roads provide access to public forests, the traffic associated with them can bring problems.

Figure 111: Burt Lake Watershed Forestry Inventory (BL-6)

BL-6 (

Figure 111): This snowmobile trail runs through the center of a large tract of forest that has many mature, marketable trees growing within. Although partial access is afforded by the trail, the soils here have been deemed too wet for harvesting without significant resource damage.

Figure 112: Burt Lake Watershed Forestry Inventory (BL-7 and BL-8)

BL-7 and BL-8 (Figure 112): State of Michigan owned forests provide a protected corridor around the lower portions of Minnehaha, Silver, and Mud Creeks near their outflow into Crooked and Pickerel Lakes. This area has been recognized as one of the Watershed's largest contiguous lowland cedar swamps, and host to numerous threatened and endangered species. Management recommendations are largely non-harvest oriented. Moving logging equipment through a forest with this type of hydrology would be detrimental to water quality.

Figure 113: Burt Lake Watershed Forestry Inventory (BL-2)

BL-2 (Figure 113): The designation "too wet" was assigned to the floodplain of the Maple River just west of Pellston. It appears that no timber species grow here. This scrub-shrub wetland provides value beyond timber production including wildlife habitat, flood regulation, and runoff filtration.

Figure 114: Burt Lake Watershed Forestry Inventory (BF-06)

BF-06 (Figure 114): An offshoot from a logging road led to this ORV ford across the Sturgeon River's West Branch. This crossing was likely contributing sediment to the River until it was restored. Boulders now block the way, and an informative closed sign stands in the middle of the old trail. No other crossings of this type have been identified on streams or rivers within the Watershed.


Figure 115: Burt Lake Watershed Forestry Inventory (BF-01 and BF-02)

BF-01 and BF-02 (Figure 115): The area adjoining this small tributary to the Sturgeon River has been designated a Riparian Management Zone.

Figure 116: Burt Lake Watershed Forestry Inventory (BF-08)

BF-08 (Figure 116): Weber Lake, a small high elevation lake in the upper reaches of the Crooked River Watershed, hosts a state forest campground. The recreational value has been realized by state foresters, and as a result there is no prescribed harvest in this area. Two mature red pines (pictured) stand at the crest of a ridge along Weber Lake. Although these trees are marketable and easily accessed, the trees have been left for aesthetic value.

Other Sites:

B-01: This site was designated as a water quality BMP area by the MDNR. The sandy soils and high slopes would have a high risk of eroding into the nearby Maple River if logged. On the floodplain, the soils were determined to be too wet. These BMP's were verified during the inventory – there were no visible signs of logging in this area.

BF-07: Verified the "too wet" no-harvest management prescription. No harvest had taken place.

BF-03: Verified the no-harvest water quality BMP as designated for this site. No harvest had taken place.

BF-04: Path to the River was closed to vehicles. The steep grade and limited space could create erosion problems and access issues if left open.

BF-05: Surveyed the edge of the "Green Timbers potential old growth and biodiversity area". No cutting had taken place recently.

Forestry pollutant loads can be found in Table 14, Table 15, Table 16, Table 17, and Table 18.

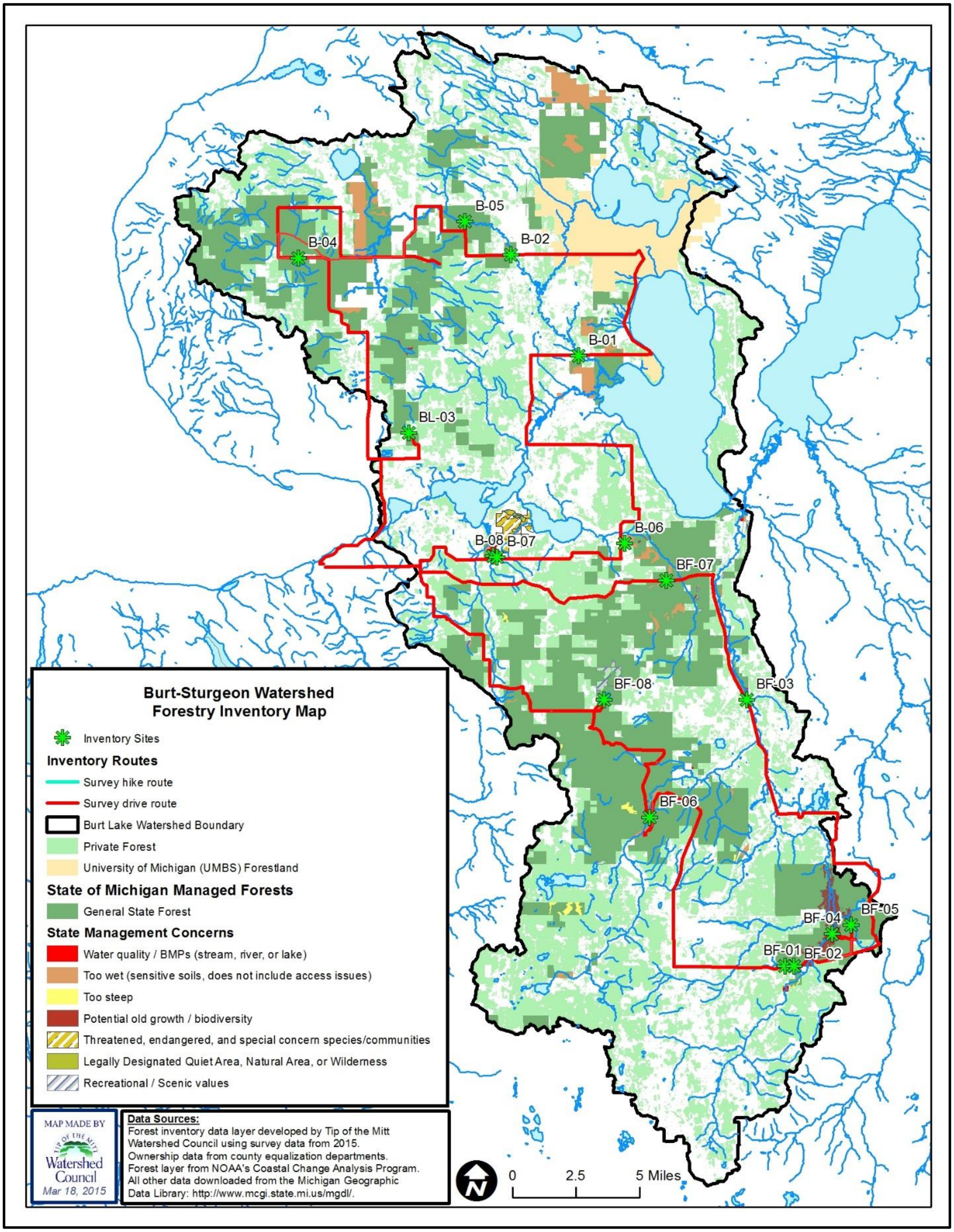


Figure 117: Burt Lake Watershed forestry inventory

Streambank Erosion Surveys

The Burt Lake Watershed's major tributaries were inventoried and evaluated for streambank erosion and alterations. The main channels were inventoried from Crooked Lake to Burt Lake on the Crooked River; from Lake Kathleen to Burt Lake on the Maple River; and from Wolverine to Burt Lake on the Sturgeon River (Table 30). The lower sections of these river systems were inventoried in their entirety. Upstream portions of these tributaries and smaller streams within the Watershed were surveyed using a spot-check system.

Table 30: River segments surveyed for greenbelts, alterations, and erosion

River	Survey Start Point	Survey End Point	Total Mileage
Sturgeon River	Trowbridge Road	Mouth at Burt Lake	19.2
Sturgeon River West Branch	Township Part, Straits Highway	Confluence with river main branch	2.4
Crooked River	Locks at Crooked Lake	Mouth at Burt Lake	8.5
Maple River	Woodland Road below dam	Brutus Road	4.8

Table 31: Streambank alterations along rivers

	Rip Rap		Cement Bulkhead		Wooden Bulkhead		Boulders		Seawall		Mowed / Lawn	
	FT.	%	FT.	%	FT.	%	FT.	%	FT.	%	FT.	%
Sturgeon River	550	<1	610	<1	2550	1.3	800	<1	1790	<1	28603	14
W.Branch Sturgeon River	250	<1	0	0	550	2.1	70	<1	0	0	4565	18
Crooked River	104	<1	370	0.4	8360	9.3	0	0	365	<1	11090	12
Maple River	730	1.4	40	<1	0	0	300	<1	0	0	3938	8
TOTAL	1634	<1	1020	<1	11460	3.2	1170	<1	2155	<1	48196	13

*Percentage of total streambank survey distance on each water body

Table 32: Streambank greenbelt scores

Greenbelt Score	Sturgeon River		Sturgeon River West Branch		Crooked River		Maple River	
	FT.	%	FT.	%	FT.	%	FT.	%
0	6189	3	1307	5	2450	3	0	0
1	6454	3	478	2	16554	19	0	0
2	4233	2	0	0	19711	22	298	<1
3	4847	2	877	3	841	1	546	1
4	4881	2	1326	5	736	<1	414	<1
5	2850	1	0	0	722	<1	934	2
6	1014	<1	309	1	246	<1	1744	3
7	171995	85	21253	83	48452	54	47227	92
TOTAL	202463	1	25550	1	89712	1	51163	100

Greenbelt scores ranged from 0 to 7, representing the greenbelt status or health. Scores of 0 were considered very poor, 1-2: poor, 3-4: moderate, 5-6: good, and 7: excellent.

Table 33: Burt Lake Watershed streambank erosion results for major streams

	Severe Sites	Moderate Sites	Minor Sites
Sturgeon River	47	57	26
Sturgeon River West Branch	0	2	2
Crooked River	0	0	0
Maple River	3	15	7
TOTAL	50	74	35

Sediment loads for major streambank erosion were determined by using a Direct Volume Method for each erosion site. Lateral recession rates (LRR) ranged from .03 to .4, depending on severity, and an average soil weight density for loamy sand/sandy loam of 100.

$$\frac{\text{(eroding area) x (lateral recession rate) x (density)}}{\text{2000 lbs/ton}} = \text{erosion in tons/year}$$

The eroding area is in square feet, the lateral recession rate is in feet/year, and density is in pounds/cubic feet (pcf).

To determine the phosphorus loads, the following formula was used:

Sediment (T/year) x .0005 lbP/lb x 2000 lb/T x soil correction factor (.85)

To determine the nitrogen loads, the following formula was used:

Sediment (T/year) x .001 lbN/lb x 2000 lb/T x soil correction factor (.85)

Table 34: Burt Lake Watershed streambank erosion pollutant loading

	Sediment loading Tons/year	Phosphorus loading lbs/year	Nitrogen loading lbs/year
Sturgeon River Watershed	557	473	947
Maple River Watershed	111	94	189
Crooked River Watershed	4	3	7
TOTAL	672	570	1143

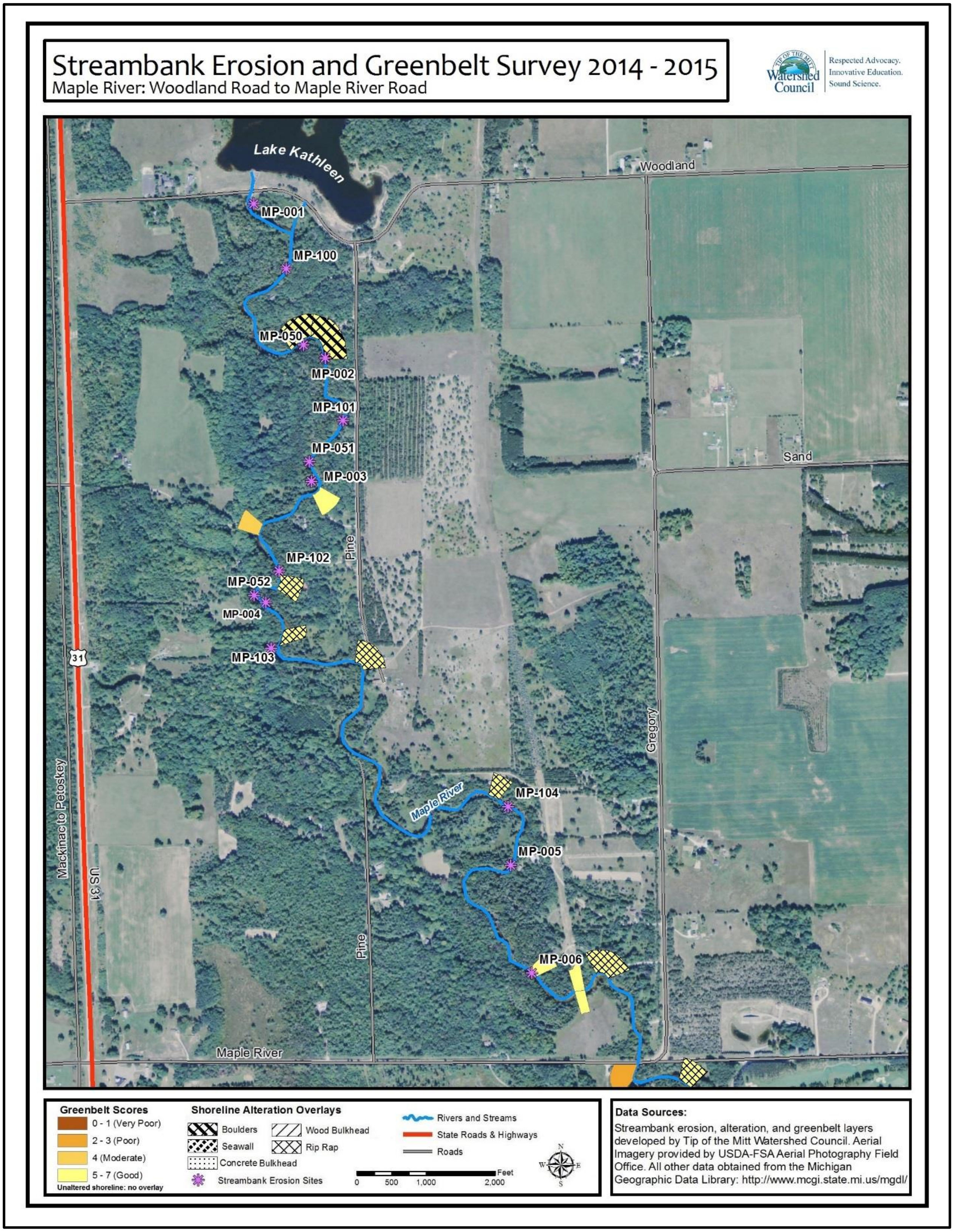


Figure 118: Streambank Erosion and Greenbelt Survey (Maple River: Woodland Rd. to Maple River Rd.)

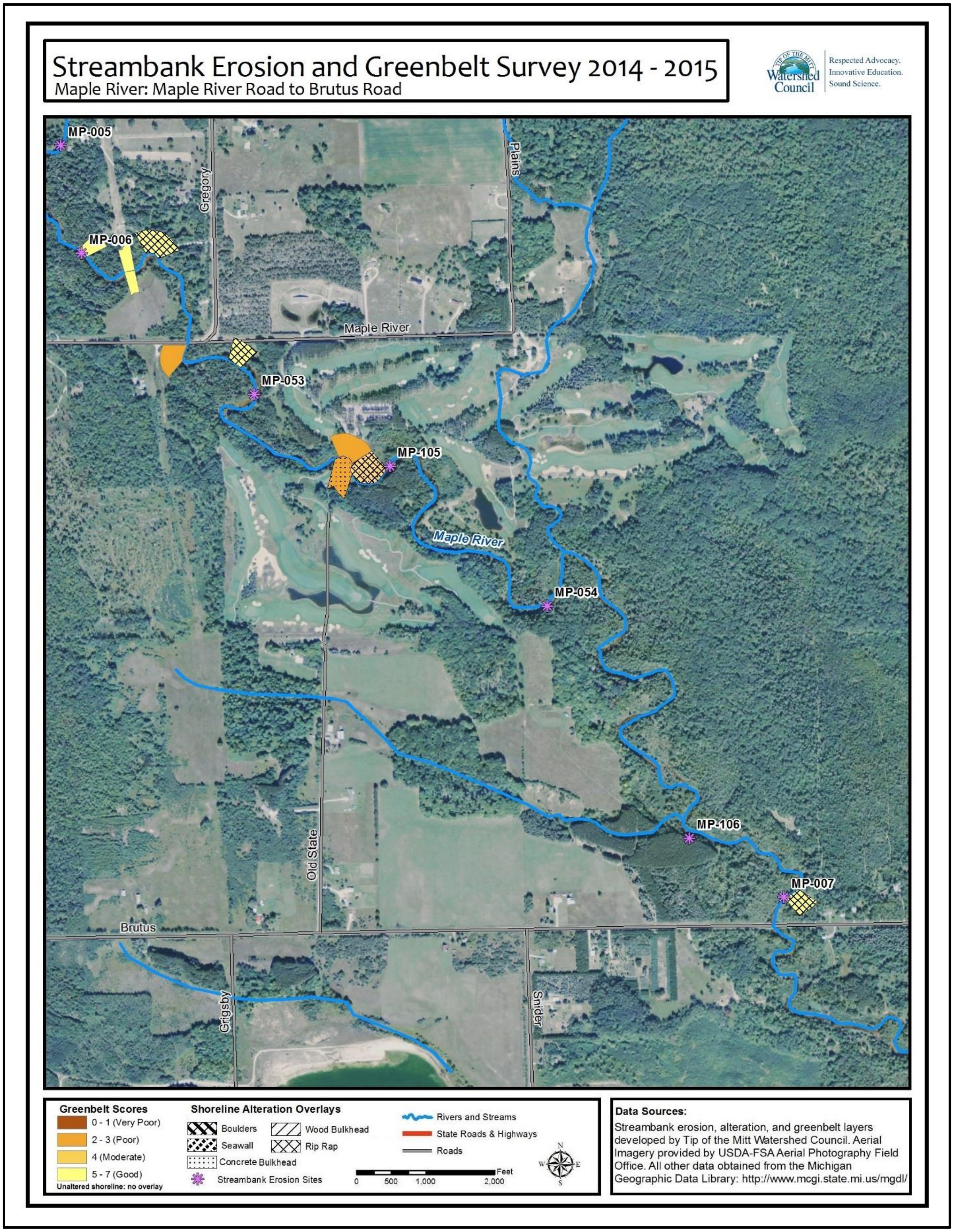


Figure 119: Streambank Erosion and Greenbelt Survey (Maple River: Maple River Rd. to Brutus Rd.)

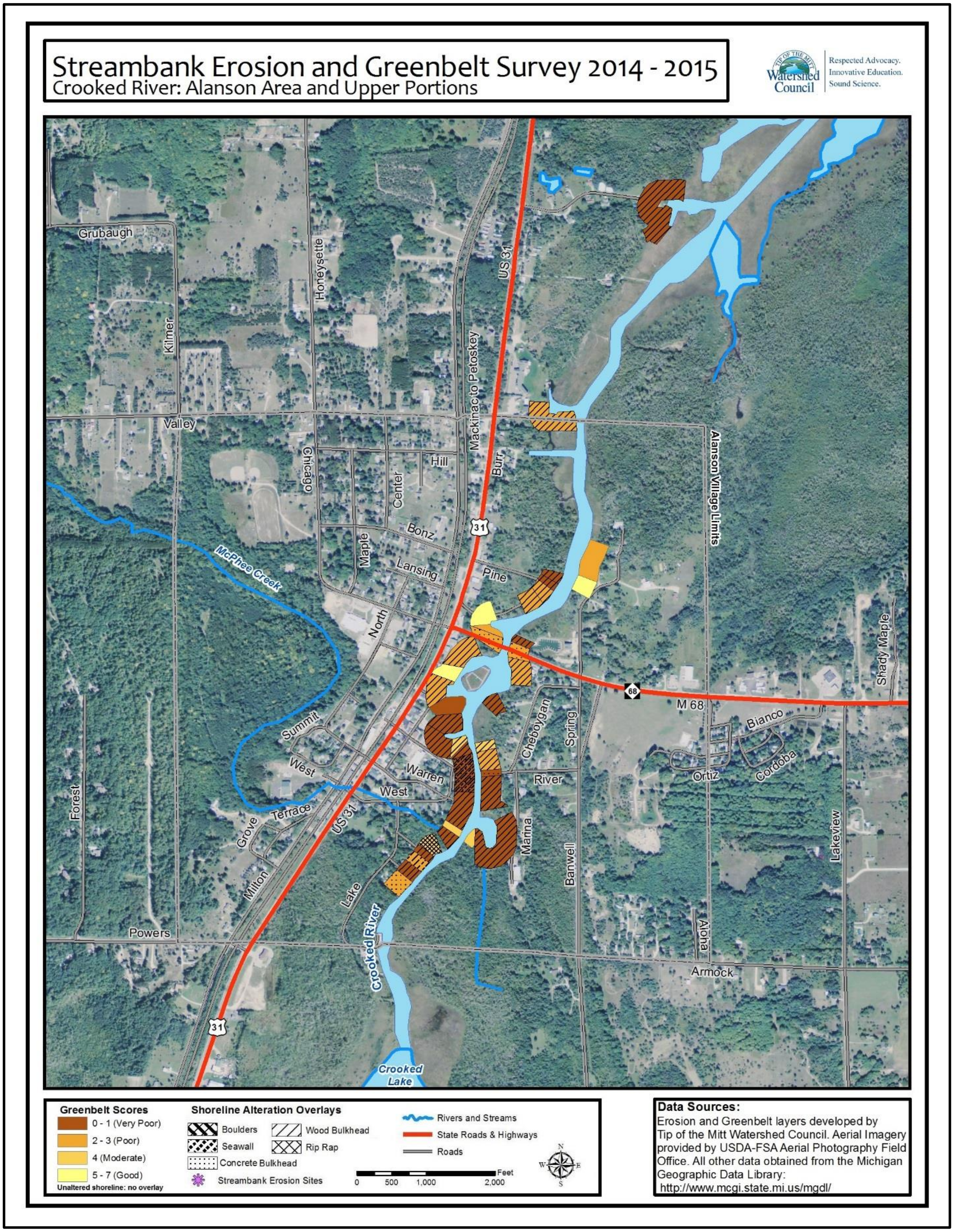


Figure 120: Streambank Erosion and Greenbelt Survey (Crooked River: Alanson area)

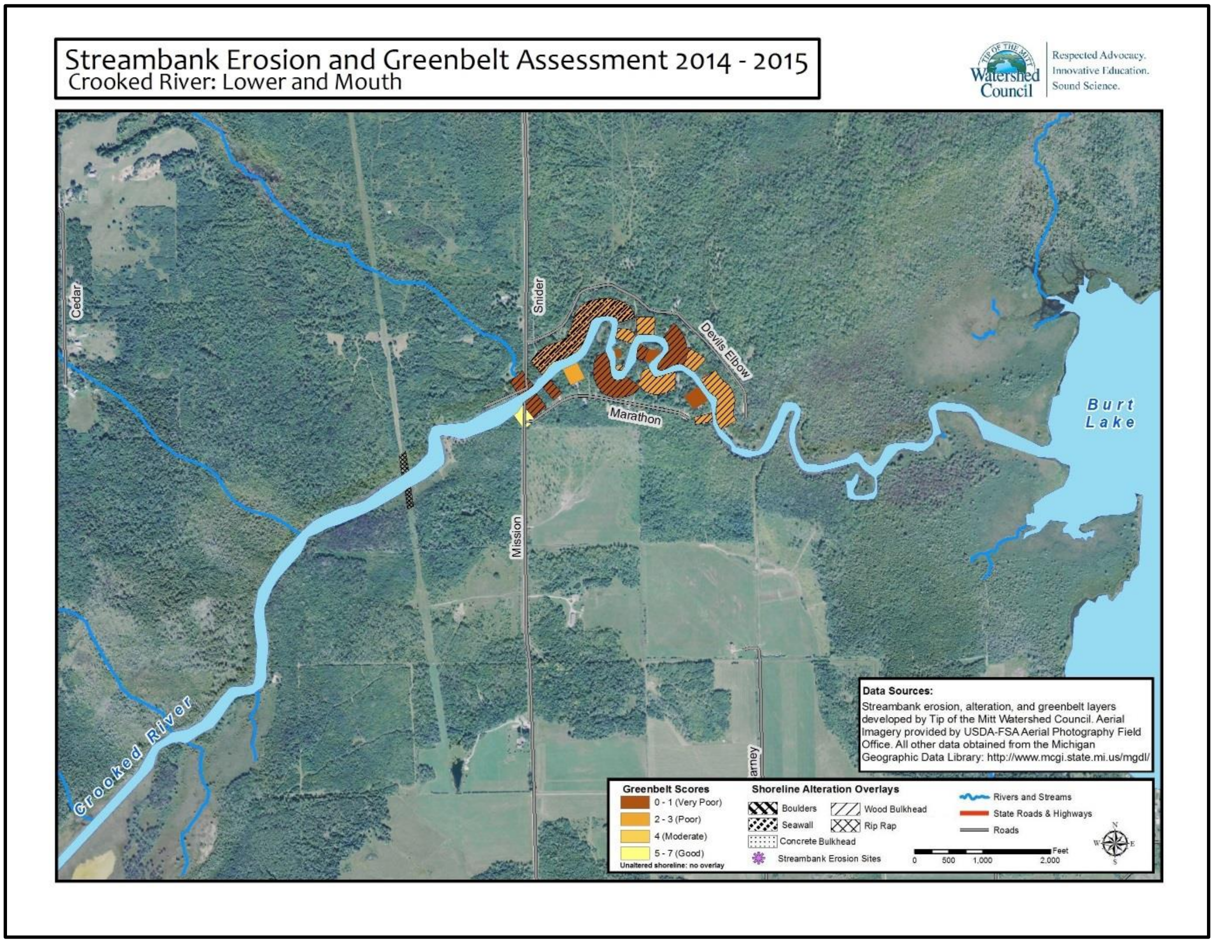


Figure 121: Streambank Erosion and Greenbelt Survey (Crooked River: Lower and Mouth)

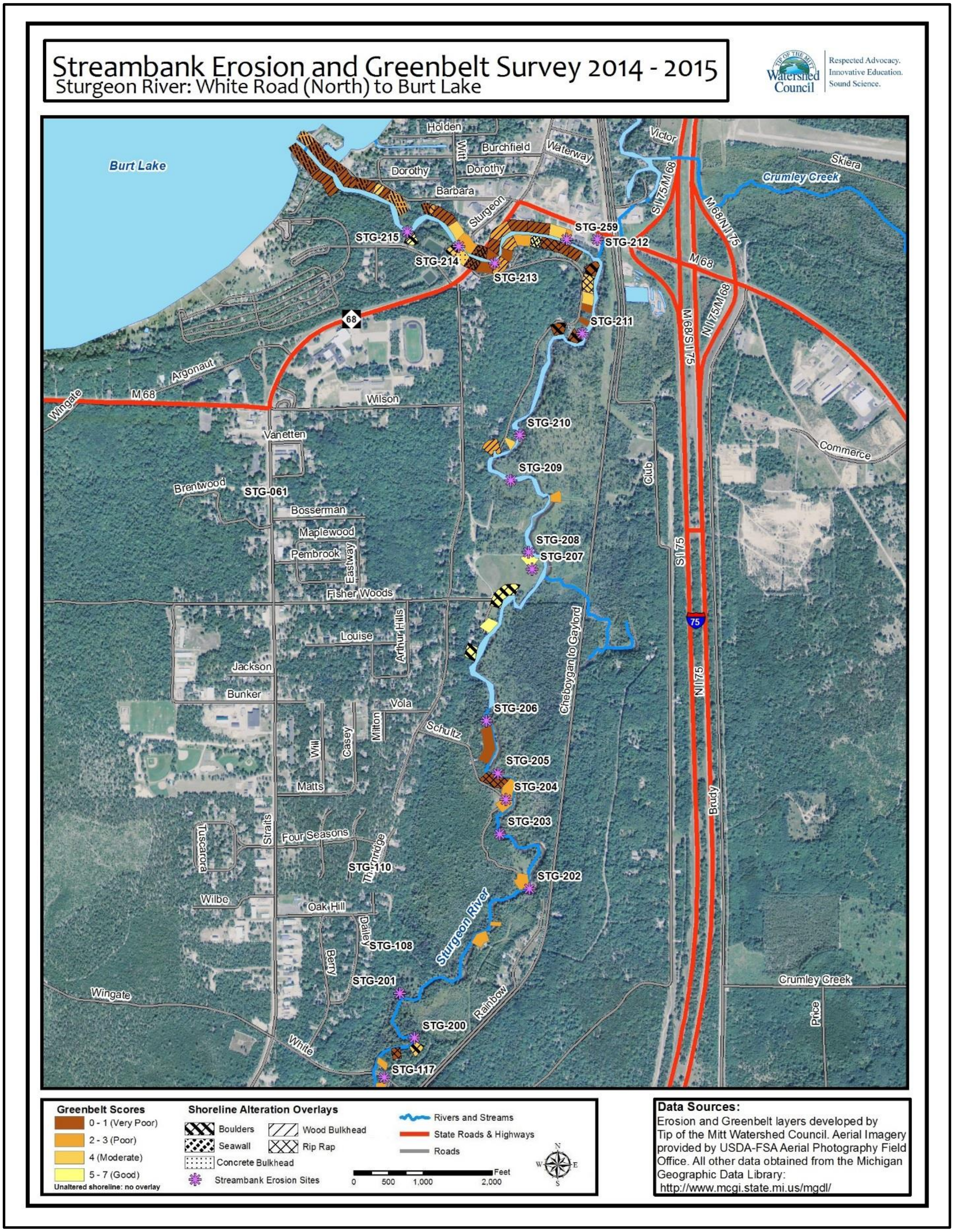


Figure 122: Streambank Erosion and Greenbelt Survey (Sturgeon River: White Rd. (north) to Burt Lake)

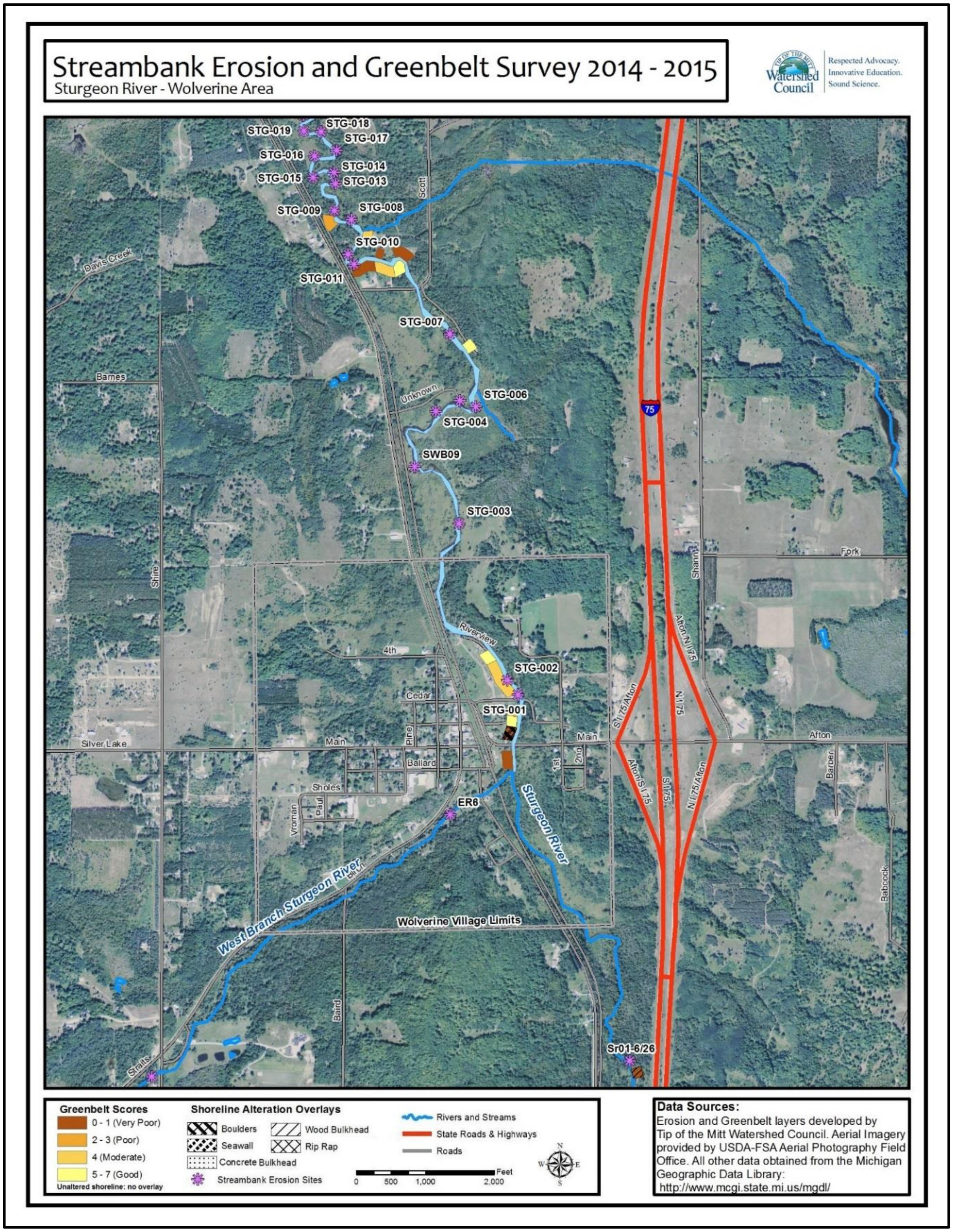


Figure 123: Streambank Erosion and Greenbelt Survey (Sturgeon River: Wolverine Area)

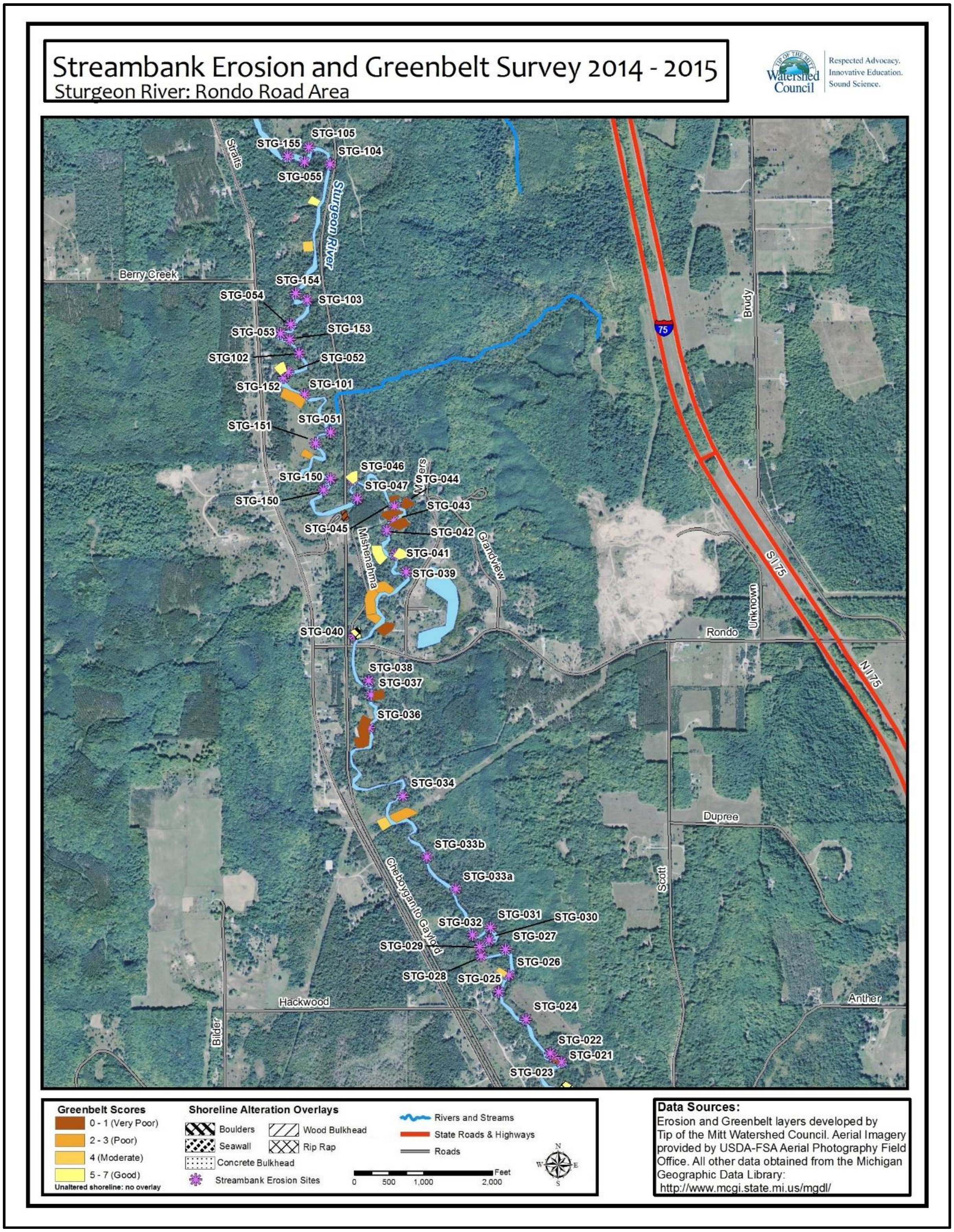


Figure 124: Streambank Erosion and Greenbelt Survey (Sturgeon River: Rondo Rd. area)

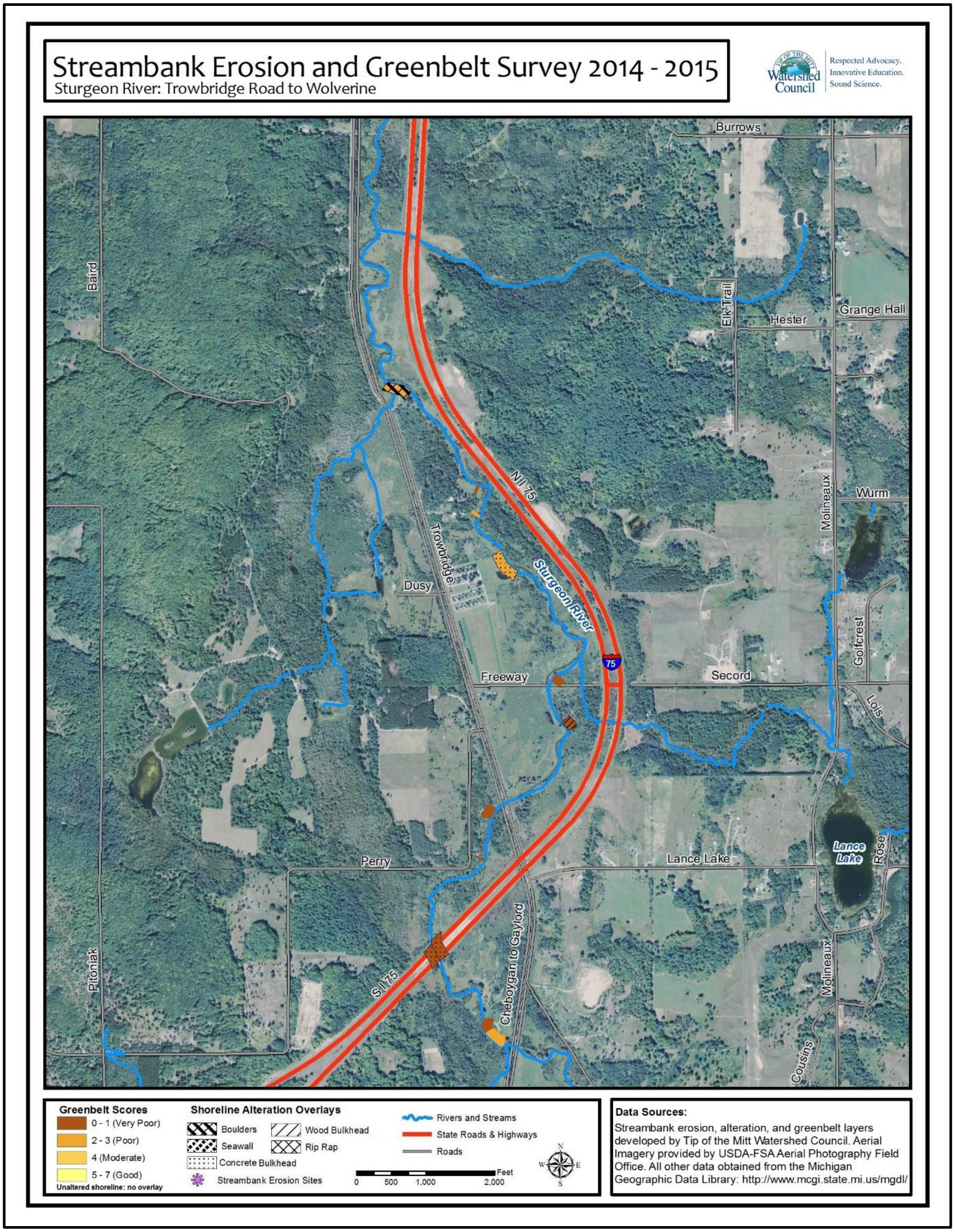


Figure 125: Streambank Erosion and Greenbelt Survey (Sturgeon River: Trowbridge Rd. to Wolverine)

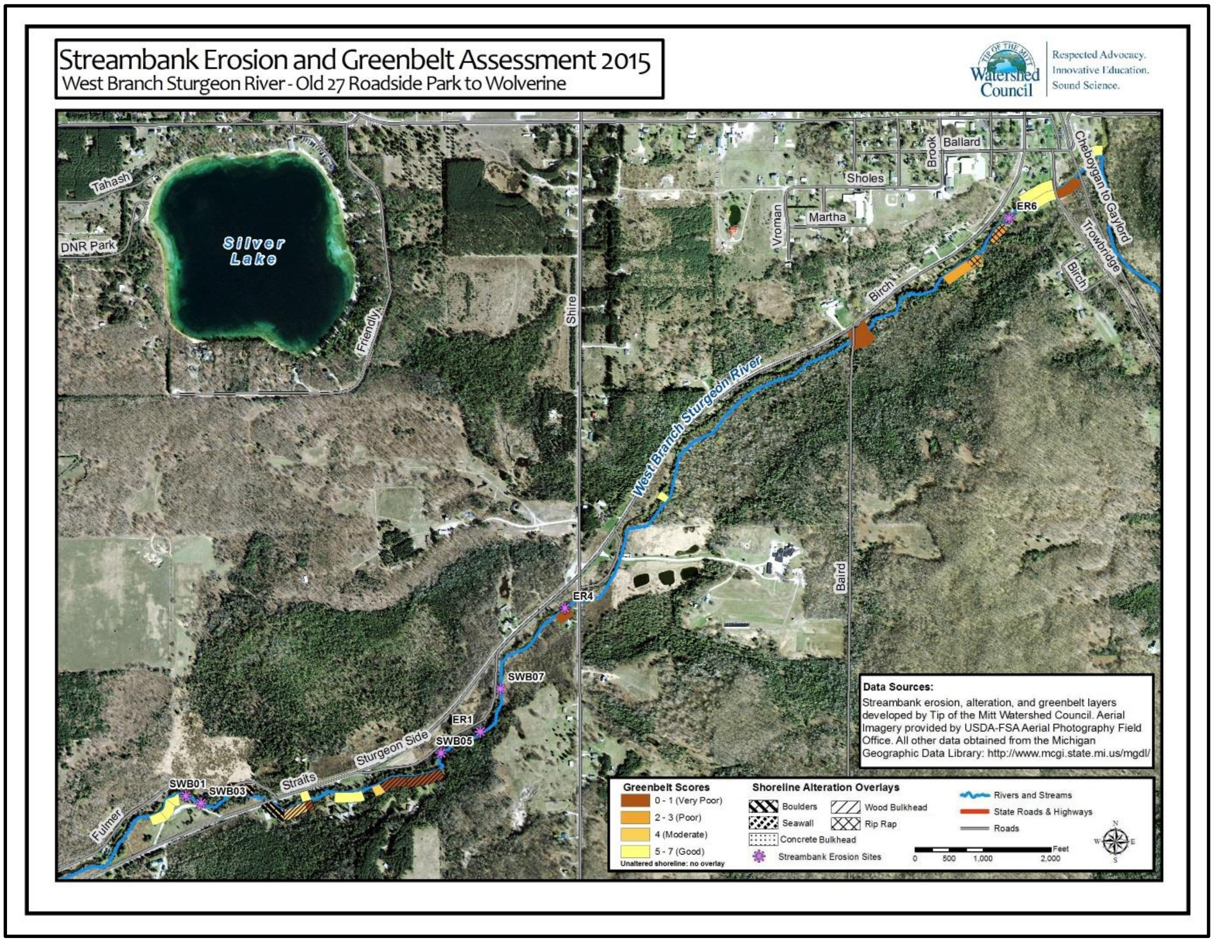


Figure 126: Streambank Erosion and Greenbelt Survey (W.B. Sturgeon: Old 27 Roadside Park to Wolverine)

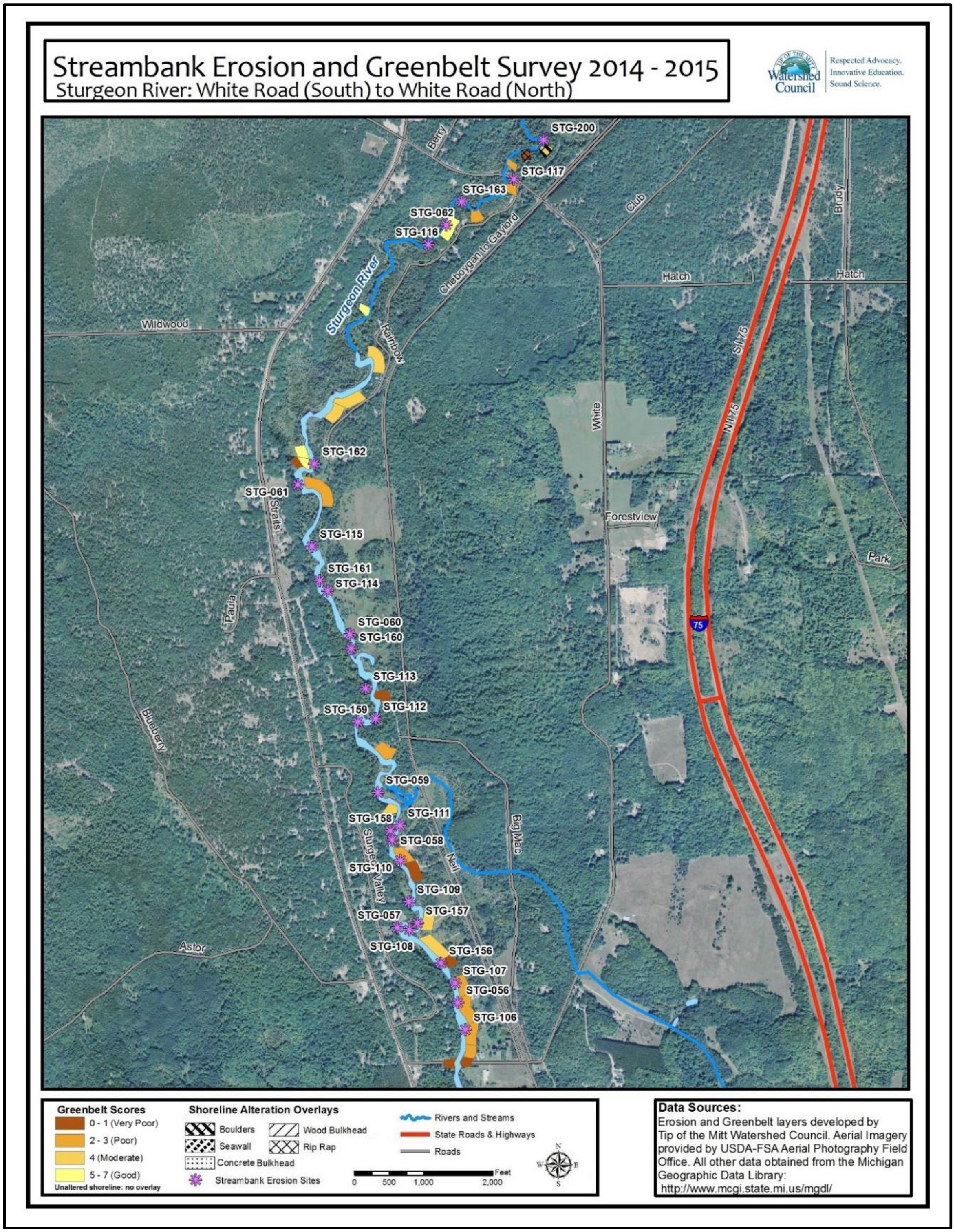


Figure 127: Streambank Erosion and Greenbelt Survey (Sturgeon River: White Rd. (south) to White Rd. (north))

Streambank Inventory for Smaller Streams

Smaller streams were surveyed using a spot-check system at road/stream crossings where erosion was suspected. Surveyors documented streambank conditions 500' upstream and 500' downstream at each crossing. In total, 46 locations were inventoried, which is only a portion of the total, due to the vast number of road/stream crossings throughout the Watershed. In total, 85,000 feet (16 miles) were inventoried. Approximately 11,000' (13%) were noted as having some type of alteration (Table 35).

Table 35: Summary of streambank alterations on smaller streams by subwatershed

	Surveyed (FT.)	Altered (FT.)	Altered (%)
Sturgeon River	20000	2749	14
Crooked River	28000	4036	14
Direct Drainage	8000	2600	33
Maple River	29000	1771	6
TOTAL	85000	11156	13

Table 36: Streambank alterations along smaller streams

	Rip Rap		Cement Bulkhead		Wooden Bulkhead		Boulders		Mowed / Lawn		Other Alterations	
	FT.	%	FT.	%	FT.	%	FT.	%	FT.	%	FT.	%
Sturgeon River	67	<1	0	0	303	1.5	184	1	2195	11	0	0
Crooked River	41	<1	559	2	30	<1	35	<1	516	2	2855	10
Direct Drainage	0	0	0	0	0	0	0	0	0	0	2600	33
Maple River	81	<1	244	<1	80	<1	0	0	568	2	798	3
TOTAL	189	<1	803	1	413	<1	219	<1	3279	4	6253	7

*Percentage of total streambank survey distance within each subwatershed

Table 37: Summary of streambank erosion for smaller streams by subwatershed

	Severe Sites	Moderate Sites	Minor Sites
Sturgeon River	0	2	3
Crooked River	1	4	7
Direct Drainage	0	0	0
Maple River	1	0	0
TOTAL	2	6	10

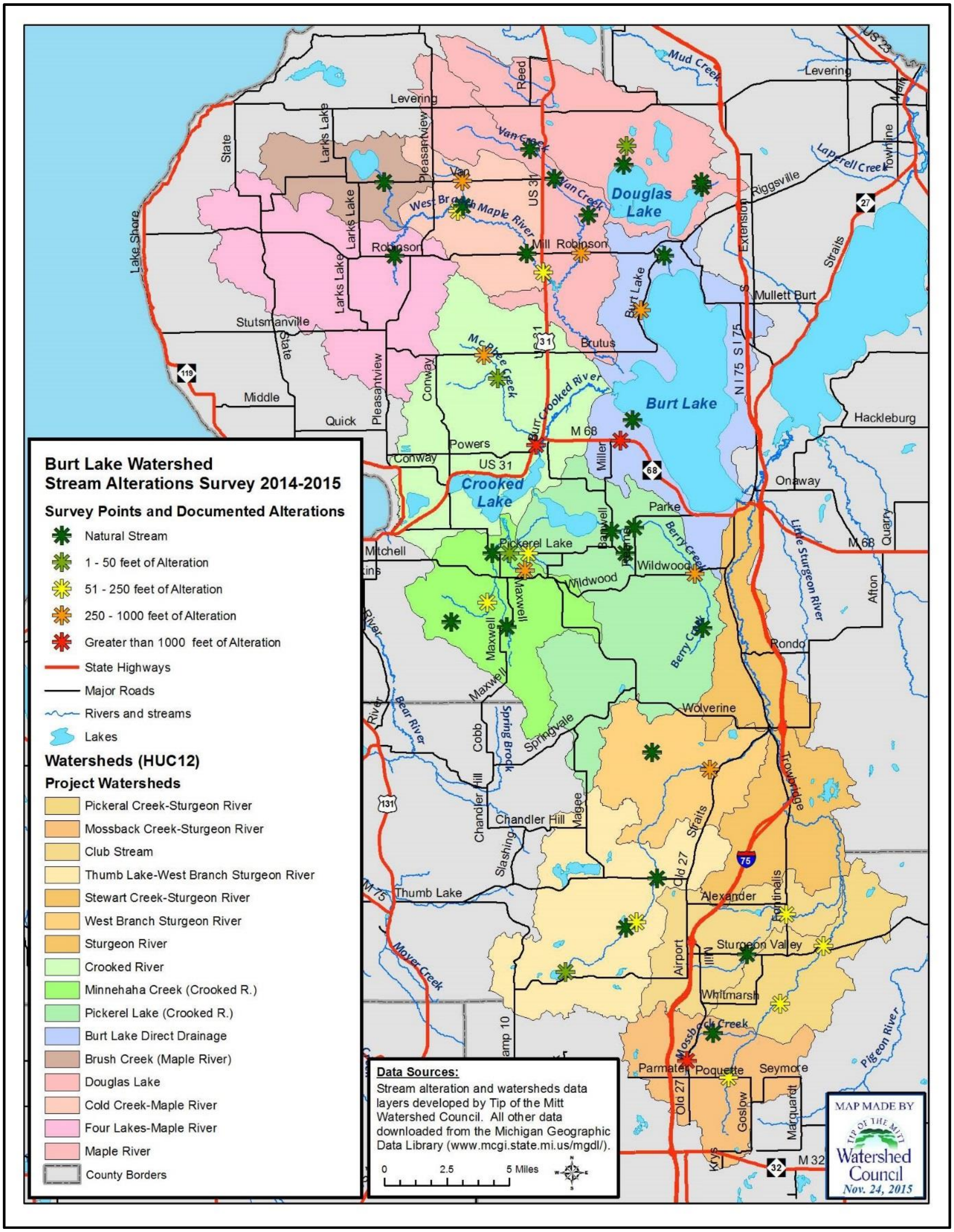


Figure 128: Burt Lake Watershed stream alteration survey

Table 38: Streambank erosion pollutant loading for small streams (spot check)

Subwatershed	Sediment Load (tons/year)	Phosphorus Load (lbs./year)	Nitrogen Load (lbs./year)
Crooked River	2	1.7	3.4
Maple River	.1	.09	.2
Sturgeon River	.5	.4	.85
Burt Lake Watershed	2.6	2.19	4.45

Tributary Monitoring

The management of nonpoint source pollutants in the Burt Lake Watershed requires an understanding of where pollutants originate and degradation exists. To improve the management of these pollutants, the Burt Lake Tributaries Monitoring Project monitored pollutant concentrations and loads near the mouths of eight tributaries of Burt Lake in 2014 and 2015. Dissolved oxygen, temperature, specific conductance, and pH were also monitored. Each site was monitored twice during each spring and fall, for a total of eight monitoring events, capturing both wet event and dry conditions. Sample sites included the mouth of the Crooked River; the Maple River at Brutus Road; Maple Bay Creek at the end of Maple Bay Road; near the mouth of an Unnamed Creek at 3016 West Burt Lake Road; Carp Creek near the mouth; White Goose Creek near the mouth; the Sturgeon River at the mouth; and Hasler Creek at Ellinger Road (Figure 129). These eight tributaries combined contribute an average of 564 cubic feet per second of water to Burt Lake. The tributaries' watersheds represent 337,378 acres, or 91% of the total Burt Lake Watershed area. The remaining 9% of the Watershed consists of direct drainage or small tributaries that were not monitored in this study.

Table 39: Watershed areas of Burt Lake tributaries

Sample Site	Acres	Percent of Total
Carp Creek	1,799	<1
Crooked River	97,334	29
Hasler Creek	1,038	<1
Maple Bay Creek	567	<1
Maple River	107,620	32
Sturgeon River	125,991	37
Unnamed Creek	1,798	<1
White Goose Creek	1,231	<1
Total of Monitored Tribs	337,378	100

Acreage and percentages of urban and agricultural landcover were calculated for each tributary watershed. The Sturgeon River and White Goose Creek have the highest percentage of urban land cover at around 5%. Hasler Creek has the highest agriculture land cover percentage of 24%, followed by the Maple River at 12%. Both urban and agricultural land cover can increase the concentrations and loads of pollutants monitored. Wetland land cover was calculated as well. Wetlands can improve water quality by absorbing nutrients, settling sediment, stabilizing streambanks, and moderating flow. Maple Bay Creek has the highest percent of wetland land cover at over 50%.

Total phosphorus, total nitrogen, and nitrate-nitrogen were monitored during the tributaries study. Michigan Part 4 Water Quality Standards do not include nutrient concentration limits for surface waters. Regulation for surface waters is limited to the following passage from Rule 60 (323.1060): "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." No injurious effects of nutrients were documented during the monitoring.

Although there is no numerical water quality standard, a total phosphorus concentration of 12 µg/L or less for streams in the Northern Michigan ecoregion is preferred by the United States Environmental Protection Agency (USEPA) "because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility" (USEPA 2001). Average total phosphorus concentrations for Maple Bay Creek, Maple River, Unnamed Creek, and White Goose Creek are all above this reference condition. The highest phosphorus concentration, 56 µg/L , occurred on the Maple River. Of the monitored tributaries, the Maple River has the highest deviation in total phosphorus concentrations, and Hasler Creek has the lowest deviation.

The USEPA total nitrogen reference condition is 440 µg/L for minimally impacted conditions for Northern Michigan streams (USEPA 2001). Average total nitrogen concentrations for Hasler Creek, Maple Bay Creek, Maple River, Sturgeon River, Unnamed Creek, and White Goose Creek are above this reference condition. The Sturgeon River has the highest average total nitrogen concentration at 714 µg/L . The Sturgeon River also has the maximum total nitrogen concentration of all monitored streams by a wide margin and the most deviation. Carp Creek has the least deviation and most consistent total nitrogen concentrations.

Sediments in a stream can degrade water quality by increasing turbidity, smothering aquatic habitat, and transporting attached nutrients. Measuring suspended sediment concentration is a way to determine the amount of sediment and other particles in a stream, which is done by drying and weighing the particles in a given volume of water. Silt, clay, and sometimes sand or larger particles can become suspended in the water. Michigan Part 4 water quality standards do not have numerical limits for suspended sediment, but rather a narrative that states "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." Hasler Creek has the highest suspended sediment concentration of all monitored tributaries, with an average of 29.2 mg/L and maximum of over 100 mg/L. The Sturgeon River has the second highest average and maximum suspended sediment concentration of monitored tributaries. However, no exceedances of the narrative standard were documented.

Even though Hasler Creek has the highest suspended sediment concentration, the Creek has a small discharge (0.21% of total), so it contributes less than half a percent of the total suspended sediment load to Burt Lake. The Sturgeon River, however, contributes nearly 70% of the total suspended sediment load. There could be multiple explanations for the high suspended sediment load. Expansive streambank erosion along the lower Sturgeon River, documented during the Streambank Erosion Inventory, is a likely contributor, along with eroding road/stream crossings documented throughout the Sturgeon River Watershed.

Pollutant concentrations and pollutant loads were calculated for the eight tributaries (Table 40). This includes an average daily load of 38 pounds of phosphorus, 406 pounds of nitrate-nitrogen, 1,948 pounds of total nitrogen, 37,545 pounds of chloride, and 45,945 pounds of suspended sediments.

Table 40: Discharge and pollutant loads of tributaries

Discharge and Loads*	Carp Creek	Crooked River	Hasler Creek	Maple Bay Creek	Maple River	Sturgeon River	Un-named Creek	White Goose Creek
Discharge: Low	11.97	53.47	.72	.18	58.45	221.71	.41	.10
Discharge: High	24.66	201.58	1.58	2.26	187.11	357.9	1.93	11.46
Discharge: Average	17.68	142.85	1.16	.87	132.84	263.54	1.14	4.10
Phosphorus, Total: Low	.02	1.01	.02	.04	2.47	2.15	.03	.01
Phosphorus, Total: High	3.2	31.53	.18	.52	56.52	37.07	.37	.84
Phosphorus, Total: Average	1.01	9.06	.07	.16	13.80	13.60	.17	.43
Nitrogen, Total: Low	7.9	74.5	1.3	.7	116.3	272.3	1.3	.30
Nitrogen, Total: High	35.7	741.5	8.1	7.2	1034.5	6204.4	10.9	36.0
Nitrogen, Total: Average	19.5	312.0	3.4	2.8	401.2	1192.4	3.6	13.3
Suspended Solids: Low	132.2	172.5	6.6	.40	336.7	2588.9	1.0	2.5
Suspended Solids: High	4341.6	27361.9	628.5	138.9	19282.8	101485.9	184.0	948.5
Suspended Solids: Average	1482.7	7239.9	194.9	43.3	4693.9	31512.3	62.1	266.3

**Units: discharge in cubic feet per second and loads in pounds per year.*

Figure 129: Burt Lake Tributary Monitoring Sample Sites

Previous Tributary Monitoring

Tip of the Mitt Watershed Council conducted a study of the Burt Lake Tributaries in 2011, funded by the Burt Lake Preservation Association (TOMWC 2012). The purpose of this study was to address concerns about water quality impacts from upstream pollution sources. Eight sites on six tributaries were monitored in April and November of 2011 immediately following storm events. Dissolved oxygen, conductivity, pH, and water temperature were measured in the field with a multi-sensor probe and water samples were collected and analyzed for orthophosphates, total phosphorus, nitrate-nitrogen, total nitrogen, dissolved organic carbon, chloride, total suspended solids, and E. coli. Stream discharge was also measured at each site. Discharge and parameter concentration values were used to calculate pollutant loadings for all sites, as well as percentages of discharge and load contributed by individual tributaries.

No serious water quality problems were found in the Burt Lake tributaries. Bacteria concentrations were low and all complied with State standards. Nutrient, chloride, and conductivity levels were low and in typical ranges for streams of Northern Michigan. Suspended solids were generally low and indicative of clear waters. Water temperatures were low and dissolved oxygen concentrations sufficiently high to sustain cold-water fisheries and had a pH within the range required by the State. Pollutant load calculations showed disproportionately high contributions of phosphorus and nitrogen from the Maple River, phosphorus and chloride from White Goose Creek, dissolved organic carbon from the Crooked River, and chloride and suspended solids from the Sturgeon River.

CHAPTER 5

Water Quality Threats

As detailed in previous chapters, different land uses (sources) and activities (causes) have the potential to impact water quality, and subsequently, threaten the designated uses of a water body. It is critical to identify and understand the link between the source of nonpoint source pollutants and the potential cause. It is this understanding that forms the framework for developing the goals, objectives, and implementation steps of the Watershed Management Plan.

Sediment Sources and Causes

Sediment pollution comes from a variety of sources and causes.

Sources of sediment can include lakeshores and streambanks, road/stream crossings, agricultural practices, construction, logging, and others.

Causes of sediment pollution range as well and oftentimes include:

- Lakeshore and streambank erosion is often a result of the removal of shoreline vegetation.
- Improperly sized culverts and lack of runoff diversions are the main reason for erosion and sedimentation associated with road/stream crossings.
- Livestock access to streams for a watering source can destroy the bank and cause erosion and sedimentation.
- New construction in the shoreline area can also contribute sediment, particularly if inadequate erosion controls are used.
- Not maintaining buffer strips during logging can also contribute to erosion and sedimentation.
- Motorboats travelling at excessive speeds in no-wake areas causes erosion and sedimentation.

Nutrient Sources and Causes

Nutrient pollution may also be derived from a variety of sources, and oftentimes is linked with sediment pollution because nutrients attach to sediment particles.

Sources of nutrient pollution include shoreline and streambank erosion, road crossings, turf management, failing septic systems, agricultural practices, stormwater discharges in urban areas, manure application and management, golf course management, and new construction.

Consequently, shoreline, streambank, and road/stream crossing erosion contribute sediment and nutrient pollution.

Causes of nutrient pollution oftentimes mirror that of sediment pollution. They may include:

- Lakeshore and streambank erosion is often a result of the removal of shoreline vegetation.
- Improperly sized culverts and lack of runoff diversions are the main reason for erosion and sedimentation associated with road/stream crossings.
- Livestock access to streams for a watering source can destroy the bank and cause erosion and sedimentation. In addition, manure may be directly entering stream.
- Outdated, poorly maintained, and improperly designed septic systems discharge nutrients.
- Improper (overuse, wrong formulation, etc.) application of fertilizers on agricultural fields, golf courses, and residential lawns.
- Urban stormwater carries pet waste and other nutrient sources and is discharged to a lake or stream without treatment.

Sources and Causes of Other Pollutants

Sources of oils, grease, and heavy metals include stormwater discharges in urban areas and road/stream crossings.

Sources of pesticides include agricultural fields and residential, commercial, and municipal turf management.

Sources of bacteria include stormwater discharges in urban areas, manure application and storage, and livestock access to streams.

Causes may include:

- Outdated, poorly maintained, and improperly designed septic systems discharge bacteria and other pathogens.
- Urban stormwater carries bacteria, oils, grease, and heavy metals and is then discharged to a lake or stream without treatment.
- Unrestricted livestock access to a stream allows waste to enter the stream directly.
- Over application of pesticides on residential, commercial, and municipal properties, as well as agricultural fields.

Reducing and preventing nonpoint source pollutants relies upon addressing the priority pollutants' sources and causes, which have been identified and ranked for the Burt Lake Watershed (Table 41). The pollutants are ranked according to their potential impact on water quality. Sources are ranked for each pollutant according to their prevalence. Causes are ranked according to their priority by source.

Figure 130: Post oil-spill cleanup on the Crooked River (2013)(TOMWC)

Other Environmental Stressors

Habitat Degradation

The disruption of a water body's hydrology can cause systemic problems that affect water quality and habitat. The most common sources of these disruptions are road/stream crossings and dams. Road/stream crossings, if designed or installed improperly, can restrict flow and create upstream flooding and downstream erosion. Downstream reaches can become sediment starved due to the interference of sediment transport. Water temperatures can increase from upstream impounding. Excess sediments and nutrients can enter a stream more readily due to localized erosion. Road/stream crossing can also create physical barriers to upstream passage of aquatic organisms due to perched culverts or accelerated velocity of water through the structure. Dams can result in many of the same conditions stated above, including disturbance of sediment transport, increased water temperatures, downstream erosion, and as barriers to aquatic organism passage.

Invasive Species

Invasive species can have a profound impact of water resources. Whether fully aquatic species, such as Eurasian watermilfoil (*Myriophyllum spicatum*), or semi-aquatic species, such as common reed (*Phragmites australis),* once a noxious invasive species becomes established within or around a waterbody, the impacts are far-reaching. Native plant communities can become outcompeted by more aggressive invasive species thereby limiting the availability of food and shelter to local wildlife. Local hydrology can change and lead to flooding and erosion. Recreation can become impaired from excess growth of plants that limit swimming, boating, etc. Decomposition of dead and decaying plant matter can deplete dissolved oxygen, which then affects fish and other aquatic organisms.

Thermal Pollution

Thermal pollution is caused when surface waters are unnaturally warmed from either a warm water discharge, such is the case when stormwater flows directly into a lake or stream, or when sunlight is allowed to penetrate deeper into the water column due to increased water clarity or impounding of water. Increased water temperatures can affect aquatic life as some species have limited tolerance for even very small increases in water temperature due to less dissolved oxygen and other factors.

Climate Change

Although climate change is not a nonpoint source pollutant, cause, or source of nonpoint source pollution, it does factor into watershed protection. Climate change predictions indicate that the Earth's average temperature will increase, which will subsequently influence the patterns and amounts of global precipitation. Sea levels will rise, ice and snow cover will be reduced, and there will be more frequent and extreme weather events. Given these predictions, it is critical that high-quality water resources are protected to maintain their resilience in the face of climate change. As described earlier, the Burt Lake Watershed includes some of the most pristine lakes, streams, and wetlands within Michigan. Protecting them now will help to mitigate not only the local effects of climate change, but also on a regional scale.

Table 41: Burt Lake Watershed pollutant sources and causes and environmental stressors

Burt Lake Watershed Pollutant Sources and Causes and Environmental Stressors				
Rank	Pollutant/ Stressors	Source (k: known; s: suspected)	Rank	Cause (listed in priority order by source)
1	Nutrients: Phosphorus and Nitrogen	Stormwater (k)	1	Inadequate treatment of stormwater (k)
		Shoreline/streambank development & property management (k)	1	Fertilizers (s)
				Removal of native shoreline vegetation (k)
		Septic systems (s)	2	Outdated, poorly maintained, and improperly designed systems (s)
		Road/stream crossings (k)	3	Inadequate infrastructure (k)
				Lack of runoff diversions (k)
				Lack of vegetation (k)
		Agriculture and Forestry (s)	4	Limited use of BMPs (s)
1	Sediment	Road/stream crossings (k)	1	Inadequate infrastructure (k)
				Lack of runoff diversions (k)
				Inadequate fill on road surface (k)
				Lack of vegetation (k)
		Shoreline/streambank development & property management (k)	2	Removal of native shoreline vegetation (k)
		Stormwater (k)	3	Inadequate treatment of stormwater (s)
		Agriculture and Forestry (s)	3	Limited use of BMPs (s)
		New development and construction (s)	4	Lack of proper erosion control and stormwater management measures (s)
				Removal of native shoreline vegetation (k)
3	Habitat Degradation	Shoreline/streambank development & property management (k)	1	Removal of native shoreline and nearshore habitat (k)
				Shoreline alterations (beach sanding, seawall construction, etc.)(k)
		Road/stream crossings (k)	2	Hydrologic disruption, barrier for aquatic organisms (k)
		Small dams (k)	3	Hydrologic disruption, barrier for aquatic organisms (k)
4	Invasive Species	Recreation (k)	1	Lack of clean boating practices and other BMPs
		New development and construction (s)	2	Lack of BMPs
5	Thermal Pollution	Stormwater (k)	1	Warmer stormwater discharged to lakes and streams (s)
		Small dams and RSXs (k)	2	Warmed water from impounded streams
5	Oils, grease, heavy metals	Urban stormwater (k)	1	Inadequate treatment of stormwater that may contain oils, grease, heavy metals (s)
5	Pesticides	Shoreline/streambank development & property management (k)	1	Misuse and over use of pesticides (s)
5	Pathogens	Urban stormwater (k)	1	Pet waste, wildlife (k)
		Septic systems (s)	2	Outdated, poorly maintained, and improperly designed systems (s)

CHAPTER 6

Critical and Priority Areas

Critical Areas

Critical areas have been identified to help prioritize and target management efforts within the Burt Lake Watershed (Table 42)(Figure 131).

Table 42: Critical Areas

Source	Critical Area Subwatershed	Critical Area Location
Stormwater	Crooked River Watershed	Alanson, Spring Lake
	Sturgeon River Watershed	Sturgeon River (Indian River area)
Shoreline Degradation	Burt Lake Direct Drainage	Six areas of concentrated development and subsequent degradation of Burt Lake's natural shoreline
	Maple River Watershed	Development on the western shore of Douglas Lake
	Crooked River Watershed	Development on Crooked Lake, esp. Conway and Ponshewaing areas
	Sturgeon River Watershed	Development on Wildwood Lake
Streambank Alterations	Crooked River Watershed	Development on the Crooked River, especially "Devil's Elbow"
	Sturgeon River Watershed	Development on the lower section of the Sturgeon River (through town of Indian River)
RSX/Hydrologic Disruption	Burt Lake Direct Drainage	Hasler Creek
	Maple River Watershed	Cold Creek, Lake Kathleen
	Crooked River Watershed	Berry Creek and Minnehaha Creek
	Sturgeon River Watershed	W. Branch of Sturgeon River
Agriculture	Maple River Watershed	W. B. Maple River near confluence of Cold Creek
	Crooked River Watershed	Headwaters of the Minnehaha Creek in western Bear Creek Township
Wetland Functional Loss	Burt Lake Direct Drainage	Area North of M-68 between Kings Point (Burt Lake) and the Crooked River
	Crooked River Watershed	Corridor between Round and Crooked Lakes, adjoining land north of Pickerel Lake, Berry Creek corridor

Subsequently, implementation steps have been developed in response to these critical areas. Implementation steps allow stakeholders to address where management steps are needed most for watershed protection.

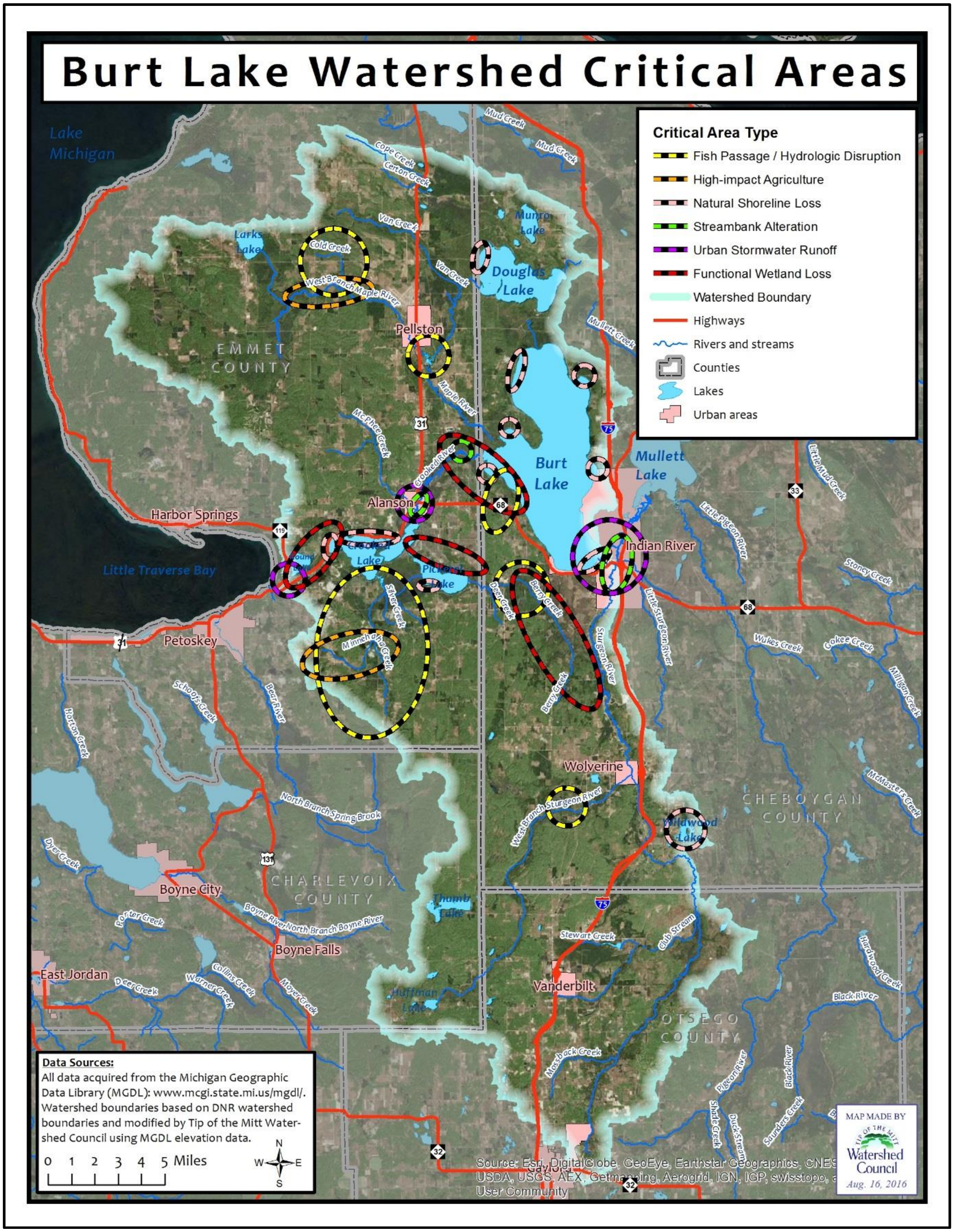


Figure 131: Burt Lake Watershed Critical Areas

Priority Areas

Priority areas are considered the areas within the Watershed with features that are most vulnerable to development and other land uses. Protecting these features will provide long-term protection of water quality within the Watershed. Figure 132 illustrates the priority areas by type, which are described below.

Table 43: Priority Areas

Source	Priority Area Subwatershed	Priority Area Location
Groundwater Recharge	Crooked River Watershed	McPhee Creek, south of Pickerel Lake
	Sturgeon River Watershed	Southwest and southeast of Vanderbilt area
Natural Shorelines and Biodiversity	Burt Lake Direct Drainage	Maple Bay Poverty Bay Bullhead Bay Carp Creek
	Maple River Watershed	Eastern half of Douglas Lake and associated wetlands
	Crooked River Watershed	Minnehaha Creek and Spreads
Wetlands	Burt Lake Direct Drainage	Carp Creek Wetland Reese's Swamp
	Maple River Watershed	Maple River Spreads Pleasantview Swamp Great Maple River Spreads Greater Northern Douglas Lake area
	Crooked River Watershed	Greater Minnehaha/Silver Creek area Greater Crooked River Spreads
		Northern Round Lake area
	Sturgeon River Watershed	Headwaters of Sturgeon River (both branches) Complex between Vanderbilt and Wildwood Lake

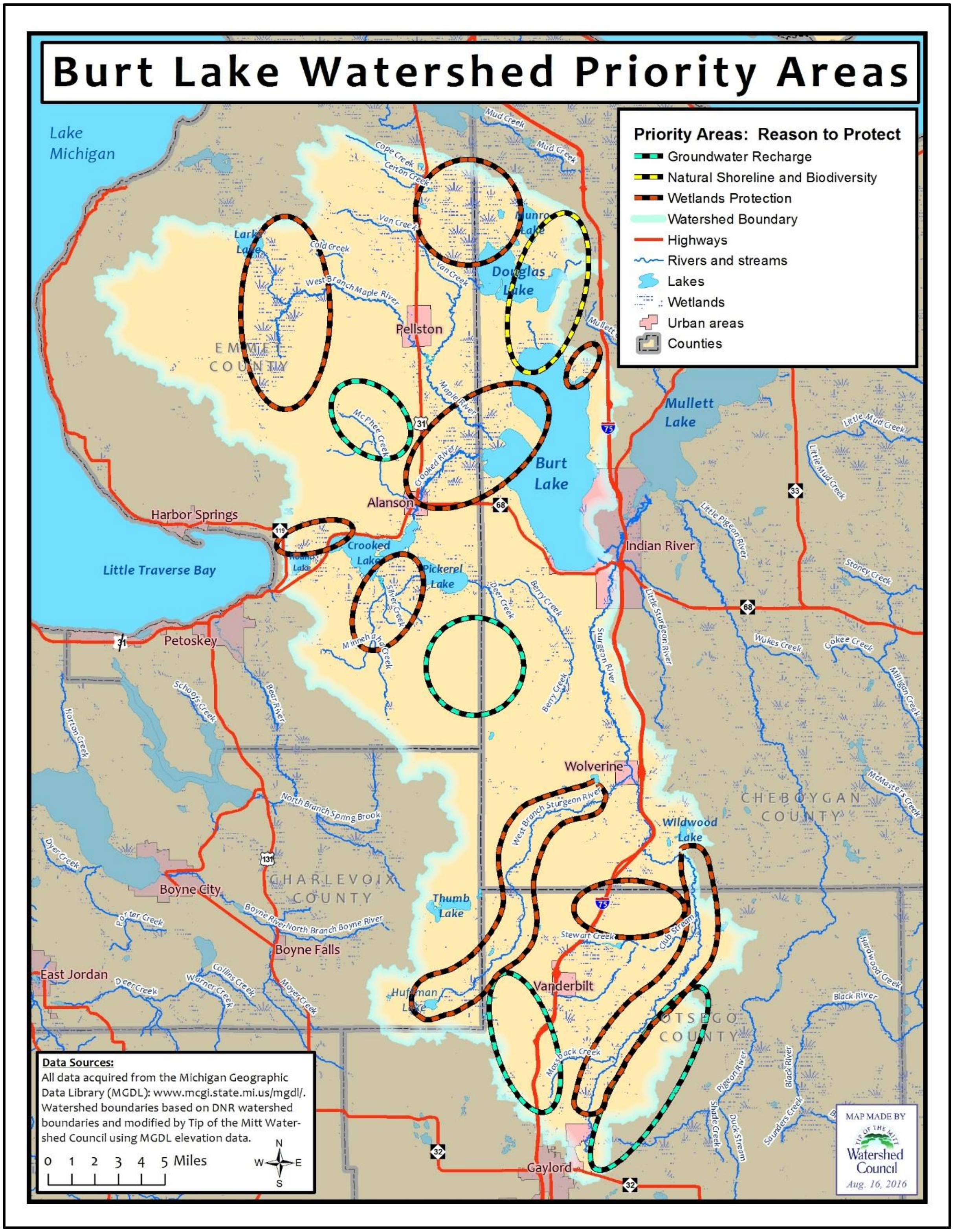


Figure 132: Burt Lake Watershed priority areas

Priority Parcel Analysis

In addition to identifying priority areas, Tip of the Mitt Watershed Council's Priority Parcel Analysis comprehensively ranks individual land parcels using a quantitative scoring system that reflects each parcel's ecological value. While the process is a holistic approach to ecological evaluation, special emphasis is placed on the protection of water resources. Anthropogenic variables pertaining to development are also used in the criteria to frame the rankings from a land acquisition and preservation standpoint. The Analysis is done entirely in a Geographic Information System (GIS), using commonly available spatial data. Many of the data layers used in the analysis were obtained from the Michigan Geographic Data Library. A portion of the data is supplied by partner organizations and government agencies, including parcel datasets from county GIS or equalization departments, and protected lands from local conservancies.

Properly managing high-quality water resources requires addressing known sources of pollution and reducing future sources. Although effective regulation and strong stewardship ethics reduce the adverse impacts of development and land management to our surface waters, the permanent protection of sensitive lands is potentially the most effective tool for long-term water quality and aquatic ecosystem protection. Permanent protection of sensitive areas helps maintain the ecological integrity of our lakes, streams, and wetlands, and arguably provides the most positive impact per conservation effort. Permanent protection is best achieved through purchase, donation, or conservation easement.

Parcels within the Burt Lake Watershed were analyzed and ranked based on variables considered important for protecting and improving the quality and ecology integrity of the Watershed's aquatic ecosystems. Descriptions of scoring criteria and the point system used to assign priority rankings to parcels are described below. The scores for each criterion were summed to produce a total score for each land parcel.

Parcel Size: Larger blocks of contiguous land typically have higher ecological value due to their potential to harbor a greater diversity of species and habitat types. Permanent protection of large parcels is also more time and cost effective than protecting small parcels. The selection threshold for parcel size criteria during this process was 10 acres. The larger the parcel, the more points it received.

Groundwater Recharge Potential: Groundwater discharge is essential for the maintenance of the cold-water fisheries that prevail in watersheds of the Northern Lower Peninsula. Land with highly permeable soils allows precipitation to percolate through the soils and recharge groundwater supplies. Predominant soil type and associated permeability were determined for each parcel using the physical properties found in county soil surveys (Natural Resource Conservation Service, Emmet and Charlevoix Counties). Parcels were scored based on the extent (acreage) of soils conducive to groundwater recharge.

Wetlands: Wetlands provide a variety of important functions that contribute to the health of the Watershed, including fish and wildlife habitat, water quality protection, flood and erosion control, and recreational opportunities. National Wetlands Inventory data were utilized to determine the acreage of wetlands on individual properties and assign scores.

Lake and Stream Riparian Ecosystems: Activities on land immediately adjacent to a waterbody are critically important to maintaining water quality and ecological health. Properties with lake or stream shorelines were given scores based on total shoreline distance contained within the parcel.

Steep Slopes: Steep, highly erodible slopes are particularly vulnerable to improper use. Large amounts of erosion can degrade terrestrial habitat and impact water quality through sedimentation. Parcels with slopes greater than 20% scored points in this category.

Protected Land Adjacency: Properties adjacent to protected lands, such as state forests or conservancy preserves, have a high ecological value because they provide a buffer to preexisting protected lands. They also increase the contiguous protected area, which essentially expands the biological corridor for species migration and interaction. Parcels bordering local or state government land and conservancy properties were identified and scored based upon the number of sides on the parcel adjacent to protected lands. Properties that linked two separate protected land parcels, or doubled the size of an existing parcel, received additional points.

Threatened or Endangered Species (state or federally listed): The protection of threatened and endangered species is important because many species are indicators of environmental quality and other dependent species could be affected. The Biological Rarity (Biorarity) Index model, developed by the Michigan Natural Features Inventory, provides an estimate of occurrence based on known sightings of threatened, endangered, or special concern species and high quality natural communities. Priority scores were based on model predictions for occurrence of threatened and endangered species or habitat types on the parcel.

Proximity to Development: Properties near urban areas have a high conservation value due to the imminent threat of development. Because these properties are near population centers, they have the greatest potential for public use and provide the most gain in terms of ecosystem preservation. NOAA CCAP (Coastal Change Analysis Program) land cover data and MGDL municipal boundary data were used to identify urban areas and growth corridors. Parcels were scored based on proximity to these areas.

Natural Land Cover Types: Land in its natural state is more ecologically valuable than altered land because natural land cover tends to contain a greater diversity of habitat and species, and is more resilient to invasion by non-native species. NOAA's CCAP land-cover dataset was used to determine a percent coverage of natural land cover types for each parcel. Parcels with greater than 50% natural land cover received points.

Drinking Water Protection Areas: Wellhead protection areas are critical recharge zones that maintain aquifer water supplies and sustain local municipal drinking water systems. Development within these areas can jeopardize water sources by contaminating water supplies or inhibiting the infiltration of rainwater. Points were assigned to parcels that lie within wellhead protection areas and based on the percentage of the parcel within the area.

Exceptional Resources: This criterion provides a fixed, two point score increase to any parcel adjacent to an exceptional resource. Exceptional resources are locally occurring conditions that are rare, vulnerable to degradation, and have high intrinsic value. The following were identified as critical resources for this analysis: critical dunes, blue-ribbon trout streams, and undeveloped lakes.

The Burt Lake Watershed was found to contain 22,907 individual parcels that lie completely within the Watershed's boundary. Parcels scored between 0 and 42, with a maximum possible score of 50. These parcels were divided into categories to simplify analysis. The ranking with the most parcels (43%) was "low" (Table 44). These parcels had an average size of 3.79 acres, compared to the Watershed-wide average of 15.50 acres. The smallest category, ranking "very high," contained 0.7% of all parcels within the Watershed. The average parcel size within the category is 278 acres. Thus, land protection is often most efficient when large parcels are protected, maximizing the benefits of protecting continuous riparian corridors, significant amounts of aquatic habitat, or large areas of hydrologically sensitive lands (i.e. wetlands, headwaters, or groundwater recharge areas).

Table 44: Priority Parcels by ranking category for the Burt Lake Watershed

Ranking Category	Number of Parcels	Percent of Parcels*
0 - 6 (very low)	5037	22
7 - 11 (low)	9731	43
12 - 22 (moderate)	7327	32
23 - 29 (high)	654	3
30 + (very high)	158	<1
TOTAL	22907	100%

Percent of parcels within the Burt Lake Watershed

A total of 744 parcels are currently protected within the Burt Lake Watershed (Table 45). These protected lands are made up of a combination of state forest, state parks, conservancy preserves, conservation easements, and local government parcels often set aside as parks. The University of Michigan Biological Station (UMBS) also protects a large amount of land within the northern part of the Watershed. Emmet County contains the most protected lands of any county at 403 parcels and includes many protected parcels, including state forest and UMBS property, within the Maple River Watershed. The majority of the East and West Branches (above their confluence) is protected.

Table 45: Protected parcels by county

Ranking Category	Number of Parcels	Percent of Parcels*
Emmet	403	2
Cheboygan	261	1
Charlevoix	41	<1
Otsego	39	<1
TOTAL	744	3+

Percent of parcels within the Burt Lake Watershed

Table 46: Priority parcels by subwatershed

Ranking Category	Crooked River Watershed	%	Sturgeon River Watershed	%	Maple River Watershed	%	Burt Lake DD	%
0 - 6 (very low)	1787	22	1533	21	979	21	738	24
7 - 11 (low)	3288	41	3068	43	1855	41	1520	49
12 - 22 (moderate)	2695	34	2307	32	1521	33	804	26
23 - 29 (high)	227	3	215	3	183	4	29	1
30 + (very high)	36	<1	62	<1	52	1	8	<1
TOTAL	8033	100	7185	100	4590	100	3099	100

Table 46 illustrates the number of parcels in each ranking category by subwatershed. Interestingly, the percentages for each category are relatively consistent for each subwatershed. This illustrates that parcels are more or less of equal value throughout the entire Burt Lake Watershed. In addition, it suggests that future efforts to protect parcels should prioritized equally among the subwatersheds.

> The analysis highlighted certain areas throughout the Watershed where land protection efforts would achieve the most gains for water resource protection.

1. Large, unprotected parcels along the East and West Branch Maple River, including Lake Kathleen shoreline. These parcels often contain large wetland complexes (such as the Pleasantview Swamp) and are bordered on both sides by state forest and other protected lands.

2. The Pleasantview Valley resort area, most notably marked by Boyne Highlands and Nubs Nob ski areas. Steep slopes and large groundwater recharge potential make this land significant to water resource protection.

3. Stewart Creek and Club Stream corridors within the Sturgeon River Watershed. Parcels in largely natural condition encompass numerous wetlands, steep slopes, and high quality stream habitat. Part of this land is currently managed as a hunting/fishing club, and is voluntarily protected by the current owners.

4. The Upper Sturgeon and West Branch Sturgeon Corridors. Although mid and lower sections of the Sturgeon River have some degree of protection, the upper sections remain largely unprotected.

5. Headwaters of the Crooked River Watershed. Although a significant amount of protection efforts have been carried out in this area, predominantly by Little Traverse Conservancy, there are a number of priority areas within the upper reaches of the Watershed that remain unprotected, and some are currently degraded. Certain areas along Minnehaha Creek, Berry Creek, and Silver Creek in the south scored highly in the analysis. In the north, headwaters of McPhee and Sanford Creeks scored highly.

6. Crooked River corridor wetlands and the adjacent high hills provide ecosystem services essential to water quality protection. This area is nearer to the US-31 development corridor, and should be considered high priority.

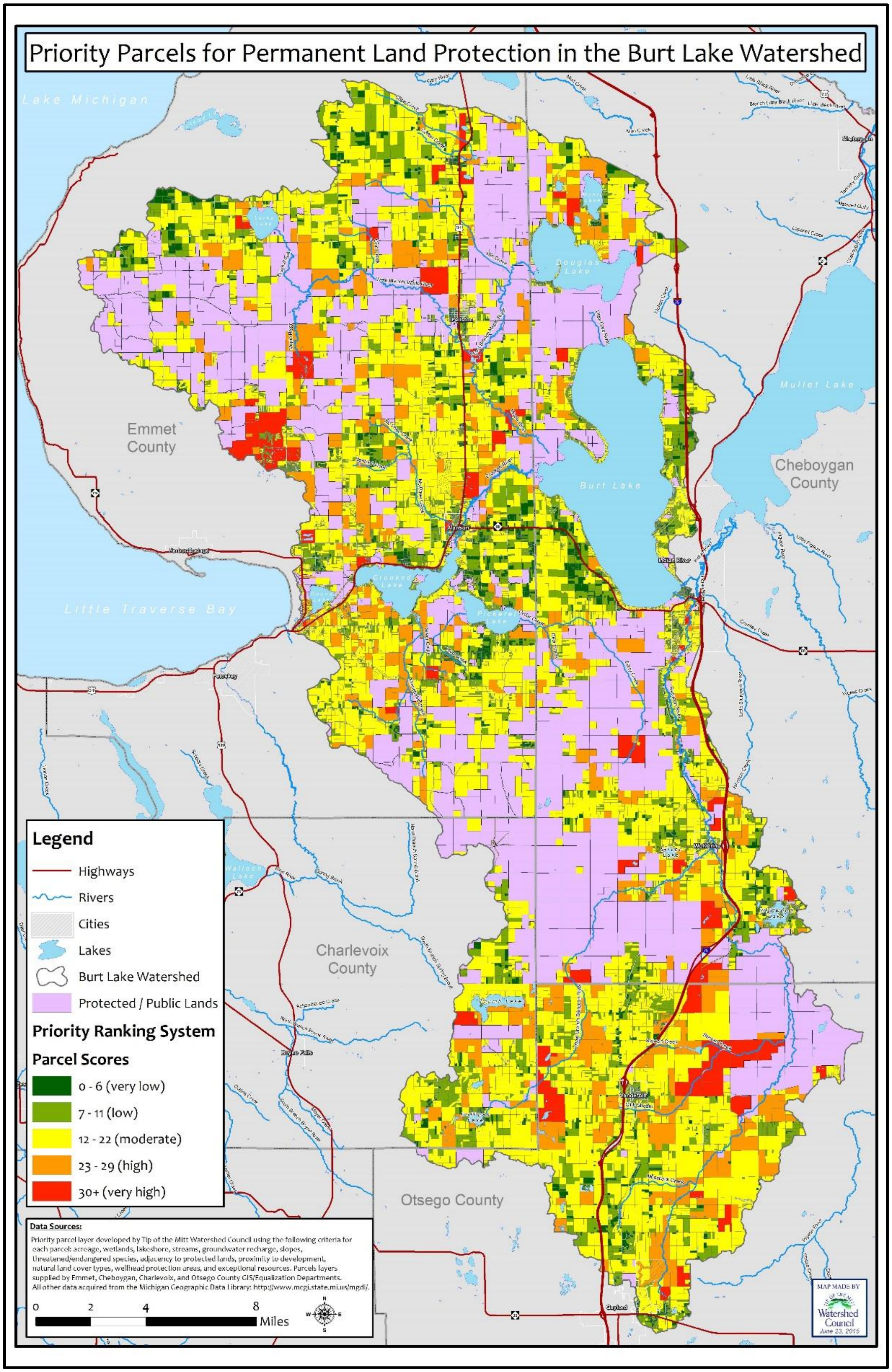


Figure 133: Priority Parcels for permanent land protection in the Burt Lake Watershed

CHAPTER 7

Goals and Objectives

Goals and objectives have been identified as part of the Burt Lake Watershed Management Plan. Goals and objectives are based upon both the Watershed's natural resources needs, including protection and restoration, as well as the health, livelihoods, recreational needs, and industries of the people that live and visit the Watershed.

Goal 1: Protect water quality of the Watershed's lakes and streams.	
Objectives:	
1.1	Reduce nutrient and sediment inputs through restoration of natural shorelines and streambanks where shore surveys and erosion inventories indicate greenbelts are "poor," erosion is moderate or severe, hardened shoreline structures are present, as well as where road/stream crossings are contributing sediment.
1.2	Reduce nutrient inputs through maintenance or replacement of nonfunctioning septic systems.
1.3	Balance the management of lake levels, where applicable, to reduce the risk of erosion due to widely fluctuating water levels.
1.4	Reduce agricultural and forestry impacts to water quality through increased implementation of best management practices.
1.5	Manage stormwater in developed areas.
1.6	Conduct resource inventories and monitor water quality on a regular basis to assess conditions that may be affecting water quality.
1.7	Identify potential water quality threats through expanded monitoring and research.
1.8	Adopt and enforce water quality protection zoning ordinances.

Goal 2: Protect and restore aquatic and riparian habitats.	
Objectives:	
2.1	Protect natural and restore degraded shorelines and streambanks along with riparian and instream habitat improvements.
2.2	Manage priority invasive species throughout the Watershed.
2.3	Protect water resources from future development by incorporating green infrastructure.
2.4	Adopt and enforce water quality protection zoning ordinances.
2.5	Implement permanent land protection strategies in priority areas and on priority parcels.
2.6	Conduct resource inventories and monitor water quality on a regular basis to assess conditions that may be affecting water quality.
2.7	Support efforts to protect or restore critical habitat for native species.

Goal 3: Sustain tourism, recreational opportunities, and industry in a manner consistent with water quality protection.	
Objectives:	
3.1	Support and expand low-impact recreational opportunities.
3.2	Incorporate watershed protection into recreational planning efforts.
3.3	Limit impacts from forestry and agriculture.
3.4	Limit impacts from recreational activities.
3.5	Support measures that minimize the risk of exposure to pathogens, bacteria, heavy metals, and other contaminants.

Goal 4: Protect regional and local hydrology.	
Objectives:	
4.1	Limit impacts to wetlands and groundwater recharge areas.
4.2	Manage stormwater throughout the Watershed.
4.3	Restore hydrology where impacted.
4.4	Protect drinking water sources.
4.5	Conduct resource inventories and monitor water quality on a regular basis to assess conditions that may be affecting water quality.

Goal 5: Protect the Burt Lake Watershed from future threats/emerging issues.	
Objectives:	
5.1	Advocate for short-term measures that will minimize risks of an oil leak from the Line 5 pipeline. Using information from the state Pipeline Advisory Board, educate partners and local citizens regarding potential long-term solutions, including decommissioning.
5.2	Mitigate climate change impacts, including more severe coastal storms in our area, by protecting and restoring vulnerable areas and implementing best management practices throughout the Watershed.
5.3	Be aware and responsive to any new threats or emerging issues that may impact the Watershed on a broad scale.

Information and Education Goals and Objectives:

Goal 1: Develop and implement effective outreach and education efforts that address nonpoint source pollution within the Watershed, engage all Watershed constituents, and convey constituents' respective roles in watershed protection.	
Objectives:	
IE.1.1	Utilize the Internet, email, social media, podcasts, video, news media, surveys, print materials, advertising, workshops, presentations, and other innovative forms of communication.
IE.1.2	Apply concepts from the United States Environmental Protection Agency's *Getting In Step: A Guide for Conducting Watershed Outreach Campaigns* (3rd edition, November 2010) to improve communication efforts.

Goal 2: Enhance watershed protection capacity among Watershed stakeholders.	
Objectives:	
IE.2.1	Capitalize on the strengths and capacity of the Watershed stakeholders along with their respective programs and skill sets to implement the Watershed Management Plan.
IE.2.2	Provide resources, data, technical assistance to local governments, residents, businesses, organizations, and other entities.
IE.2.3	Provide watershed protection incentives.
IE.2.4	Provide watershed protection volunteer opportunities.
IE.2.5	Sustain and broaden the Burt Lake Watershed Advisory Committee.
IE.2.6	Implement school age educational programs that foster water resource awareness and stewardship.

CHAPTER 8

Implementation Steps

Overview of Implementation Tasks and Actions

The Burt Lake Watershed Management Plan Advisory Committee seeks an integrative approach to reduce existing sources of nonpoint source pollution and prevent future contributions. Effective watershed management must rely upon an integrative approach that includes:

1) Best management practices (BMPs)
2) Partnerships, community consensus building, and work with local governments,
3) Information and education components

The recommended implementation tasks and actions represent the best management practices and initiatives identified by the Advisory Committee as being the most critical for water quality protection within the Watershed.

Proposed Best Management Practices (BMPs)

BMPs are techniques, measures, or structural controls designed to minimize or eliminate runoff and pollutants from entering surface and ground waters. Non-structural BMPs are preventative actions that involve management and source controls. These include policies and ordinances that provide requirements and standards to direct growth of identified areas, protection of sensitive areas such as wetlands and riparian areas, and maintaining and/or increasing open space. Other examples include providing buffers along sensitive water bodies, limiting impervious surfaces, and minimizing disturbance of soils and vegetation. Additional non-structural BMPs can be education programs for homeowners, students, businesses, developers, and local officials about everyday actions that protect water quality. Educational efforts are expounded upon in the Information and Education Strategy.

Structural BMPs are physical systems that are constructed to reduce the impact of development and stormwater on water quality. They can include stormwater facilities such as stormwater wetlands; filtration practices such as grassed swales and filter strips; and infiltration practices such as bioretention areas and infiltration trenches.

Structural and non-structural BMPs will be used in combination in the Watershed to obtain the maximum reduction or elimination NPS pollutants. BMPs should be selected according to their potential to reduce the targeted NPS pollutant, as well as budget, maintenance requirements, available space, and other factors. Some examples of possible BMPs for the most common sources of nonpoint source pollutants are listed in Table 47. Specific BMP recommendations for the Watershed are located in the Implementation Tasks table.

Table 47: Structural and nonstructural best management practices (BMPs) (EPA 2008)

	Structural Practices	Nonstructural Practices
Agriculture	Contour buffer strips Grassed waterway Herbaceous wind barriers Mulching Live fascines Live staking Livestock exclusion fence Revetments Riprap Sediment basins Terraces Waste treatment lagoons	Brush management Conservation coverage Conservation tillage Educational materials Erosion and sediment control plan Nutrient management plan Pesticide management Prescribed grazing Residue management Requirement for minimum riparian buffer Rotational grazing Workshops/training for developing nutrient management plans
Forestry	Broad-based dips Culverts Establishment of riparian buffer Mulching Revegetation of firelines with adapted herbaceous species Temporary cover crops Windrows	Education campaign on forestry-related NPS control Erosion and sediment control plans Forest chemical management Fire management Operation of planting machines along the contour to avoid ditch formation Planning and proper road layout and design Preharvest planning Training loggers and landowners about forest management practices, forest ecology, etc.
Urban	Bioretention cells Breakwaters Brush layering Infiltration basins Green roofs Live fascines Marsh creation/restoration Establishment of riparian buffers Riprap Stormwater ponds Sand filters Sediment basins Tree revetments Vegetated gabions Water quality swales	Planning for disconnection of impervious surface (e.g., eliminating or reducing curb and gutter) Educational materials Erosion and sediment control plan Fertilizer management Ordinances Pet waste programs Pollution prevention plans No-wake zones Setbacks Workshops on proper installation of structural BMPs Zoning overlay districts

Note: Practices listed under one land use category can be applied in other land use settings.

Figure 134: Greenbelt signage displayed on Burt Lake (TOMWC)

BMP Effectiveness

The actual effectiveness or efficiency of a BMP is determined by the size of the BMP implemented (e.g., feet of vegetated buffer or acres of stormwater detention ponds), and how much pollution was initially coming from the source. Table 48 (Huron River Watershed Council, 2003) lists estimates of pollutant removal efficiencies for stormwater BMPs that may be used in the Watershed.

Information regarding pollutant removal efficiency, designs of BMPs, and costs are continually evolving and improving. As a result, it is critical to research the latest technologies, design, and methodologies before implementing BMPs within the Watershed.

Table 48: Pollutant Removal Efficiencies of Stormwater BMPs

Pollutant Removal Efficiencies						
Management Practice	Total Phosphorus	Total Nitrogen	TSS	Metals	Bacteria	Oil & Grease
High-powered street sweeping	30-90%		45-90%			
Riparian buffers Forested: 20-40 m width Grass: 4-9 m width	Forested: 23-42%; Grass: 39-78%	Forested: 85%; Grass: 17-99%	Grass: 63-89%			
Vegetated roofs	70-100% runoff reduction, 40-50% of snow/rainfall. 60% temperature reduction. Structural addition of plants over a traditional roof system.					
Vegetated filter strips 7.5 m length 45 m width	40-80%	20-80%	40-90%			
Bioretention	65-98%	49%	81%	51-71%	90%	
Wet extended detention pond	48-90%	31-90%	50-99%	29-73%	38-100%	66%
Constructed wetland	39-83%	56%	69%	(-80)-63%	76%	
Infiltration trench	50-100%	42-100%	50-100%			
Infiltration basin	60-100%	50-100%	50-100%	85-90%	90%	
Grassed swales	15-77%	15-45%	65-95%	14-71%	(-50)-(-25)%	
Catch basin inlet devices		30-40% sand filter	30-90%			
Sand and organic filter	41-84%	22-54%	63-109%	26-100%	(-23)-98%	
Soil stabilization on construction sites			80-90%			
Sediment basins or traps at construction sites			65%			
Porous pavement	65%	80-85%	82-95%	98-99%		

Implementation Steps

The following implementation steps tables includes a comprehensive list of proposed tasks and actions that, if implemented, will result in water quality protection or improvements. Tasks and actions are organized by category to facilitate easy reference. The recommendations are based on a 10-year timeline (2017-2026), a standard duration of time for a watershed management plan. Each task and action identifies the following:

Priority Level: Each task and action has been assigned a priority level based on one or more of the following factors:

- Urgency to correct or reduce an existing problem
- Need to enact a specific task or action before a problem develops
- Availability of funds, partner(s), or program(s) ready to implement
- Overall need to balance low, medium, and high priorities over the course of ten years

Unit Cost/Total Cost estimate: An estimated unit cost is provided when applicable. An estimated total cost is provided when applicable and calculable.

Milestones: Milestone(s) are identified, when possible, to establish an interim, measurable benchmark for determining progress of a specific task or action.

Timeline: Based on the ten-year span of the Watershed Management Plan, steps fall into short-term (1-2 years), mid-term (3-5 years), and long-term (5-10 years). When a task or action is ongoing, it is noted as spanning the ten years.

Potential Partners: The potential partners specified are those who have the interest or capacity to implement the task or action. They are not obligated to fulfill the task or action. It is expected that they will consider pursuing funds to implement the task or action, work with other identified potential partners, and communicate any progress with the Burt Lake Watershed Advisory Committee.

Partner:	Abbreviation:
Burt Lake Preservation Association	BLPA
Burt Township	BTN
Cheboygan County Planning & Zoning	CCPZ
Cheboygan County Planning Commission	CCPC
Cheboygan County Road Commission	CCR
Conservation Resource Alliance	CRA
Douglas Lake Improvement Association	DLIA
Emmet County Planning & Zoning	ECPZ
Emmet County Road Commission	ECRC

Huron Pines	HP
Little Traverse Bay Bands of Odawa Indians	LTBB
Little Traverse Conservancy	LTC
Michigan Department of Environmental Quality	MDEQ
Michigan Department of Natural Resources	MDNR
Michigan Department of Transportation/North Region	MDOT
Miller Van Winkle Chapter of Trout Unlimited	MVWTU
Pickerel-Crooked Lakes Association	PCLA
Sturgeon for Tomorrow	SFT
Tip of the Mitt Watershed Council	TOMWC
Wilmot Township	WTN
Trish Woollcott	Indiv.

Potential Funding Sources: Potential funding sources for each task or action include, but are not limited to:

- Private foundation (PF)
- State grant (SG)
- Federal grant (FG)
- Local government (LG)
- Partner organization (PO)
- Revenue generated (RG)
- Private cost-share (CS)
- Local businesses (LB)

Objectives Addressed: Each task and action supports one or more of the objectives in Chapter 7.

Steps shown in **bold** are actions that should be prioritized.

Italicized Potential Project Partners indicates the anticipated project lead.

Table 49: Implementation steps* cost estimates by category

Water Quality Monitoring	$527,000
Wetlands	$195,000
Shoreline and Streambank Protection	$1,491,000
Stormwater Management	$230,000
Planning and Zoning	$171,500
Land Use	$69,000
Road/stream crossings	$4,024,000
Land Protection	$2,005,000
Ecosystem Health	$1,164,000
Recreation, Safety, and Human Health	$580,600
Hydrology and Groundwater	$107,500
Threatened and Endangered Species	$60,000
Aquatic Invasive Species	$665,000
Septic Systems	$375,000
Emerging Issues	$450,000
Total	**$12,114,600**

*Includes I/E Strategy costs

Table 50: Burt Lake Implementation Steps

Burt Lake Watershed Management Plan Implementation Steps

WQ Water Quality Monitoring

Priority		Categories	Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	WQ.1	**Continue surface water quality monitoring conducted by various agencies, governments, and academic institutions according to their respective programs.**	**NA**	**$200,000**	**Monitor**			**LTBB, MDEQ, MDNR, TU**	**PF, SG, FG, LG, PO,**	**1.6, 2.6, 4.5**	
		Notes: Various groups monitor different bodies of water within the Watershed according to their individual protocols. Data should be share regularly with the Advisory Committee.									
	WQ.2	**Continue implementing Comprehensive Water Quality Monitoring (CWQM) program every 3 years on all lakes and streams currently included in the program.**	**$6,000**	**$18,000**	**NA**	**Monitor 2019**	**Monitor 2022, 2025**	**TOMWC**	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2**
		Notes: TOMWC conducts monitoring, along with entities listed in WQ.1. Likewise, data should be shared regularly through the Advisory Committee and other public outreach.									
	WQ.3	**Expand CWQM monitoring parameters (PAHs, pharmaceuticals, etc.) to address newly emerging water quality threats.**	**NA**	**$25,000**	**Identify, Plan, Funding**	**Monitor new parameter**	**Continue**	**TOMWC**	**SG, FG, PO**	**1.6, 1.7, 2.6, 3.5, 4.5**	**IE.2.2**
		Notes: Identify priority parameters, develop monitoring plan, and secure funding; begin monitoring new parameter in 2019; retain parameter (new in 2019) through 2025 monitoring.									
	WQ.4	**Continue implementing TOMWC's Volunteer Stream Monitoring (VSM) program and expand to include the Minnehaha, Cold, Bessie, Beavertail, and Hasler Creeks.**	**$1,000/year**	**$9,000**	**Recruit and Monitor**	**Monitor**	**Continue**	**TOMWC**	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2, IE.2.4**
		Notes: Recruit and maintain new VSM team for three new creeks by year 2; monitor new streams and all currently monitored streams annually for 10 years.									
	WQ.5	**Continue implementing Tip of the Mitt Watershed Council's Volunteer Lake Monitoring (VLM) program and expand to include Wildwood, Lancaster, Spring, Mud Lakes, and Lake Kathleen.**	**NA**	**$5,000**	**NA**	**Recruit and Monitor**	**Continue**	**TOMWC**	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2, IE.2.4**
		Notes: Recruit new lake monitors for lakes by 2019; retain monitors through 2025.									

	WQ.6	Continue monitoring mercury deposition within the Watershed's lakes by assessing fish tissue.	NA	$200,000		Monitor		UMBS	SG, FG, PO	3.5	
		Notes: Secure research funding necessary to continue program.									
	WQ.7	Continue the Fish Contaminant Monitoring program in both lakes previously monitored and not monitored to date, following protocol established by the MDEQ/MDNR. Continue to report results via the program's online database.	NA	$5,000		Monitor		*MDEQ*, MDNR	SG, PO	3.5	IE.2.2
		Notes: Monitor surface waters within the Watershed.									
	WQ.8	Determine the effectiveness of water quality protection efforts achieved through Watershed Management Plan implementation by using the criteria set forth in the Evaluation Strategy.	NA	$3,000	NA	NA	Compare	TOMWC	SG, PO		IE.2.1
		Notes: Compare 10 years of monitoring data with Evaluation Strategy criteria.									
	WQ.9	Continue and expand as necessary the study of golden-brown benthic algae in lakes. Provide shoreline property information on the algae and its management.	NA	$25,000		Study and Outreach		UMBS, lake associations	PF, SG, FG, PO	1.7	
		Notes: Identify project partners and study locations, secure funding, determine and implement outreach efforts as needed.									
Medium	WQ.10	**Conduct water quality and discharge monitoring of all major tributaries and at least three minor tributaries to assess the impacts to Burt Lake. Additional data are needed under various conditions (wet and dry).**	**NA**	**$10,000**	**NA**	**Monitor and Report**	**NA**	**LTBB, *TOMWC, UMBS***	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2**
		Notes: Secure funding, identify methods, conduct monitoring, complete monitoring report; distribute report.									
	WQ.11	Conduct septic evaluations on lakefront properties by monitoring groundwater along the shoreline and using dye tracers to determine if septic leachate is contaminating the lake or stream.	$300	$12,000	Develop campaign	Evaluations	Continue	TOMWC	PF, SG, FG, PO, CS	1.6, 1.7	

Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
		Notes: Promote septic evaluation services to lake associations in conjunction with septic outreach/campaign, develop cost/share program for lakefront property owners.									
Low	WQ.12	Develop a nutrient budget to determine the amount of nutrients and sediments that are sequestered in Burt Lake. Data should be collected over a period of several years, sampling throughout all seasons and hydrologic conditions (i.e., low, normal, and high discharge).	NA	$15,000	NA	NA	Partners, Funding, Study	LTBB, *TOMWC*, UMBS	SG, FG, PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Identify project partners, secure funding, develop study design.									

WL Wetlands

Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	WL.1	Continue to review DEQ Part 303 Wetland Permit Applications to evaluate proposed wetland impacts. Submit comments to DEQ regarding anticipated wetland impacts when appropriate and work with applicants to minimize impacts.	NA	$25,000	Ongoing			TOMWC, lake associations	PF, PO		IE.2.1
		Notes: Respond to all permit applications when potential wetland impacts are high.									
Medium	WL.2	Restore high-value wetlands.	NA	$150,000	NA	Identify and Funding	Restore	TOMWC	PF, SG, FG, LG, PO	2.3, 4.1, 4.3	
		Notes: Identify wetland restoration site, secure funding, develop plans; Complete one wetland restoration (>5 acres).									
	WL.3	Ground-truth wetlands identified through Landscape Level Wetlands Functional Analysis to confirm high-value wetland status.	NA	$20,000	NA	NA	Ground-truth	*MDEQ*, HP, LTBB, TOMWC	PF, SG, FG, LG, PO	2.6	
		Notes: Identify priority areas for ground-truthing and project partners.									

SP	Shoreline and Streambank Protection										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	SP.1	Repeat shoreline surveys on Burt, Larks, and Pickerel-Crooked Lakes (completed on or before 2012).	NA	$40,000	NA	Survey and Distribute	NA	TOMWC, lake associations	PF, SG, FG, LG PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Secure funding to conduct surveys.									
	SP.2	Repeat streambank inventory on the Sturgeon River and its tributaries.	$6,000	$6,000	NA	NA	Funding and Inventory	*HP, TOMWC*	PF, SG, FG, PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Secure funding to conduct survey; Completion of inventory and results summary.									
	SP.3	Prioritize streambank erosion sites on a subwatershed basis.	NA	$10,000	NA	Matrix	Update	CRA, HP, TOMWC	PF, SG, FG, PO		IE.2.1
		Notes: Convene working group to develop a prioritization matrix to guide streambank projects; update every five years.									
	SP.4	**Restore priority streambank erosion sites on the Sturgeon River.**	**Varies**	**$100,000**	**Identify**	**Restore**	**Restore**	***HP, TOMWC***	**PF, SG, FG, PO, CS**	**1.1, 2.1**	
		Notes: Identify sites and secure funding to implement projects; 500' streambank stabilized/restored.									
	SP.5	**Implement best management practices (BMPs) on moderate and severe shoreline erosion sites on large inland lakes in conjunction with property owner outreach.**	**NA**	**$100,000**	**NA**	**Funding and begin Installation**	**Continue Installation**	**CCD, *HP*, MSUE, *TOMWC***	**PF, SG, FG, LG, PO, CS**	**1.1**	
		Notes: Secure funding to implement outreach program; Implement 5 erosion control projects.									
	SP.6	**Address Sturgeon River erosion along Fulmer Road by stabilizing roadbed and streambank. Pave Fulmer and hill of Peters Roads to address sediment runoff.**	**NA**	**$950,000**	**Funding**	**Install**	**NA**	**CCRC, HP, TOMWC**	**PF, SG, FG, PO**	**1.1, 1.5**	
		Notes: Secure funding and engineering.									
	SP.7	**Promote the Michigan Shoreland Stewards program.**	**NA**	**$30,000**	**Ongoing**			**HP, MSUE, TOMWC, lake associations**	**SG,FG,PO**		**IE.1.1, IE.2.2**

		Notes: Conduct trainings, site assessments, presentations to lake associations; Increase overall program enrollment by 30% on lakes within Watershed.									
	SP.8	**Promote the use of Certified Natural Shoreline Professionals to riparians for bioengineering projects.**	**NA**	**$5,000**	**Ongoing**			**HP, MSUE, TOMWC, lake associations**	**SG,FG,PO**		**IE.1.1, IE.2.2**
		Notes: Conduct trainings, site assessments, presentations to lake associations; Increase overall program enrollment by 30% on lakes within Watershed.									
	SP.9	**Provide riparian property owners with assistance and resources (publications, websites, workshops, and on-site assessments) as they relate to shoreline and streambank management.**	**NA**	**$30,000**	**Ongoing**			**HP, MSUE, TOMWC, lake associations**	**PF, SG, FG, PO**		**IE.1.1, IE.2.2**
		Notes: Conduct at least 10 site assessments/year and 3 workshops (total); 100 site assessments and 3 workshops.									
	SP.10	Continue to review DEQ Part 301 Inland Lakes and Streams Permit Applications to evaluate proposed wetland impacts. Submit comments to DEQ regarding anticipated impacts when appropriate and work with applicants to minimize impacts.	NA	$25,000	Ongoing			TOMWC, lake associations	PF, PO		IE.2.1
		Notes: Respond to all permit applications when potential impacts are high.									
	SP.11	Repeat streambank inventory on the Maple River and its tributaries.	$6,000	$6,000	NA	NA	Funding and Inventory	*CRA, TOMWC*	PF, SG, FG, PO	1.6, 2.6, 4.5,	
		Notes: Secure funding to conduct survey; Completion of inventory and results summary.									
Medium	SP.12	Repeat streambank inventory on the Crooked River and its tributaries.	$4,000	$4,000	NA	NA	Funding and Inventory	TOMWC	PF, SG, FG, PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Secure funding to conduct survey; Completion of inventory and results summary.									
	SP.13	Restore priority streambank erosion sites on the Maple River.	Varies	$40,000	Identify	Restore	Restore	*CRA, TOMWC*	PF, SG, FG, PO, CS	1.1, 2.1	
		Notes: Identify sites and secure funding to implement projects; 300' streambank restoration.									
	SP.14	Restore priority streambank erosion sites on the Crooked River.	Varies	$20,000	Identify	Restore	Restore	*HP, TOMWC*	PF, SG, FG, PO, CS	1.1, 2.1	
		Notes: Identify sites and secure funding to implement projects; 200' streambank restoration.									

	SP.15	Restore priority streambank erosion sites on Bessie, McPhee, Berry, Cedar, and Minnehaha Creeks.	Varies	$50,000	Identify	Restore	Restore	*HP, TOMWC*	PF, SG, FG, PO, CS	1.1, 2.1	
		Notes: Identify sites and secure funding to implement projects; 200' streambank restoration.									
	SP.16	Implement best management practices (BMPs) on moderate and severe shoreline erosion sites on smaller inland lakes in conjunction with property owner outreach.	NA	$25,000	NA	Funding and begin Installation	Continue Installation	CCD, *HP*, MSUE, *TOMWC*	PF, SG, FG, LG, PO, CS	1.1	
		Notes: Secure funding to implement outreach program; Implement 5 erosion control projects.									
	SP.17	Develop and implement cost/share greenbelt program(s) on lakes with supportive lake associations, including demonstration sites.	NA	$50,000	Adoption	Implementation		HP, TOMWC, lake associations	PF, SG, FG, PO, CS	1.1, 2.1	IE.2.3
		Notes: Adoption of program by at least one lake association; Approximately 20% increase in greenbelts rated good or excellent overall.									

SW	Stormwater Management										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	SW.1	Monitor stormwater discharge to Alanson, Spring Lake, and the Sturgeon River in Indian River to establish baseline data.	$10,000	$10,000	NA	Identify and Funding	Monitor	Municipalities, *TOMWC*	PF, SG, FG, LG	1.5, 1.6, 4.2	IE.2.2
		Notes: Identify outfalls and monitoring parameters; secure funding; monitor; Distribution of monitoring report.									
	SW.2	Incorporate green infrastructure into new or re-developments where the potential to impact water resources is present.	NA	$100,000	NA	Identify and Funding	Installation	TOMWC, *local governments and businesses*	PF, SG, FG, PO, CS, LB	1.5, 2.3	IE.2.1, IE.2.2, IE.2.3
		Notes: Identify potential project(s), secure funding, implement and promote/publicize; One or more local examples of green infrastructure, project publicity, public awareness.									
	SW.3	**Promote green infrastructure to watershed residents to increase stormwater awareness and implementation of best management practices.**	**NA**	**$15,000**	**Funding**	**Develop and Distribute**	**NA**	**HP, TOMWC**	**PF, SG, PO, LB**		**IE.1.1, IE.1.2, IE.2.2**

		Notes: Secure funding, develop/distribute green infrastructure publication and other resources to a minimum of 5,000 watershed residents; Print (5,000) and electronic publication, watershed-wide distribution.									
	SW.4	**Install stormwater best management practices, including rain gardens, oil/grit separators, and other structures in Alanson (East St.), Indian River (drainage basin to Sturgeon River), and Spring Lake (near M-119).**	**NA**	**$100,000**	**NA**	**Identify and Funding**	**Installation**	**TOMWC, local governments, and businesses**	**PF, SG, FG, LG, PO, CS, LB**	**1.5, 4.2**	
		Notes: Identify locations and secure funding; Install at least three BMPs.									
Medium	SW.5	Provide developers, builders, architects, and landscape architects with green infrastructure resources.	NA	$5,000	NA	Workshop	NA	TOMWC	PF, SG, LG, PO, RG, LB	2.3	IE.1.1, IE.1.2, IE.2.2, IE.2.3
		Notes: Secure funding, develop workshop(s), promote; Conduct at least one workshop with a minimum of 25 attendees.									

PZ	Planning and Zoning										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	PZ.1	Utilize the recommendations of the Cheboygan County Gaps Analysis (2014) to encourage adoption of model standards in zoning ordinances to protect water quality.	NA	$60,000	Ongoing			Lake associations, local governments	PF, LG, PO	2.4	IE.2.2
		Notes: 3 model standards adopted by year 7.									
	PZ.2	Utilize the recommendations of the Emmet County Gaps Analysis (2013) to encourage adoption of model standards in zoning ordinances to protect water quality.	NA	$60,000	Ongoing			Lake associations, local governments	PF, LG, PO	2.4	IE.2.2
		Notes: 3 model standards adopted by year 7.									
	PZ.3	**Work with Cheboygan County to require a Natural Vegetation Strip in the Lake and Stream Protection District.**	**NA**	**$10,000**	**NA**	**Support**	**Implement**	**TOMWC, lake associations, local governments**	**PF, LG, PO**	**2.4**	

	Notes: Majority support established from citizens and local officials by year 3; Vegetation Strip required by year 6 to protect surface waters.									
PZ.4	Establish requirement that state permits must be issued for regulated wetlands before a Zoning permit is issued in Cheboygan or Emmet County.	NA	$3,000	NA	Support	Implement	TOMWC, lake associations, local governments	PF, LG, PO	2.4	
	Notes: Majority support established from citizens and local officials by year 5; State permit approval required by year 7 to protect local wetlands.									
PZ.5	Work with Cheboygan County and Emmet County to adopt a wetland setback of at least 25', similar to shoreline setbacks.	NA	$3,000	NA	NA	Support and Implement	TOMWC, lake associations, local governments	PF, LG, PO	2.4	
	Notes: Majority support established from citizens and local officials by year 6; Setback established to protect wetlands by year 8.									
PZ.6	Work with Emmet County to provide incentives for using LID techniques to mitigate impacts of impervious surfaces. Establish lot coverage limits in all zoning districts to limit impervious surfaces to 15% in exchange for incentives.	NA	$8,000	NA	NA	Support and Implement	TOMWC, lake associations, local governments	PF, LG, PO	2.4	
	Notes: Stakeholders in agreement and supporting change by year 7; Incentive-based lot coverage limits by year 9 to protect surface waters from NPS.									
PZ.7	**Work with Burt Township to improve the greenbelt ordinance and solve enforcement issues.**	**NA**	**$3,000**	**Support and Ordinance**	**NA**	**NA**	**Burt Township, TOMWC**	**PF, SG, FG**	**2.4**	
	Notes: Stakeholders in agreement and supporting change by year 1; New ordinance in place with enforcement measures by year 2.									
PZ.8	**Complete research, including local statistics, and create a Septic System Local Report for all local officials in Cheboygan County.**	**NA**	**$5,000**	**Report**	**NA**	**NA**	**TOMWC**	**PF, SG, FG**		**IE.2.2**
	Notes: Report completed by year 1; Report distributed to local governments by year 1 to encourage debate on septic system oversight.									
PZ.9	**Work with Burt Township to pass a Time of Transfer Septic Inspection Ordinance.**	**NA**	**$7,000**	**Ordinance**	**NA**	**NA**	**Burt Township, TOMWC**	**LG, PO**	**2.4**	
	Notes: Ordinance language drafted by year 1; Ordinance passed and protecting surface water quality by year 2.									
PZ.10	**Complete research, including local statistics, and create a Septic System Local Report for all local officials in Emmet County.**	**NA**	**$5,000**	**Report and Distribute**	**NA**	**NA**	**TOMWC**	**PF, LG, SG, FG**		**IE.2.2**

		Notes: Report completed by year 2; Report delivered to local governments by year 2 to encourage debate on septic system oversight.									
Medium	PZ.11	Conduct an Impervious Surface Assessment for Cheboygan County and provide recommendations to guide stormwater management based upon findings.	NA	$6,000	NA	Assessment	Rec.'s	TOMWC	PF, SG, FG	1.5	IE.2.2
		Notes: Assessment completed by year 5 and presented to County; Recommendations in place by year 6.									
Low	PZ.12	Require groundwater protection steps to be specified for mining operations in Cheboygan and Emmet County.	NA	$1,500	NA	NA	BMPs	Local governments	PF, SG	2.4	
		Notes: Stakeholders in agreement and supporting change by year 10; Mining BMPs in place to protect groundwater resources.									

LU	Land Use										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	LU.1	Implement agricultural BMPs in designated critical areas.	NA	$50,000	NA	Identify	Implement	Local governments, CCD/ECD, MSUE	CS	1.4, 3.3	IE.2.3
		Notes: Identify and prioritize BMPs, engage with land owner, fundraise; Implement a minimum of 2 BMPs.									
Medium	LU.2	Promote forestry best management practices to practitioners.	NA	$5,000	NA	Workshop	NA	CCD/ECD, MDNR, MSUE	SG	1.4, 3.3	IE.2.2
		Notes: Conduct Better Back Roads workshops for timber harvesters.									
	LU.3	Enroll private property owners in Forest Management programs, such as State of Michigan's Forest Stewardship Program or Natural Resource Conservation Service's Environmental Quality Incentives Program.	NA	$2,000	Identify	Enroll		CCD/ECD, MDNR, MSUE	SG, FG	1.4, 3.3	IE.2.1, IE.2.2, IE.2.3
		Notes: Identify private forested lands with high potential to yield water quality benefits; engage with property owners; Increase enrollment in either program by 15%.									

Priority	Code	Categories	Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
	LU.4	Increase designation of MDNR Forestry Riparian Management Zones to ensure greater water quality protection.	NA	$1,000	Identify	Designate		MDNR	PO	1.4, 3.3	IE.2.1
		Notes: Review current and identify potential RMZs; relay to MDNR; 50% increase in designated RMZs.									
	LU.5	Address illegal dumping on MDNR forest lands.	NA	$1,000	NA	Identify	Implement	MDNR	PO	3.4	
		Notes: Identify recurring dump sites near surface waters; Develop and implement strategies to monitor and control.									
	LU.6	Promote MAEAP to agricultural producers.	NA	$10,000	Ongoing			CCD/ECD, MSUE	PO	1.4, 3.3	IE.2.1
		Notes: Conduct site assessments to potential enrollees; Increase enrollment by 20% by year 10.									

RSX Road/Stream Crossing

Priority	Code	Categories	Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	RX.1	Survey the remaining RSXs (Tier 3) that were not included in the 2014 survey.	NA	$6,000	NA	Funding and Inventory	NA	*HP, TOMWC*	PF, SG, FG,	1.6, 2.6, 4.5	
		Notes: Secure funding to conduct survey; Completion of inventory and results summary; Completion of inventory and upload data to www.northernmichiganstreams.org.									
High	RX.2	Repeat road/stream crossing inventories of the three major subwatersheds, as well as the Burt Lake direct drainage, to determine if priorities are the same, and to document newly installed BMPs or improvements.	$6,000	$18,000	NA	NA	Funding and Inventory	*HP, TOMWC*	PF, SG, FG, LG, PO	1.6, 2.6, 4.5	
		Notes: Secure funding to conduct survey; Completion of inventory and results summary; Completion of inventory and upload data to www.northernmichiganstreams.org.									
High	RX.3	**Implement priority RSX projects for improved hydrology, erosion control, and fish passage in the Sturgeon River Watershed.**	**Varies**	**$1,000,000**	**Identify and Funding**	**Implement**		***HP, TOMWC*, Road Commissions**	**LG, PO**	**1.1, 2.1, 4.3**	
		Notes: Identify five priority sites and secure funding; Completion of three priority RSX projects by year 10.									
High	RX.4	**Implement priority RSX projects for improved hydrology, erosion control, and fish passage in the Maple River Watershed.**	**Varies**	**$1,000,000**	**Identify and Funding**	**Implement**		***CRA, TOMWC*, Road Commissions**	**PF, SG, FG, PO**	**1.1, 2.1, 4.3**	

		Notes: Identify three priority sites and secure funding; Completion of three priority RSX projects by year 10.									
	RX.5	Implement priority RSX projects for improved hydrology, erosion control, and fish passage on coldwater streams within the Crooked River Watershed that support self-sustaining brook trout populations.	**Varies**	**$1,000,000**	**Identify and Funding**	**Implement**		**TOMWC, Road Commissions**	**PF, SG, FG, PO**	**1.1, 2.1, 4.3**	
		Notes: Identify three priority sites and secure funding; Completion of three priority RSX projects by year 10.									
	RX.6	**Implement priority RSX projects (e.g. Hogsback Rd at Carp Creek) for improved hydrology, erosion control, and fish passage in the Burt Lake Direct Drainage**	**Varies**	**$1,000,000**	**Identify and Funding**	**Implement**		**HP, TOMWC, Road Commissions**	**PF, SG, FG, PO**	**1.1, 2.1, 4.3**	
		Notes: Identify two priority sites and secure funding; Completion of two priority RSX projects.									

LP	Land Protection and Management										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	LP.1	Repeat priority parcel process (PPP) for the entire Watershed to identify additional priority parcels.	NA	$5,000	NA	NA	Complete	LTC, *TOMWC*	PF, LG, PO	2.5	
		Notes: Evaluate criteria used for PPP; obtain updated data; Complete by year 6.									
	LP.2	Permanently protect 1500 acres or more of high and very high priority parcels throughout the Watershed.	NA	$2,000,000	Outreach	Protect		*LTC*, TNC, TOMWC	PF, SG, FG, LG, PO	2.5	
		Notes: Conduct outreach via workshop, newsletters, direct contact, or other means to engage with land owners; 1500 ac. permanently protected (700 acres land acquisition, 800 ac. conservation easements).									

EH	Ecosystem Health											
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	EH.1	**Protect and restore the physio-chemical habitat within the Watershed's priority areas that currently support, or have the potential to support, robust populations of native fish species (e.g. brook trout).**	**NA**	**$600,000**	**Identify**	**Implement**		**CRA, HP, MDNR, TOMWC, TU**	**PF, SG, FG, PO, CS**	**2.1, 2.7**	
		Notes: Identify priority projects for fish habitat projects based on fish and habitat surveys; Secure funding and implement at least one project by year 10.									
	EH.2	Compile known information about small dams within the Watershed. Remotely gather additional information to fill in gaps. Prioritize field assessments and work to meet with property owners to discuss options.	NA	$4,000	Convene	Report	NA	CRA, HP, MDEQ, MDNR, TOMWC	SG, FG, PO	1.6, 2.6, 4.5	IE.2.1, IE.2.2
		Notes: Convene small dam projects working group to begin implementation; Report of small dam findings with priority projects and property owners identified.									
	EH.3	Develop and implement outreach and education strategy targeting owners of priority small dams. Focus on ecosystem impacts, dam removal options, and available assistance.	NA	$5,000	NA	Engage		CRA, HP, MDEQ, MDNR, TOMWC	PF, SG, FG, PO		IE.1.1, IE.1.2, IE.2.2, IE.2.3
		Notes: Develop materials packet for distribution; Engage with at least 10 priority small dam owners.									
	EH.4	Remove priority small dams throughout the Watershed where ecosystem benefits outweigh dam utility.	Varies	$200,000	NA	Funding	Removal	CRA, HP, MDEQ, MDNR, TOMWC	SG, FG, PO, CS	4.3	
		Notes: Secure funding for dam removal; Remove at least two priority small dams.									
Medium	EH.5	Conduct habitat mapping on Silver creek, Berry Creek, Stewart Creek, Club Stream, Lower Maple, and Hasler Creek to establish baseline data.	NA	$5,000	NA	Funding	Monitor	HP, MDNR, TOMWC, *USGS*	SG, FG, PO	1.6, 2.6, 2.7	
		Notes: Secure funding to conduct surveys; Baseline data collected for six streams.									

	EH.6	Increase fish cover throughout the Sturgeon River based on recommendations from Trout Unlimited Sturgeon River Instream Fish Habitat Assessment (2016).	NA	$100,000	NA	Funding and Methods	Implement	CRA, HP, MDNR, TOMWC, TU	PF, SG, FG, PO, CS	2.1. 2.7	
		Notes: Secure funding, identify priority areas and methods; Implement fish cover projects in priority stream segments.									
	EH.7	Implement fish habitat improvement projects on major streams (in addition to the Sturgeon River EH.5) and their tributaries throughout the Watershed.	NA	$250,000	Identify	Implement		CRA, HP, MDNR, TOMWC, TU	PF, SG, FG, PO, CS	2.1, 2.7	
		Notes: Identify priority projects for fish habitat projects based on fish and habitat surveys; Secure funding and implement at least three fish habitat projects.									

RSH	Recreation, Safety, and Human Health										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	RH.1	Monitor public beaches annually for potential health hazards, report advisories and beach closings via Beachguard.	$250/per beach sample	$440,000	Monitor			DHD#4, HDNWM, MDEQ, USGS	SG, FG, LG, PO	3.5	IE.1.1
		Notes: Secure funding to implement program annually.									
	RH.2	Increase number of certified Michigan Clean Marinas within the Watershed.	$400	$1,600	Promote and certify			MI Sea Grant (program administrator)	PF, LG, PO	3.4	
		Notes: Promote program and conduct consultations; At least four new marinas certified by year 10.									
	RH.3	Restrict ORV access to public lands where the potential to impact water resources is high.	NA	$30,000	NA	Identify	Implement	MDNR, local governments	SG, FG, PO	3.2	
		Notes: Identify areas where restrictions are needed; Implement measures to restrict access.									

Medium	RH.4	Implement stormwater and erosion BMPs at boat launches and other access points where water quality impacts are noted.	NA	$40,000	NA	Report and Implement		HP, MDNR, TOMWC, lake associations, local governments	PF, LG, SG, FG, PO	3.4	
		Notes: Identify sites and partners, compile report, prioritize project(s), and improve 3-4 launches.									
	RH.5	Develop Inland Waterway campaign that includes social media, advertisements, printed materials, and signage that highlights exceptional natural resources, boating safety, clean boating, invasive species, water quality, and the Inland Waterway-Water Trail, etc. to educate recreationists about both enjoying and protecting the resource.	NA	$50,000	NA	Convene	Launch	All	PO, SG, FG, PF		IE.1.1, IE.1.2, IE.2.1, IE.2.4
		Notes: Convene working group to identify needs, develop communications plan, seek funding and additional partners; Launch campaign.									
	RH.6	Provide information and feedback to local and state governments regarding their recreational planning efforts that may impact the Watershed.	NA	$6,000	Ongoing			All	SG, LG, PO	3.2	
		Notes: Respond to planning efforts as projects are proposed.									
	RH.7	Promote clean boating practices and state boating regulations at marinas, boat launches, fishing tournaments, events, and other public venues.	NA	$5,000	NA	Partner		TOMWC, lake association, local businesses	PF, PO, LB	3.4	
		Notes: Identify partner businesses, identify needs and methods to convey message; Partner with at least two businesses to reduce recreational impacts.									
Low	RH.8	Partner with liveries and outfitters to promote low-impact recreation.	NA	$8,000	NA	Partner		TOMWC, lake association, local businesses	PF, PO, LB	3.4	
		Notes: Identify partner businesses, identify needs and methods to convey message; Partner with at least two businesses to reduce recreational impacts.									

HG	Hydrology and Groundwater										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	HG.1	Assess changes (net gain or loss) in permanently protected lands in areas with high groundwater recharge rates.	NA	$2,500	NA	NA	Compile and Distribute	DHD#4, MDEQ, *NEMCOG*, TOMWC, USGS	SG, FG, PO	2.5, 4.5	
		Notes: Complete assessment concurrent with Watershed Management Plan update; Compile and distribute results.									
Medium	HG.2	Compile all existing groundwater information, identify problems, determine data gaps, and develop a strategy for long-term monitoring.	NA	$5,000	NA	NA	Strategy	DHD#4, HDNWM, MDEQ, NEMCOG, TOMWC, USGS, local governments	SG, FG, PO	1.6, 1.7, 3.5, 4.1, 4.4	
		Notes: Complete compilation and assessment of existing data.									
	HG.3	Monitor groundwater based on strategy (HG.2).	NA	$10,000	NA	NA	Monitor	DHD#4, HDNWM, MDEQ, NEMCOG, TOMWC, USGS, local governments	SG, FG, LG	1.6, 1.7, 3.5, 4.1, 4.4	
		Notes: Secure funding, identify project partners, and implement.									
	HG.4	Employ Landscape Hydrology Model to assess pollutant loadings and sources concurrent with Watershed Management Plan update.	NA	$10,000	NA	NA	Model	Michigan State University, *TOMWC*	SG, FG, PO	4.5	IE.2.2
		Notes: Secure funding, identify project partners, apply model; Incorporate model results into plan update.									

Priority		Categories	Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
	HG.5	Implement Wellhead Protection Programs (WHPP) in communities where greater protection of groundwater is critical to safeguard against drinking water contamination.	NA	$40,000	NA	Identify and Funding	Develop	DHD#4, HDNWM, MDEQ, NEMCOG, TOMWC, local governments	SG, PO	2.5, 3.5, 4.1, 4.4	IE.1.1, IE.2.2
		Notes: Identify communities that are at greatest risk for drinking water contamination; secure funding through WHPP grant program; Develop WHPP for at least one community within Watershed.									
Low	HG.6	Work with area businesses and property owners to encourage proper maintenance, monitoring, and removal of underground fuel storage tanks and other potential hazards.	NA	$40,000	NA	Identify	Removal	DHD#4, HDNWM, MDEQ, NEMCOG, TOMWC, local governments	PF, SG, CS, LB	3.5, 4.4	IE.2.1, IE.2.2, IE.2.3
		Notes: Identify potential sites for future removal or replacement, secure funding to support; removal or replacement of at least one tank.									

TE	Threatened, Endangered, and Species of Concern										
Priority		Categories	Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	TE.1	Protect and restore critical Lake Sturgeon habitat through stream conservation practices, such as maintaining or establishing sufficient riparian buffers or natural flows, water quality protection, and invasive species management.	NA	$60,000	Identify and Funding		Implement	HP, SFT, TOMWC, lake associations	PF, SG, LG, PO, LB	2.1, 2.2	
		Notes: Identify priority projects and project partners, secure funding.									

AI Aquatic Invasive Species

Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	AI.1	**Report introductions and spread of invasive species to at least one tracking database (USGS, MISIN, etc.).**	**NA**	**$20,000**		**Report**		**C.A.K.E, HP, *NE MI CISMA*, TOMWC**	**PF, SG, FG, LG, PO**	**2.2**	
		Notes: Report introductions annually beginning year 1.									
	AI.2	**Implement on-the-ground management projects to stop the introduction, spread, and distribution of invasive species within the Watershed.**	**NA**	**$100,000**		**Implement**		**C.A.K.E, HP, *NE MI CISMA*, TOMWC, local governments**	**SG, FG, LG, PO**	**2.2**	
		Notes: Implement at least 20 private or public property projects by year 5.									
	AI.3	**Provide property owners with assistance and resources with invasive species management through site assessments, distribution of resources, and other outreach.**	**NA**	**$50,000**		**Implement**		**C.A.K.E, HP, *NE MI CISMA*, TOMWC, local governments**	**PF, SG, FG, PO, CS**	**2.2**	**IE.2.1, IE.2.2**
		Notes: Perform 50 site assessments and publish 10 widely-distributed AIS articles via newsletters or other media.									
	AI.4	Install signage at public boat launches that highlight Clean Boats, Clean Waters program and message.	$1,000/sign	$10,000	Locations and Funding	Install		HP, LTBB, MDNR, MSUE, TOMWC, lake associations	PF, SG, PO, LB	2.2	IE.1.1
		Notes: Identify locations, secure funding; Install 10 signs throughout the Watershed.									
	AI.5	Conduct volunteer-based boater education program through Clean Boats, Clean Waters program.	NA	$5,000		Recruit and Train		HP, MI Sea Grant, TOMWC, lake associations	SG, FG, LG, PO	2.2	IE1.1, IE.2.1, IE.2.4
		Notes: Recruit volunteers, host training; Conduct boater outreach at popular launches.									
	AI.6	Install permanent or access mobile boat washing stations for use at public boat launches.	Varies	$100,000	Location, Funding, Strategy	Install or Purchase		HP, TOMWC, lake assns., local govts.	PF, SG, FG, LG, PO	2.2	

		Notes: Identify locations, secure funding, develop user and operator strategy; Install or purchase either one permanent or two mobile units or combination of both									
	AI.7	Recruit and coordinate multiple lake association-based volunteer teams to operate boat washing stations (AI.6).	NA	$30,000	Develop	Operate		HP, TOMWC, lake associations	PF, PO	2.2	IE.2.4
		Notes: Develop and promote program, recruit volunteers, trainings, and coordination.									
	AI.8	Monitor and manage purple loosestrife throughout the Watershed with biological control agent.	NA	$25,000	Ongoing			C.A.K.E, HP, NE MI CISMA, TOMWC, lake associations		2.2	
		Notes: Release *Galerucella* beetles annually									
Medium	AI.9	Develop volunteer-based aquatic invasive species monitoring program.	NA	$15,000	NA	Implement		*HP, TOMWC*	PF, SG, FG, LG, PO	2.2	IE.2.4
		Notes: Develop program and begin implementation by year 5; Continue program through year 10									
	AI.10	Survey zebra/quagga mussel populations on GLRI-funded Zequanox study lake(s) beyond GLRI grant.	NA	$10,000	NA	Compile, Identify, Funding		TOMWC, USGS	SG, FG, PO	2.2	
		Notes: Compile results from GLRI-funded study, identify future survey needs, and secure funding.									
	AI.11	Eliminate use of lampricide within the Inland Waterway through sterile male release technique (SMRT) or modifying the Cheboygan lock system, or a combination of both in order to treat existing and potential populations.	NA	$300,000	SMRT and Research	SMRT and Research	NA	*USFWS, USGS*	SG, FG	2.2	
		Notes: Conduct SMRT for three years beginning in 2017, concurrent with USGS research; Complete initial research by 2020, determine most effective lamprey control measures for the Inland Waterway.									

SS	Septic Systems										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	SS.1	Develop septic system outreach campaign, including incentives such as a septic giveaway, free inspections.	NA	$75,000	NA	Develop and Funding	Implement	TOMWC, lake associations, local governments	PF, SG, FG, LG, PO, CS, LB		IE.1.1, IE.1.2, IE.2.1 IE.2.2, IE.2.3
		Notes: Develop outreach materials, identify potential project partners, secure funding.									
Medium	SS.2	Replace individual septic systems in communities where systems are ineffective or insufficient for given demand with community sewer systems.	$10,000	$300,000	NA	Identify and Fundraise	Convert	TOMWC, lake associations	SG, FG, LG, CS, LB	1.2	
		Notes: Identify priority community to convert to sewer system, fundraise; Approximately 30 households converted to sewer system.									

EI	Emerging Issues and Future Threats										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	EI.1	**Conduct education and outreach to local government officials, lake associations, and other community groups and members about Line 5.**	**NA**	**$100,000**		**Ongoing**		**TOMWC, lake associations, local governments**	**PF, PO**	**5.1**	**IE.1.1, IE.2.2**
		Notes: Conduct presentations, workshops, publish articles, press releases, and utilize social media to provide current and accurate information.									
	EI.2	**Develop climate-change strategies to protect most vulnerable aquatic resources.**	**NA**	**$100,000**	**Funding**	**Strategies**		**NEMCOG, TOMWC, lake associations, local governments**	**PF, SG, FG, LG, PO**	**5.2**	**IE.1.1, IE.1.2, IE.2.2**

		Notes: Convene working group to identify and prioritize vulnerable areas; develop strategies given climate predictions, disseminate strategies via climate change campaign.							
Medium	EI.3	**Monitor microplastics concentrations as new technology becomes available.**	**NA**	**$250,000**	**Support and Implement**	**All**	**PF, SG, FG, LG, PO**	**5.3**	**IE.1.1, IE.2.2**
		Notes: Support new research and implement both pilot and permanent technologies where applicable to reduce future microplastics inputs.							

CHAPTER 9

Information and Education Strategy

> Every watershed plan should include an Information and Education (I/E) component that involves the watershed community. Because many water quality problems result from individual actions and the solutions are often voluntary practices, effective public involvement and participation promote the adoption of management practices, help to ensure the sustainability of the watershed management plan, and perhaps most important, encourage changes in behavior that will help to achieve your overall watershed goals.
>
> -EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters

Effective watershed protection is most successful when I/E efforts are incorporated into watershed management planning. In the previous chapter, I/E implementation steps were included in the overall Implementation Steps table to highlight the connection. In this chapter, only the information and education steps are included.

Goal 1: Develop and implement effective outreach and education efforts that address nonpoint source pollution within the Watershed, engage all Watershed constituents, and convey constituents' respective roles in watershed protection.	
Objectives:	
IE.1.1	Utilize the Internet, email, social media, podcasts, video, news media, surveys, print materials, advertising, workshops, presentations, and other innovative forms of communication.
IE.1.2	Apply concepts from the United States Environmental Protection Agency's Getting In Step: A Guide for Conducting Watershed Outreach Campaigns (3rd edition, November 2010) to improve communication efforts.

Goal 2: Enhance watershed protection capacity among Watershed stakeholders.	
Objectives:	
IE.2.1	Capitalize on the strengths and capacity of the Watershed stakeholders along with their respective programs and skill sets to implement the Watershed Management Plan.
IE.2.2	Provide resources, data, technical assistance to local governments, residents, businesses, organizations, and other entities
IE.2.3	Provide watershed protection incentives
IE.2.4	Provide watershed protection volunteer opportunities
IE.2.5	Sustain and broaden the Burt Lake Watershed Advisory Committee
IE.2.6	Implement school age educational programs that foster water resource awareness and stewardship.

The I/E Strategy reflects the various watershed audiences and the potential means of informing and educating. The following groups have been identified as the key audiences in which the I/E Strategy is based.

Component 1: General Watershed Community

General watershed protection and resource information should continue to be developed and disseminated through print and social media, websites, and educational events. Information should be general in nature with the following topic areas of focus:

- Water resources and water quality of the Watershed
- Stormwater: what is it, how it affects water quality, and how to manage it
- Cultivating the next generation of watershed stewards
- Boater education: clean boating practices

Component 2: Riparian Education

Riparians play an enormous role in watershed protection. Many riparians, however, remain unaware of the connection between water quality and riparian management. Focus areas should include what role riparians play in resource protection. The Michigan Shoreland Stewards program, an education and outreach component of the Michigan Natural Shoreline Partnership, is a valuable resource that applies to all lakes within the state. Promotion of this program, along with other local initiatives, is key in order to increase awareness of stewardship opportunities. In addition to shoreline management, efforts to increase awareness of aquatic invasive species should be emphasized among riparians. Riparians should have adequate access to current invasive species information, including identification, current range/distribution, modes of spread, and best management practices.

Component 3: Targeted Engagement

Efforts to identify, address, and engage with targeted groups should be at the forefront. Examples of these types of targeted groups include private property owners or homeowner associations known to have:

- A small dam
- A particularly threatening invasive species
- Suspected septic system issues

Other groups may include agricultural producers/farmers, local government officials, septic haulers, engineers, road commissions, and others to encourage best management practices where they are lacking.

Component 4: Burt Lake Watershed Advisory Committee

There are many watershed stakeholders given the vast size of the Burt Lake Watershed. They include local governments, resource agencies, nonprofits, lake associations, and others. Although not unique to this watershed, many of the groups and agencies have overlapping service areas and services. As more watershed protection projects are implemented, it is critical that information is shared among stakeholders to prevent duplication, assist with prioritization of watershed needs, pool resources, and leverage future opportunities. In order to maintain this important connectivity, the Burt Lake Watershed Advisory Committee will continue to meet quarterly. New committee members should be recruited, particularly from groups that have yet to be represented. Furthermore, the committee should adopt a logo of other means of fostering a unique identity.

Table 51: I/E Strategy cost estimates by category

Water Quality Monitoring	$90,000
Wetlands	$25,000
Shoreline and Streambank Protection	$200,000
Stormwater Management	$130,000
Planning and Zoning	$136,000
Land Use	$69,000
Road/stream crossings	0
Land Protection	0
Ecosystem Health	$9,000
Recreation, Safety, and Human Health	$490,000
Hydrology and Groundwater	$90,000
Threatened and Endangered Species	0
Aquatic Invasive Species	$110,000
Septic Systems	$75,000
Emerging Issues	$450,000
Total	**$1,874,000**

Table 52: Burt Lake Watershed I/E Implementation Steps

Burt Lake Watershed Management Plan Implementation Steps											
WQ	Water Quality Monitoring										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	WQ.2	**Continue implementing Comprehensive Water Quality Monitoring (CWQM) program every 3 years on all lakes and streams currently included in the program**	**$6,000**	**$18,000**	**NA**	**Monitor 2019**	**Monitor 2022, 2025**	**TOMWC**	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2**
		Notes: TOMWC conducts monitoring, along with entities listed in WQ.1. Likewise, data should be shared regularly through the Advisory Committee and other public outreach.									
	WQ.3	**Expand CWQM monitoring parameters (PAHs, pharmaceuticals, etc.) to address newly emerging water quality threats**	**NA**	**$25,000**	**Identify, Plan, Funding**	**Monitor new parameter**	**Continue**	**TOMWC**	**SG, FG, PO**	**1.6, 1.7, 2.6, 3.5, 4.5**	**IE.2.2**
		Notes: Identify priority parameters, develop monitoring plan, and secure funding; begin monitoring new parameter in 2019; retain parameter (new in 2019) through 2025 monitoring									
	WQ.4	**Continue implementing TOMWC's Volunteer Stream Monitoring (VSM) program and expand to include the Minnehaha, Cold, Bessie, Beavertail, and Hasler Creeks**	**$1,000/year**	**$9,000**	**Recruit and Monitor**	**Monitor**	**Continue**	**TOMWC**	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2, IE.2.4**
		Notes: Recruit and maintain new VSM team for three new creeks by year 2; monitor new streams and all currently monitored streams annually for 10 years									
	WQ.5	**Continue implementing Tip of the Mitt Watershed Council's Volunteer Lake Monitoring (VLM) program and expand to include Wildwood, Lancaster, Spring, Mud Lakes, and Lake Kathleen**	**NA**	**$5,000**	**NA**	**Recruit and Monitor**	**Continue**	**TOMWC**	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2, IE.2.4**
		Notes: Recruit new lake monitors for lakes by 2019; retain monitors through 2025									
	WQ.7	Continue the Fish Contaminant Monitoring program in both lakes previously monitored and not monitored to date, following protocol established by the MDEQ/MDNR. Continue to report results via the program's online database	NA	$5,000	Monitor			*MDEQ*, MDNR	SG, PO	3.5	IE.2.2

		Notes: Monitor surface waters within the Watershed									
	WQ.8	Determine the effectiveness of water quality protection efforts achieved through Watershed Management Plan implementation by using the criteria set forth in the Evaluation Strategy	NA	$3,000	NA	NA	Compare	TOMWC	SG, PO		IE.2.1
		Notes: Compare 10 years of monitoring data with Evaluation Strategy criteria									
Medium	WQ.10	**Conduct water quality and discharge monitoring of all major and at least three minor tributaries to assess the impacts of individual tributaries to Burt Lake. Additional data are needed under various conditions (wet and dry)**	**NA**	**$10,000**	**NA**	**Monitor and Report**	**NA**	**LTBB, *TOMWC, UMBS***	**SG, FG, PO**	**1.6, 2.6, 4.5**	**IE.2.2**
		Notes: Secure funding, identify methods, conduct monitoring, complete monitoring report; distribute report									
Low	WQ.12	Develop a nutrient budget to determine the amount of nutrients and sediments that are sequestered in Burt Lake. Data should be collected over a period of several years, sampling throughout all seasons and hydrologic conditions (i.e., low, normal, and high discharge)	NA	$15,000	NA	NA	Partners, Funding, Study	LTBB, *TOMWC*, UMBS	SG, FG, PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Identify project partners, secure funding, develop study design									

WL	Wetlands										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	WL.1	Continue to review DEQ Part 303 Wetland Permit Applications to evaluate proposed wetland impacts. Submit comments to DEQ regarding anticipated wetland impacts when appropriate and work with applicants to minimize impacts	NA	$25,000	Ongoing			TOMWC, lake associations	PF, PO		IE.2.1
		Notes: Respond to all permit applications when potential wetland impacts is high									

SP	Shoreline and Streambank Protection										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	SP.1	Repeat shoreline surveys on Burt, Larks, and Pickerel-Crooked Lakes (completed on or before 2012)	NA	$40,000	NA	Survey and Distribute	NA	TOMWC, lake associations	PF, SG, FG, LG PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Secure funding to conduct surveys									
	SP.2	Repeat streambank inventory on the Sturgeon River and its tributaries	$6,000	$6,000	NA	NA	Funding and Inventory	*HP, TOMWC*	PF, SG, FG, PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Secure funding to conduct survey; Completion of inventory and results summary									
	SP.3	Prioritize streambank erosion sites on a subwatershed basis	NA	$10,000	NA	Matrix	Update	CRA, HP, TOMWC	PF, SG, FG, PO		IE.2.1
		Notes: Convene working group to develop a prioritization matrix to guide streambank projects; update every five years									

	SP.7	**Promote the Michigan Shoreland Stewards program**	**NA**	**$30,000**		**Ongoing**		**HP, MSUE, TOMWC, lake associations**	**SG,FG,PO**		**IE.1.1, IE.2.2**
		Notes: Conduct trainings, site assessments, presentations to lake associations; Increase overall program enrollment by 30% on lakes within the Watershed									
	SP.8	**Promote the use of Certified Natural Shoreline Professionals to riparians for bioengineering projects**	**NA**	**$5,000**		**Ongoing**		**HP, MSUE, TOMWC, lake associations**	**SG,FG,PO**		**IE.1.1, IE.2.2**
		Notes: Conduct trainings, site assessments, presentations to lake associations; Increase overall program enrollment by 30% on lakes within the Watershed									
	SP.10	**Provide riparian property owners with assistance and resources (publications, websites, workshops, and on-site assessments) as they relate to shoreline and streambank management**	**NA**	**$30,000**		**Ongoing**		**HP, MSUE, TOMWC, lake associations**	**PF, SG, FG, PO**		**IE.1.1, IE.2.2**
		Notes: Conduct at least 10 site assessments/year and 3 workshops (total); 100 site assessments and 3 workshops									
	SP.11	Continue to review DEQ Part 301 Inland Lakes and Streams Permit Applications to evaluate proposed wetland impacts. Submit comments to DEQ regarding anticipated impacts when appropriate and work with applicants to minimize impacts	NA	$25,000		Ongoing		TOMWC, lake associations	PF, PO		IE.2.1
		Notes: Respond to all permit applications when potential impacts are high									
Medium	SP.13	Repeat streambank inventory on the Crooked River and its tributaries	$4,000	$4,000	NA	NA	Funding and Inventory	TOMWC	PF, SG, FG, PO	1.6, 2.6, 4.5	IE.2.2
		Notes: Secure funding to conduct survey; Completion of inventory and results summary									
	SP.18	Develop and implement cost/share greenbelt program(s) on lakes with supportive lake associations, including demonstration sites	NA	$50,000	Adoption	Implementation		HP, TOMWC, lake associations	PF, SG, FG, PO, CS	1.1, 2.1	IE.2.3
		Notes: Adoption of program by at least one lake association; Approximately 20% increase in greenbelts rated good or excellent overall									

SW	Stormwater Management										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	SW.1	Monitor stormwater discharge to Alanson, Spring Lake, and the Sturgeon River in Indian River to establish baseline data	$10,000	$10,000	NA	Identify and Funding	Monitor	Municipalities, *TOMWC*	PF, SG, FG, LG	1.5, 1.6, 4.2	IE.2.2
		Notes: Identify outfalls and monitoring parameters; secure funding; monitor; Distribution of monitoring report									
	SW.2	Incorporate green infrastructure into new or re-developments where the potential to impact water resources is present	NA	$100,000	NA	Identify and Funding	Installation	TOMWC, *local governments and businesses*	PF, SG, FG, PO, CS, LB	1.5, 2.3	IE.2.1, IE.2.2, IE.2.3
		Notes: Identify potential project(s), secure funding, implement and promote/publicize; One or more local examples of green infrastructure, project publicity, public awareness									
	SW.3	**Promote green infrastructure to Watershed residents to increase stormwater awareness and implementation of best management practices**	**NA**	**$15,000**	**Funding**	**Develop and Distribute**	**NA**	**HP, TOMWC**	**PF, SG, PO, LB**		**IE.1.1, IE.1.2, IE.2.2**
		Notes: Secure funding, develop/distribute green infrastructure publication and other resources to a minimum of 5,000 Watershed residents; Print (5,000) and electronic publication, Watershed-wide distribution									
Medium	SW.5	Provide developers, builders, architects, and landscape architects with green infrastructure resources	NA	$5,000	NA	Workshop	NA	TOMWC	PF, SG, LG, PO, RG, LB	2.3	IE.1.1, IE.1.2, IE.2.2, IE.2.3
		Notes: Secure funding, develop workshop(s), promote; Conduct at least one workshop with a minimum of 25 attendees									

PZ	Planning and Zoning											
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	PZ.1	Utilize the recommendations of the Cheboygan County Gaps Analysis (2014) to encourage adoption of model standards in zoning ordinances to protect water quality	NA	$60,000		Ongoing		Lake associations, local governments	PF, LG, PO	2.4	IE.2.2
		Notes: 3 model standards adopted by year 7									
	PZ.2	Utilize the recommendations of the Emmet County Gaps Analysis (2013) to encourage adoption of model standards in zoning ordinances to protect water quality	NA	$60,000		Ongoing		Lake associations, local governments	PF, LG, PO	2.4	IE.2.2
		Notes: 3 model standards adopted by year 7									
	PZ.8	**Complete research, including local statistics, and create a Septic System Local Report for all local officials in Cheboygan County**	**NA**	**$5,000**	**Report**	**NA**	**NA**	**TOMWC**	**PF, SG, FG**		**IE.2.2**
		Notes: Report completed by year 1; Report distributed to local governments by year 1 to encourage debate on septic system oversight									
	PZ.10	**Complete research, including local statistics, and create a Septic System Local Report for all local officials in Emmet County**	**NA**	**$5,000**	**Report and Distribute**	**NA**	**NA**	**TOMWC**	**PF, LG, SG, FG**		**IE.2.2**
		Notes: Report completed by year 2; Report delivered to local governments by year 2 to encourage debate on septic system oversight									
Medium	PZ.11	Conduct an Impervious Surface Assessment for Cheboygan County and provide recommendations to guide stormwater management, based upon findings	NA	$6,000	NA	Assessment	Rec.'s	TOMWC	PF, SG, FG	1.5	IE.2.2
		Notes: Assessment completed by year 5 and present to County; Recommendations in place by year 6									

LU	Land Use											
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	LU.1	Implement agricultural BMPs in designated critical areas	NA	$50,000	NA	Identify	Implement		CS	1.4, 3.3	IE.2.3
		Notes: Identify and prioritize BMPs, engage with land owner, fundraise; Implement a minimum of 2 BMPs									
Medium	LU.2	Promote forestry best management practices to practitioners	NA	$5,000	NA	Workshop	NA			1.4, 3.3	IE.2.2
		Notes: Conduct Better Back Roads workshops for timber harvesters									
	LU.3	Enroll private property owners in Forest Management programs, such as State of Michigan's Forest Stewardship Program or Natural Resource Conservation Service's Environmental Quality Incentives Program	NA	$2,000	Identify	Enroll				1.4, 3.3	IE.2.1, IE.2.2, IE.2.3
		Notes: Identify private forested lands with high potential to yield water quality benefits; engage with property owners; Increase enrollment in either program by 15%									
	LU.4	Increase designation of MDNR Forestry Riparian Management Zones to ensure greater water quality protection	NA	$1,000	Identify	Designate				1.4, 3.3	IE.2.1
		Notes: Review current and identify potential RMZs; relay to MDNR; 50% increase in designated RMZs									
	LU.6	Promote MAEAP to agricultural producers	NA	$10,000	Ongoing					1.4, 3.3	IE.2.1
		Notes: Conduct site assessments to potential enrollees; Increase enrollment by 20% by year 10									

EH	Ecosystem Health										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	EH.2	Compile known information about small dams within the Watershed. Remotely gather additional information to fill in gaps. Prioritize field assessments and work to meet with property owners to discuss options	NA	$4,000	Convene	Report	NA	CRA, HP, MDEQ, MDNR, TOMWC	SG, FG, PO	1.6, 2.6, 4.5	IE.2.1, IE.2.2
		Notes: Convene small dam projects working group to begin implementation; Report of small dam findings with priority projects and property owners identified									
	EH.3	Develop and implement outreach and education strategy targeting owners of priority small dams. Focus on ecosystem impacts, dam removal options, and available assistance	NA	$5,000	NA	Engage		CRA, HP, MDEQ, MDNR, TOMWC			IE.1.1, IE.1.2, IE.2.2, IE.2.3
		Notes: Develop materials packet for distribution; Engage with at least 10 priority small dam owners									

RSH	Recreation, Safety, and Human Health										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	RH.1	Monitor public beaches annually for potential health hazards, report advisories and beach closings via Beachguard	$250 per beach sample	$440,000		Monitor		DHD#4, HDNWM, MDEQ, USGS	SG, FG, LG, PO	3.5	IE.1.1
		Notes: Secure funding to implement program annually									

Medium	RH.5	Develop Inland Waterway campaign that includes social media, advertisements, printed materials, and signage that highlights exceptional natural resources, boating safety, clean boating, invasive species, water quality, and the Inland Waterway-Water Trail, etc. to educate recreationists about both enjoying and protecting the resource	NA	$50,000	NA	Convene	Launch	All	PO, SG, FG, PF		IE.1.1, IE.1.2, IE.2.1, IE.2.4
		Notes: Convene working group to identify needs, develop communications plan, seek funding and additional partners; Launch campaign									

HG	Hydrology and Groundwater										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
Medium	HG.4	Employ Landscape Hydrology Model to assess pollutant loadings and sources concurrent with Watershed Management Plan update	NA	$10,000	NA	NA	Model	Michigan State University, *TOMWC*		4.5	IE.2.2
		Notes: Secure funding, identify project partners, apply model; Incorporate model results into plan update									
Medium	HG.5	Implement Wellhead Protection Programs (WHPP) in communities where greater protection of groundwater is critical to safeguard against drinking water contamination	NA	$40,000	NA	Identify and Funding	Develop	DHD#4, HDNWM, MDEQ, NEMCOG, TOMWC, local governments	SG, PO	2.5, 3.5, 4.1, 4.4	IE.1.1, IE.2.2
		Notes: Identify communities that are at greatest risk for drinking water contamination; secure funding through WHPP grant program; Develop WHPP for at least one community within Watershed									
Low	HG.6	Work with area businesses and property owners to encourage proper maintenance, monitoring, and removal of underground fuel storage tanks and other potential hazards	NA	$40,000	NA	Identify	Removal		PF, SG, CS, LB	3.5, 4.4	IE.2.1, IE.2.2, IE.2.3

		Notes: Identify potential sites for future removal or replacement, secure funding to support; removal or replacement of at least one tank

AI Aquatic Invasive Species

Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	AI.3	**Provide property owners with assistance and resources with invasive species management through site assessments, distribution of resources, and other outreach**	**NA**	**$50,000**		**Implement**		***C.A.K.E*, HP, *NE MI CISMA*, TOMWC, local governments**	**PF, SG, FG, PO, CS**	**2.2**	**IE.2.1, IE.2.2**
		Notes: Perform 50 site assessments and publish 10 widely-distributed AIS articles via newsletters or other media									
	AI.4	Install signage at public boat launches that highlight Clean Boats, Clean Waters program and message	$1,000/sign	$10,000	Locations and Funding	Install		HP, LTBB, MDNR, MSUE, TOMWC, lake associations	PF, SG, PO, LB	2.2	IE.1.1
		Notes: Identify locations, secure funding; Install 10 signs throughout the Watershed									
	AI.5	Conduct volunteer-based boater education program through Clean Boats, Clean Waters program	NA	$5,000		Recruit and Train		HP, MI Sea Grant, TOMWC, lake associations	SG, FG, LG, PO	2.2	IE1.1, IE.2.1, IE.2.4
		Notes: Recruit volunteers, host training; Conduct boater outreach									
	AI.7	Recruit and coordinate multiple lake association-based volunteer teams to operate boat washing stations (AI.6)	NA	$30,000	Develop	Operate		HP, TOMWC, lake associations	PF, PO	2.2	IE.2.4
		Notes: Develop and promote program, recruit volunteers, trainings, and coordination									
Medium	AI.9	Develop volunteer-based aquatic invasive species monitoring program	NA	$15,000	NA	Implement		*HP, TOMWC*	PF, SG, FG, LG, PO	2.2	IE.2.4
		Notes: Develop program and begin implementation by year 5; Continue program through year 10									

SS	Septic Systems										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	SS.1	Develop septic system outreach campaign, including incentives such as a septic giveaway, free or discounted inspections.	NA	$75,000	NA	Develop and Funding	Implement	TOMWC, lake associations, local governments	PF, SG, FG, LG, PO, CS, LB		IE.1.1, IE.1.2, IE.2.1 IE.2.2, IE.2.3
		Notes: Develop outreach materials, identify potential project partners, secure funding									

EI	Emerging Issues and Future Threats										
Priority	Categories		Unit Cost	Est. Total Cost	Milestone 2017-2018	Milestone 2019-2021	Milestone 2022-2026	Potential Project Partners	Potential Funding Sources	Objectives Addressed	Information & Education Objectives Addressed
High	EI.1	**Conduct education and outreach to local government officials, lake associations, and other community groups and members about Line 5**	**NA**	**$100,000**		**Ongoing**		**TOMWC, lake associations, local governments**	**PF, PO**	**5.1**	**IE.1.1, IE.2.2**
		Notes: Conduct presentations, workshops, publish articles, press releases, and utilize social media to provide current and accurate information									
	EI.2	**Develop climate change strategies to protect most vulnerable aquatic resources**	**NA**	**$100,000**	**Funding**	**Strategies**		**NEMCOG, TOMWC, lake associations, local governments**	**PF, SG, FG, LG, PO**	**5.2**	**IE.1.1, IE.1.2, IE.2.2**

		Notes: Convene working group to identify and prioritize vulnerable areas; develop strategies given climate predictions, disseminate strategies via climate change campaign						
Medium	EI.3	**Monitor microplastics concentrations as new technology becomes available**	**NA**	**$250,000**	**Support and Implement**	**All**	**PF, SG, FG, LG, PO**	**5.3**	**IE.1.1, IE.2.2**
		Notes: Support new research and implement both pilot and permanent technologies where applicable to reduce future microplastics inputs						

CHAPTER 10

Monitoring Strategy

Implementation tasks and actions include many different types of monitoring activities. Monitoring is essential in order to evaluate effectiveness of the collective watershed efforts or individual actions. The following narrative details many of the recommended implementation actions and tasks.

Surface Water Quality Monitoring

Surface water quality monitoring will be used to evaluate the overall effectiveness of the nonpoint source Watershed Management Plan and assess changes resulting from specific implementation activities. Water quality data collected by MDEQ, USGS, TOMWC, LTBB, academic institutions, and other sources will be used to assess changes over time in the Burt Lake Watershed where data is available.

Physical and chemical parameters to be monitored include, but are not limited to:

- Dissolved oxygen
- pH
- Temperature
- Conductivity
- Chemical oxygen demand
- Biological oxygen demand
- Suspended solids
- Dissolved solids
- Water clarity
- Turbidity
- Light
- Carbon
- Phosphorus
- Nitrogen
- Chloride
- Zinc
- Copper
- Lead
- Cadmium
- Nickel
- Mercury
- Arsenic

Biological monitoring of bacteria, algae, aquatic macrophytes, aquatic macroinvertebrates, fish, and other aquatic organisms will supplement physicochemical data. Discharge will be measured at sites on any lotic systems that are monitored. Additional physical, chemical, or biological parameters will be included in monitoring efforts in response to emerging water quality threats.

The primary pollutants of concern that will be monitored in the tributaries are sediments and nutrients, but will also include other parameters such as chloride. Discharge measurements will be made to determine pollutant loads and make comparisons among tributaries in terms of pollutant loads relative to discharge.

Shoreline and Streambank Surveys

Shoreline protection will be achieved by surveying the shorelines of the major inland lakes every five to ten years. Parameters to be surveyed include indicators of nutrient pollution, erosion, greenbelt health, and shoreline alterations. Streambank surveys will be conducted every five to ten years on the Sturgeon, Crooked, and Maple Rivers and their tributaries to document erosion. The results of these surveys will be used to conduct follow-up activities directed toward riparian property owners, which will identify specific problems and encourage corrective actions. Survey results will also be used for trend analyses to determine if riparian areas are improving or deteriorating over time.

Shoreline protection will also be assessed by monitoring the interest in the Michigan Shoreland Stewards program. Monitoring will consist of reviewing statistics of the Burt Lake Watershed's riparians who take the survey on the Michigan Shoreland Stewards website. Furthermore, Watershed riparians who qualify as gold, silver, bronze, and starter will be assessed to determine trends in shoreline protection.

Stormwater Management

Pollutants associated with cars and roads, including metals, chlorides, and Polycyclic Aromatic Hydrocarbons (PAHs), are also commonly found in urban stormwater and warrant monitoring. The USEPA lists metals and salts as pollutants associated with urban runoff that "can harm fish and wildlife populations, kill native vegetation, foul drinking water, and make recreational areas unsafe and unpleasant." PAHs are not water-soluble and persist in the environment for long periods, although they can breakdown from UV light exposure.

Stormwater discharge will be monitored to determine negative impacts to surface waters and to evaluate changes in the quality and quantity of stormwater runoff. The first priority is to collect baseline water quality data from the stormwater outfalls that discharge into Alanson, Spring Lake, and the lower stretch of the Sturgeon River (in Indian River). Baseline data will be used to identify serious water quality problems, investigate problem sources, and determine and implement corrective actions. In addition to identifying and correcting problems, subsequent monitoring will provide the means to evaluate future BMP implementation projects.

Implementation of low-impact development (LID) or green infrastructure projects is an important aspect of stormwater management. As more LID projects are implemented, public interest, awareness, and familiarity with LID practices will increase. Tracking the number of implemented projects through Information/Education (I/E) efforts, as well as public interest and awareness, will be ongoing.

Land Use

Land use change and landscape alterations caused by humans will be monitored because of the strong potential to influence nonpoint source pollution. Although primarily done using remotely sensed data in a GIS, field surveys may also be required. Landcover data will be used to assess changes in land use every 10 years. Increases or decreases in landcover associated with development (e.g., agricultural or urban) will be examined in context of changes in water quality and aquatic ecosystem health.

Implementation of both forestry and agriculture BMPs will be monitored through increased enrollment in stewardship-based programs, such as MAEAP and the State of Michigan's Forest Stewardship Program with a focus on enrollment in critical areas.

Road/Stream Crossing Inventories

Road/stream crossings throughout the Watershed will be surveyed by major subwatershed approximately every 10 years to document current conditions, update prioritization, and to evaluate improvements or BMP installations. The three major subwatersheds, as well as the Burt Lake Direct Drainage, will be surveyed separately during the last three years of implementation. Data will be uploaded to www.northernmichiganstreams.org for public access. As is the practice with road/stream crossings, most are not given attention until they fail and create problems. Therefore, monitoring should also include discussion with resource managers and other partners to ascertain whether any road/stream crossings need more immediate attention.

Land Protection and Management

The priority parcel process is a tool that reduces nonpoint source pollution impacts to water resources by identifying parcels that are high priority for permanent protection based on ecological value and other criteria. This prioritization process will be carried out approximately every five years to monitor land protection efforts. Parcels will be reevaluated and assigned updated rankings. Progress in land protection will be evaluated by determining change over time in the number of parcels and the total land area in the Watershed considered to be protected from development. Updated prioritization information will be shared with land conservancies that are active in the Watershed to assist with land protection efforts.

Ecosystem Health

Habitat diversity is important for maintaining healthy, vibrant aquatic ecosystems, particularly in small streams and the littoral zone of lakes. Nonpoint source pollution can reduce the variety of available habitat in an aquatic ecosystem through excessive sedimentation and cultural eutrophication. Therefore, monitoring habitat conditions throughout the Watershed is an important component for evaluating the effectiveness of nonpoint source pollution management plans.

Habitat mapping on Silver creek, Berry Creek, Stewart Creek, Club Stream, Lower Maple, and Hassler Creek will be prioritized in order to establish baseline data. Follow-up mapping will occur approximately ten years afterward. Field surveys will be conducted with a particular emphasis on large woody debris, riffle, pool, run, gravel, cobble, and other important aquatic habitat features.

Ecosystem health will also be monitored by gauging the interest in small dam removal. Stakeholders will identify and work with property owners with small dams in order to ultimately remove dams that are affecting ecosystem health.

Recreation, Safety, and Human Health

Monitoring of recreation, safety, and human health can be measured by the health alerts issued by the local health agencies. Oftentimes, health alerts are issued when water-related recreation, such as swimming, is prohibited due to a detected pathogen or other health threat. Beach closings are the most common alert; they are usually due to elevated *E. coli* levels. Other threats include avian botulism and swimmer's itch. Monitoring of mercury is also important. Mercury accumulates in fish tissue. Fish consumption, therefore, results in ingestion of mercury. Although the most significant source of mercury in the Burt Lake Watershed is air deposition (which is outside the scope of Watershed Management efforts), monitoring of mercury levels in local fish should be a priority for the MDEQ.

Hydrology and Groundwater

Groundwater is susceptible to contamination by nonpoint source pollution. In addition, landscape development and groundwater withdrawals (e.g., agricultural irrigation and drinking water) have the potential to reduce the amount of available groundwater. Therefore, groundwater monitoring is needed to assess the effectiveness of the nonpoint source management plan.

There is limited groundwater data for the Burt Lake Watershed. The first step is to compile all existing groundwater information, identify problems, determine data gaps, and develop a strategy for feasible, effective, and long-term groundwater monitoring. This assessment of existing information and development of a monitoring plan will be completed in 10 years.

High groundwater recharge areas are determined by the presence of permeable soils that allow for relatively rapid recharge of groundwater stores. They have been delineated for the Burt Lake Watershed because groundwater in these areas is particularly vulnerable to landscape development and nonpoint source pollution. The same permeability that lends itself to high groundwater recharge rates can also result in nonpoint source pollution passing relatively quickly through the soils and contaminating groundwater stores. Furthermore, increased impervious surface area as a result of landscape development leads to relatively greater decreases in groundwater recharge in areas with highly permeable soils (versus areas with lower soil permeability).

One approach for protecting high groundwater recharge areas is to limit impervious surface coverage. This can be accomplished through various means, such as implementing ordinances that limit the amount of impervious surface area on a parcel or limiting build-out potential through permanent land conservation. Efforts focused on protecting high groundwater recharge areas will be evaluated every ten years by determining changes (net gain or loss) in the extent of permanently protected lands in areas with high groundwater recharge rates.

Wetland Monitoring

Wetland restoration and protection efforts will be monitored by performing land cover change analyses in a GIS. A watershed-level analysis will be performed every 10 years using remote sensing data to determine increases or decreases in wetland acreage throughout the Watershed.

High-value wetlands will be identified and mapped out by assessing wetlands throughout the Watershed in terms of ecological and environmental values (e.g., habitat value, water quality benefits, and flood control contributions). Following identification and mapping, the areas containing high value wetlands will be calculated every 10 years to determine any net change.

Threatened and Endangered Species

Lake sturgeon research will continue as a means of monitoring their populations and habitat needs. As new information is learned, regulations and rearing of the species will adjust in order to achieve the desired population.

Aquatic Invasive Species

Many invasive species have become well established within the Burt Lake Watershed, including invasive *Phragmites*, purple loosestrife, Eurasian watermilfoil, zebra mussels, quagga mussels, sea lamprey, and curly-leaf pondweed. Although eradication of these species is not feasible, efforts to control their spread within and out of the Watershed is a priority.

Using databases maintained by TOWMC and Michigan Invasive Species Information Network (MISIN), both the *introduction* of additional aquatic invasive species and the *spread* of documented aquatic invasives species within the Watershed will be tracked. Biological control, where applicable, will be used to control purple loosestrife and zebra/quagga mussels. Alternative management strategies of sea lamprey within the Inland Waterway will be conducted and assessed. Outreach and education, volunteer programs, technical and financial assistance to property owners, and innovative communication and control measures (e.g. mobile boat washing station) will collectively reduce the spread and thwart the introduction of aquatic invasive species.

Septic Systems

Develop septic system outreach campaign, including incentives such as a septic giveaway and free septic evaluations. In communities where individual septic systems are no longer affective at protecting water quality, community sewer systems will be installed. Local jurisdictions will adopt septic ordinances as a means to protect water quality

Emerging Issues and Future Threats

Line 5 Pipeline

Conduct education and outreach to local government officials, lake associations, and other community groups and members about Line 5.

Climate Change

Develop and conduct information and education programs to continue to bring awareness among all Watershed residents and stakeholders. Programs will highlight importance of supporting state and federal climate change adaptation initiatives, including the Great Lakes Restoration Initiative and other grant programs that can support local Watershed management efforts.

Socio-economic Monitoring

Many projects carried out as a result of the Watershed Management Plan will have social and economic impacts. For example, nonpoint source pollution education of Watershed residents may affect behavior and result in a reduction of nonpoint source pollution, or nonpoint source pollution reductions in surface waters may increase local tourism revenues and boost the economy. Therefore, monitoring activities should also include social and economic elements.

There are many methods for monitoring social and economic changes as a result of the Management Plan. Some of the primary tools for conducting this type of monitoring include surveys and demographic/economic change analyses. To establish relationships between socio-economic factors and nonpoint source pollution, data from other monitoring activities (e.g. surface water quality monitoring) will be incorporated into this monitoring effort.

CHAPTER 11

Evaluation Strategy

To ensure that the recommended actions are meeting the goals of the Watershed Plan, an evaluation will be required to determine the progress and effectiveness of the proposed activities. The evaluation step is an important part of any watershed planning effort in that it provides feedback on the success of an activity or the project's goals. It also provides communities with important information about how to conduct future efforts, or how to change the approach to a specific problem in order to be more successful the next time. If activities are successful, this will gain more support for future activities amongst decision makers.

The Burt Lake Watershed Management Plan will be evaluated by:

- Progress in completing the recommended actions and tasks (plan implementation)
- Effectiveness in protecting water quality

Evaluation Strategy for Plan Implementation

Tip of the Mitt Watershed Council will act as the lead organization and will oversee both the coordination of the Advisory Committee and the evaluation strategy for Plan implementation. The evaluation strategy will be used to determine progress in completing the recommended actions and tasks identified in the Plan. The Advisory Committee will review the recommended tasks and actions every five years and identify what has been accomplished during the previous five years. The assessment will include an advisory committee "stocktaking" based on an effective evaluation strategy developed for the Little Traverse Bay Watershed Management Plan in 2011. The Little Traverse Bay Advisory Committee decided to take stock of the progress that had been made on the actions recommended in the Plan; to identify the highest priorities for action today, given developments over the past five years; and to get input from partners on how to improve implementation of the Little Traverse Bay Watershed Protection Plan. The evaluation was based on soliciting opinions of the Advisory Committee on a one-on-one basis. A series of interview questions were used to elicit responses that would gauge the interviewee's sense of the effectiveness of the Plan, its strengths and weaknesses, areas in need of change, its usefulness, etc. Interviewee responses were compiled into a report of key findings and suggestions. The stocktaking effort was considered very insightful and will influence the future success of the Advisory Committee through implementing change, such as meeting structure and agendas. As an example, one key finding includes:

> The scope of the Plan and, thus, the agendas for many of the Committee's meetings, are too broad for many partner organizations and their representatives, and may have contributed to lower participation at Committee meetings. To address this, one suggestion was to convene smaller working group meetings around a few priority topics and hold general

meetings less frequently (e.g., once a year). Another was to focus each meeting on a different aspect of the Plan and target speakers, field visits, and participation accordingly.

Based upon the informative result of this evaluation method, the Burt Lake Watershed Advisory Committee will undergo a similar stocktaking strategy every five years. Although an intensive process, the results will be very valuable to the success of the overall Watershed management effort.

After ten years, the Watershed Advisory Committee will seek funding to update the plan. The resource inventories will be repeated and included in the update. Any implementation steps not completed after the first ten years of Plan implementation will be assessed as to their relevance in the Plan update. New implementation steps will also be developed based on current conditions of the Watershed and the priorities of the Watershed Advisory Committee.

Evaluation Strategy for the Overall Protection Plan

The evaluation strategy for the overall Protection Plan in protecting water quality is based on comparing criteria with monitoring results. The Monitoring Strategy in Chapter 10 provides the framework in which to collect the appropriate data. For the Burt Lake Watershed, a set of criteria were developed to determine if the proposed pollutant reductions in the Burt Lake Watershed are being achieved and that water quality is being maintained or improved. The water quality criteria for parameters that reflect nutrient and sediment pollution are as follows:

1. **Total phosphorus concentrations in nutrient-poor lakes remain below 8 ppb (parts per billion)**

Total phosphorus concentrations in large, deep, oligotrophic lakes are typically less than 8 ppb, which is the case for Burt, Crooked, Pickerel, Huffman, Silver, and Round Lakes.

2. **Total phosphorus concentrations in other lakes remain below 12 ppb (parts per billion)**

Total phosphorus concentrations in minimally impacted surface waters are typically below 12ppb. All lakes within the Burt Lake Watershed have long-term averages values below 12ppb except Lancaster Lake and Thumb Lake.

3. **Total phosphorus concentrations in tributaries remain below 20 ppb.**

Phosphorus concentrations in surface waters are not regulated by the State of Michigan or the USEPA. For the Burt Lake Watershed, most tributaries have total phosphorus concentrations below 20 ppb. Certain streams may naturally exceed phosphorus concentrations of 20 ppb. These include White Goose and Maple Bay

Creeks. Other streams currently exceeding 20 ppb are Van Creek and an unnamed tributary on the northwest side of the Lake. These streams may be impacted by nutrient pollution.

4. Total Nitrogen concentration in lakes and their tributaries should remain below 1 ppm (parts per million).

Nitrogen concentrations in surface waters are also not regulated by the State of Michigan or the USEPA. All water bodies within the Burt Lake Watershed have historical averages of total nitrogen concentrations below 1 ppm, with the exception of Mud and Spring Lakes, which are in exceedance of this standard.

5. Maintain high dissolved oxygen levels in lakes and their tributaries

Dissolved oxygen concentrations in the Watershed's lakes and streams are typically above the 7 ppm standard that is required by the State of Michigan for water bodies that support cold-water fisheries.

6. Reduce nutrient inputs from stormwater in urban areas.

Depending on numerous factors, such as drainage area, land-cover type, and period between rain events, nutrient loads in stormwater can vary widely. More data is needed to generate a comprehensive baseline data set and accurately assess stormwater impacts. Once baseline data are available, implementation projects that aim to reduce nutrient loads from stormwater in urban areas can be assessed through future stormwater monitoring. It is important to note that implementing stormwater management projects prior to baseline data collection will still achieve pollutant reductions; however, site-specific data will result in more targeted efforts.

7. Maintain or reduce sediment loads in tributaries and stormwater.

Similar to nutrient inputs in stormwater, additional sediment data is needed to generate a comprehensive baseline data set for stormwater impacts. Once baseline data are generated, comparisons can be made to determine changes in time as related to implementation projects.

8. Maintain pH levels within range of 6.5 to 9.0 in lakes and their tributaries as required by the State of Michigan.

Data from the TOMWC Comprehensive Water Quality Monitoring program show that pH levels consistently fall within this range.

9. Maintain or reduce the level of conductivity in lakes and their tributaries.

Conductivity levels have been monitored as part of the TOMWC CWQM program and typically ranged from 200 to 300 µS/cm. Groundwater can range from 300 to 500 µS/cm depending on sub-surface conditions. Therefore, conductivity levels in surface waters should consistently be less than 500 µS/cm.

10. Maintain low water temperatures in water bodies designated for or capable of sustaining cold-water fisheries.

The water bodies listed in Table 8 above have naturally cold water. Within these water bodies, maintain low water temperatures to sustain the cold-water fishery. Water temperatures should generally not exceed 20° Celsius throughout summer months.

11. Prevent beach closings due to bacteriological contamination.

Prevent beach closings throughout the Watershed as a result of *E. coli* levels that exceed the State of Michigan water quality standard for single day (>300 *E. coli* per 100 ml of water). Prevent extended beach closings (there have been none to date) that result from a 30-day geometric mean measurement that exceeds State standards (>130 *E. coli* per 100 ml of water in 5 samples over 30 days).

12. Maintain or improve aquatic macroinvertebrate community diversity throughout the Watershed.

Aquatic macroinvertebrate diversity in a stream varies depending on many variables, including stream size, stream flow, habitat diversity, water temperature, riparian vegetation, land use, and more. Therefore, aquatic macroinvertebrate diversity at a given location on a stream must be viewed through a lens that accounts for such variables and is best compared with similar stream sites to accurately gauge stream ecosystem health. Reliable baseline data requires monitoring a site for a minimum of three years, after which the site can be compared to others, using diversity indices to determine if the site and stream are normal and healthy. Thereafter, future monitoring can be conducted to assess the benefits of implementation projects to stream ecosystem health.

13. Reduce *Cladophora* algae growth that is caused by nutrient pollution on all inland lakes where it has been documented.

Cladophora algae occurs naturally in small amounts along the shorelines of Northern Michigan lakes, but grows more extensively and densely as nutrient availability increases. Shoreline surveys conducted on many of the Watershed's lakes documented the occurrence of *Cladophora* on the shoreline, as well as the density of growth. Results from these surveys illustrate that *Cladophora* is present and dense, especially along certain shoreline segments. Thus, the same information generated during future surveys can be used to determine if there were reductions in the number of properties with *Cladophora* growth or the number with heavy-density growth because of implementation projects.

14. Maintain low chloride concentrations in surface waters.

Data from the TOMWC CWQM program show that chloride concentrations have increased significantly over the last 20 years in most lakes and streams monitored in Northern Michigan. Chloride levels in the Watershed's surface waters average ~15 ppm, with most pristine water bodies reading below 10 ppm. However, Spring, Mud, and Round Lakes have much higher chloride levels. Chloride is monitored because it is a good indicator of human activity in a watershed, i.e., as human population increases and urban and agricultural land use increases, so do chloride levels. In addition, monitoring chloride is valuable because it indicates that more damaging pollutants associated with chloride, such as leaking fluids and metals from automobiles that accumulate on roads along with deicing salts, are washing into and negatively impacting adjacent surface waters. Although most aquatic life is not affected by chloride until levels reach very high concentrations (>1000 ppm), some sensitive organisms may be lost at lower levels over the long-term. Chloride concentrations in the Watershed's surface waters should not surpass 50 ppm and remedial actions should be taken if levels reach 100 ppm.

In addition to applying the abovementioned criteria, more qualitative evaluation methods will be used. Field assessments of BMPs, such as LID or streambank or shoreline bioengineering projects, will determine effectiveness by taking photographs, gathering physical, chemical, and/or biological data. We will also document projects with photographs to evaluate their effectiveness or need for improvement or modification. For example, shoreline and streambank restoration projects will be photographed before any restoration begins, during project installation, and after project completion. Other project types that may also warrant photographic documentation include road/stream crossings, stormwater and agricultural best management practices (BMPs), recreational access sites, etc.

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APPENDICES

Appendix A: Focus group and interview questions

Local Officials Focus Group Sessions

1. Please introduce yourself by telling us first, your first name, second, your current governmental role, and, third, how long you have been involved with local government?

2. What do you like best about this area?

3. When you think of Burt Lake/Sturgeon River, what words or phrases come to mind that describe those areas?

4. How does the quality of the water in and around Burt Lake and the Sturgeon River influence activities like fishing, swimming, boating, or picnicking?

5. What are the challenges you face in protecting water quality in your role as a local official?

6. In general, how well do you think townships, the city, and the county work together? How about when it comes to water quality issues? How could they be improved?

7. A chapter from the Local Ordinance Gaps Analysis Guide from a nearby county was sent to you before this meeting. What are your first impressions about the Local Ordinance Gaps Analysis Guide? What do you like about the Guide? What do you not like about the Guide?

8. How do you think a guide like this might be used in your community?

9. To wrap up our conversation, how do you recommend that the Tip of the Mitt Watershed Council inform local officials and get them involved in using the Guide in the effort to develop a watershed protection plan?

10. Is there anything else you would like to add?

Residents (shoreline–large lake) Focus Group Session

1. Please introduce yourself by your first name and tell us in general terms about where you live and what you do?

2. What do you like best about this area?

3. When you think of Burt Lake/Sturgeon River, what words or phrases come to mind that describe those areas?

4. How do you use the natural resources of the Burt Lake/Sturgeon River? This could be purely recreational (hiking or bird watching) or to supply needs like food or firewood.

5. How does the quality of the water in and around Burt Lake and the Sturgeon River influence your participation in activities like fishing, swimming, boating, or picnicking?

6. Are there places in the Watershed we should be concerned about, like places where pollutants may enter the water, where there's erosion, or other things you have noticed that could risk water quality? Feel free to point them out on the map, or if you would prefer, describe them.

7. We're interested in your opinions about water quality educational information. In front of you are examples of publications. What do you like and dislike about them? Which ones do you think would be most useful to you and your neighbors?

8. What are some of the other ways that the Tip of the Mitt Watershed Council and other organizations could inform you and your neighbors about water quality in lakes and streams? Examples are TV, radio, workshops, Facebook, email newsletters, newspaper articles, etc.

9. To wrap up our conversation, how do you recommend that the Tip of the Mitt Watershed Council and other organizations get residents in your area involved in this water quality protection?

10. Is there anything else you would like to add?

Residents (except shoreline–large lake) Individual interviews

1. What do you like best about this area?

2. How do you use the natural resources of the Burt Lake/Sturgeon River? This could be purely recreational (hiking or bird watching) or to supply needs like food or firewood.

3. How does the quality of the water in and around Burt Lake and the Sturgeon River influence your participation in activities like fishing, swimming, boating, or picnicking?

4. Are there places in the Watershed we should be concerned about, like places where pollutants may enter the water, where there's erosion, or other things you have noticed that could risk water quality?

5. What are some of the other ways that the Tip of the Mitt Watershed Council and other organizations could inform you and your neighbors about water quality in lakes and streams? Examples are TV, radio, workshops, Facebook, email newsletters, newspaper articles, etc.

6. To wrap up our conversation, how do you recommend that the Tip of the Mitt Watershed Council and other organizations get residents in your area involved in this water quality protection?

7. Is there anything else you would like to add?

Appendix B: Threatened and Endangered Species

Species information presented in the following format:

- **Species Common Name, *Latin Name*** [State Protected Status (State Rank), Federal Protected Status]
- Minor Watersheds
- Sources

Animals

Hungerford's crawling water beetle, *Brychius hungerfordi* [E (S1), LE]
Maple River
Hyde and Smar (2000), MNFI (2007), Tansy (2006)

- Small, yellowish-brown beetle with irregular dark markings and narrow longitudinal stripes
- Populations have been observed in only four locations in Michigan (including the East Branch of the Maple River) and one location in Ontario's Bruce Peninsula
- Prefer clean, cool streams with well-aerated riffles, cobble and sand substrate, and alkaline waters
- Most often found on cobbles in riffles downstream of culverts, natural debris dams, beaver dams, and human-made impoundments
- Likely feed on macro-algae
- Surveying for *B. hungerfordi* should be performed prior to the removal of any structure that produces ripples
- Modification to stream channel conditions and the introduction of game fish (particularly brown trout) are possible threats

King rail, *Rallus elegans* [E (S1), N/A]
Crooked River
MNFI (2007), Rabe (2001)

- Large, rust-colored marsh bird with long bill and toes
- Migratory to the Great Lakes region
- Breeds almost exclusively in coastal wetlands and only sporadically in inland wetlands
- Preservation and restoration of inland wetland areas act to maintain and increase potential nesting habitat

Planorbella smithi [E (S2), N/A]
Burt Lake Direct Drainage, Maple River (Douglas Lake), Sturgeon River

MNFI (2007)

- Medium-sized freshwater snail, shell is 0.5 – 0.75" in diameter
- Found in marl, sand, and mud substrate along the shore of large oligotrophic lakes
- Management practices to be avoided: loss of habitat through shoreline development (especially shorelines with marl substrate), introduction of fish species for recreational or commercial purposes, molluscicdes (copper sulfate or copper carbonate) commonly used to treat lakes with swimmer's itch

Lake Sturgeon, *Acipense fulvescens* [T (S2), N/A]
Burt Lake Direct Drainage, Sturgeon River
Goforth (2000), MNFI (2007)

- Only sturgeon species native to the Great Lakes
- Prefer deep run and pool habitats of rivers (> 5 ft.) and shallow areas of large lakes
- Require rocky substrate to spawn, preferably in a river but can also use lakeshores
- Burt, Mullet, and Black Lakes and the Cheboygan River is one of four inland waterways in Michigan with a significant lake sturgeon population
- World-wide population estimated to be 1% of its original size
- Restoration made difficult by species' late maturity, infrequent reproduction, and lack of parental care
- Susceptible to physical barriers to migration, loss of spawning area, and fishing pressure
- Habitat improvements include: removal of migration barriers, restoration and maintenance of sand and gravel stream substrate, maintenance and restoration of riparian areas, and reduced nonpoint source pollution

Lake Huron locust, *Trimerotropsis huroniana* [T (S2S3), N/A]
Burt Lake Direct Drainage, Maple River
MNFI (2007), Rabe (1999)

- Occurs only in sparsely vegetated, high-quality sand dunes in the northern Great Lakes
- Prefers shoreline dunes, but can live in similar inland habitats
- Highly sensitive to disturbance to dunes and over-vegetation
- Maintenance of undisturbed sand dune habitat is integral to this species' survival

Common Loon, *Gavia immer* [T (S3S4), N/A]]
Burt Lake Direct Drainage, Crooked River, Maple River
Gibson (2007), MNFI (2007)

- Lakes > 40 acres, with undeveloped shorelines, small islands or bog mats, and alkaline waters are preferred for nesting and rearing
- Very large inland lakes are often utilized as a migratory staging area and food source for young adult and non-breeding birds
- Very sensitive to disturbance by human activity during the breeding season
- Susceptible to mercury poisoning and botulism

Red-shouldered hawk, *Buteo lineatus* [T (S3S4), N/A]
Burt Lake Direct Drainage, Crooked River, Maple River, Sturgeon River
Cooper (1999), MNFI (2007)

- Widespread in North America and Michigan
- North-west Lower Peninsula hosts a high concentration of breeding activity in Michigan
- Prefers mature hardwood or mixed forests near wetlands
- Builds nests 35 – 40 ft. above the ground, but below the canopy; prefer at least 70% canopy cover
- Species would benefit from the preservation of large, contiguous tracts of mature hardwood and mixed forests near or containing wetlands

Plants
Michigan monkey flower, *Mimulus michiganensis* [E (S1), LE]
Crooked River, Maple River, Burt Lake Direct Drainage
MNFI (2007), Penskar and Higman (2001)

- Prostrate, mat-forming forb
- Only plant species entirely endemic to Michigan
- Requires cold, alkaline springs, seeps, and streams (silty-sand substrate, temperature 8.7 to 16.6 °C, and pH range of 7.66 – 8.21)
- Any known colonies should be directly protected
- Sensitive to changes in water flow, oxygenation, and turbidity

Small round-leaved orchis, *Amerorchis rotundifolia* [E (S1), N/A]
Crooked River, Maple River
MNFI (2007), Penskar and Higman (1999)

- One of the rarest orchids in North America
- Predominantly boreal, but found in cold northern swamps or semi-open fens in the northern Great Lakes Region
- Prefer sites with a source of persistent, cold groundwater and alkaline to circumneutral soil pH
- Populations in Michigan are susceptible to natural extirpation
- Management strategies involve supporting healthy ecosystems through insulation from human activity

- Locations of populations should be kept confidential

Limestone oak fern, *Gymnocarpium robertianum* [T (S1), N/A]
Burt Lake Direct Drainage
MNFI (2007)

- Small fern, 10 – 50 cm
- Prefer dense cedar swamps and limestone outcroppings
- Management should focus on preservation of hydrology and forest canopy in preferred habitats

Large water starwart, *Callitriche heterophylla* [T (S1), N/A]
Burt Lake Direct Drainage
MNFI (2007), Wisconsin Natural Heritage Inventory (2016)

- Small, aquatic annual with some floating leaves
- Found in Michigan rivers with slow-moving waters, but can also be found along the shores of streams and in slow-moving pools of faster streams
- Prefers sandy or muddy substrate
- Maintenance of host rivers' and wetlands' water quality is likely key to preserving species

Blunt-lobed woodsia, *Woodsia obtusa* [T (S1S2), N/A]
Crooked River
MNFI (2007)

- Medium-sized fern, 40 – 60 cm
- Prefers dry, shady, calcareous cliffs and crevices
- Should be protected from excessive foot traffic

False violet, *Dalibarda repens* [T (S1S2), N/A]
Crooked River
MNFI (2007), Penskar and Higman (2002)

- Small, perennial forb
- Prefers slightly moist depressions in coniferous uplands
- Grows in acidic pine needle littler and humus over sand
- Very little is known about this species and few sites have been confirmed in Michigan
- Management efforts should be targeted at seeking it out in its preferred habitat

Bog bluegrass, Poa paludigena [T (S2), N/A]
Maple River

MNFI (2007)

- Small, slender grass
- Found in muck soils of swampy, usually hardwood forests
- Likely requires natural hydrologic cycles and intact canopy

Calypso or fairy-slipper, Calypso bulbosa [T (S2), N/A]
Minor Watersheds
Higman and Penskar (1996b), MNFI (2007)

- Very small, perennial orchid
- Prefers moist, coniferous forests with cool soils and calcareous substrates
- The location of colonies should not be publicized, because small plants are susceptible to trampling in high-use areas

Goblin moonwort, Botrychium mormo [T (S2), N/A]
Maple River
MNFI (2007), Penskar and Higman (1996)

- Very small (8-10 cm), rare grapefern with succulent habit
- Prefers mature mesic northern hardwood forests rich in humus, but has been observed in disturbed, second-growth stands
- The range, extent, and status are poorly known so management strategies are difficult to devise

Pumpelly's bromegrass, Bromus pumpellianus [T (S2), N/A]
Crooked River
Higman and Penskar (1996a), MNFI (2007)

- Perennial, rhizomatous grass, 0.5 m – 1 m tall
- Prefers active low dunes and sandy shorelines, but can inhabit sandy or gravelly prairies, slopes, and tundra
- Common throughout western North America with small, disjunct populations in the northern Great Lakes
- Susceptible to heavy recreational use of dune and shoreline areas, but can tolerate moderate use

Slough Grass, Beckmannia syzigachne [T (S2), N/A]
Burt Lake Direct Drainage, Crooked River
MNFI (2007), Penskar and Crispin (2010), Wynia (2006)

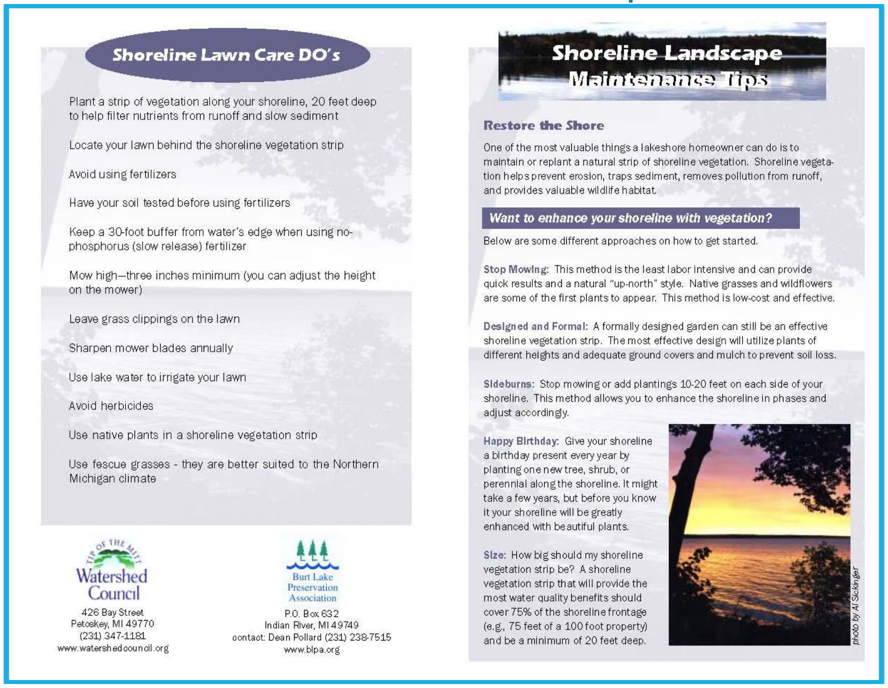
- Tufted annual grass with a stout stem, 0.5 m – 1 m tall
- Rare in Michigan, but a common wetland grass throughout much of northern North America and frequently planted as a hay or grazing crop in western states
- Relies on the preservation of wetlands

Appendix C: Priority Parcels Process Criteria for Prioritization and Scoring

Parcel Size (acreage)	
(GIS Field "acre_scr")	
Acres >= 10 AND acres < 20	1 pts
Acres >= 20 AND acres < 40	2 pts
Acres >= 40 AND acres < 80	3 pts
Acres >= 80	4 pts
Groundwater Recharge Potential (acreage)	
(GIS Field "gw_rcg_scr")	
Groundwater Recharge Acres >= 0 AND < 5	1 pts
Groundwater Recharge Acres >= 5 AND < 10	2 pts
Groundwater Recharge Acres >= 10 AND < 20	3 pts
Groundwater Recharge Acres >= 20+	4 pts
Wetland Preservation (acreage)	
(GIS Field "wetld_scr")	
Wetland Acres > 0 AND < 2	1 pts
Wetland Acres >= 2 AND < 5	2 pts
Wetland Acres >= 5 AND < 10	3 pts
Wetland Acres >= 10+	4 pts
Lake Shoreline/Riparian Protection (linear feet)	
(GIS Field "Lk_Scr")	
Lake Shore Distance > 100' AND < 200'	1 pts
Lake Shore Distance >= 200' AND < 400'	2 pts
Lake Shore Distance >= 400' AND < 600'	3 pts
Lake Shore Distance >= 600'	4 pts
River and Stream Shoreline/Riparian Protection (linear feet)	
(GIS Field "stream_scr")	
Stream Distance >= 100' AND < 500'	1 pts
Stream Distance >= 500' AND < 1000'	2 pts
Stream Distance >= 1000' AND < 2000'	3 pts
Stream Distance >= 2000'	4 pts
Steep Slopes for Erosion Prevention	
(GIS Field "slope_scr")	
Slopes >= 20 and < 30%	1 pts
Slopes >= 30 and < 35%	2 pts
Slopes >= 35 and < 40%	3 pts
Slopes > 40%	4 pts
Proximity to Protected Lands (Wildlife Corridors)	
(GIS Field "protct_scr")	
Parcel edge within 250' of conservation lands	1 pts
Abutting conservation land	2 pts
Linking conservation land	3 pts
Adjacent to conservancy lands and doubles size	4 pts

Threatened/Endangered Species (using MNFI model)	
(GIS Field "endang_scr")	
Probability = 'Low' AND "RI" >= 3 AND "RI" < 4	1 pts
Probability = 'Low' AND "RI" >=4	2 pts
Probability = 'Moderate' AND "RI" >=0	3 pts
Probability = 'High' AND "RI" >=0	4 pts
Proximity to Development (CCAP land cover = "Developed")	
(GIS Field "devpres_scr")	
Adjacent to any "developed" land cover	1 pts
Within 2.5 miles of City Development or .75 miles of non-incorporated development	2 pts
Within .75 miles of City Development	3 pts
Within City Development	4 pts
Natural Land Cover Types (CCAP = non-agriculture, non-developed)	
(GIS Field "NatPct_Scr")	
Natural Land Cover >= 50% AND < 70%	1 pts
Natural Land Cover >= 70% AND < 80%	2 pts
Natural Land Cover >= 80% AND < 90%	3 pts
Natural Land Cover >= 90%	4 pts
Drinking Water Protection Areas	
(GIS Field "wellHD_scr")	
Wellhead Protection Area >= 1% and < 20%	1 pts
Wellhead Protection Area >= 20% and < 35%	2 pts
Wellhead Protection Area >= 35% and < 50%	3 pts
Wellhead Protection Area > 50%	4 pts
Exceptional Resources	
(Multiple GIS Fields)	
Lakeshore w/Shoreline <= 25 parcels/mile average	2 pts
Intersects a Blue Ribbon Trout Stream	2 pts
Intersects Critical Dune Habitat	2 pts

Appendix D: Educational and Outreach Examples



Shoreline Lawn Care DO's

Plant a strip of vegetation along your shoreline, 20 feet deep to help filter nutrients from runoff and slow sediment

Locate your lawn behind the shoreline vegetation strip

Avoid using fertilizers

Have your soil tested before using fertilizers

Keep a 30-foot buffer from water's edge when using no-phosphorus (slow release) fertilizer

Mow high—three inches minimum (you can adjust the height on the mower)

Leave grass clippings on the lawn

Sharpen mower blades annually

Use lake water to irrigate your lawn

Avoid herbicides

Use native plants in a shoreline vegetation strip

Use fescue grasses - they are better suited to the Northern Michigan climate

Tip of the Mitt Watershed Council
426 Bay Street
Petoskey, MI 49770
(231) 347-1181
www.watershedcouncil.org

Burt Lake Preservation Association
P.O. Box 632
Indian River, MI 49749
contact: Dean Pollard (231) 238-7515
www.blpa.org

Shoreline Landscape Maintenance Tips

Restore the Shore

One of the most valuable things a lakeshore homeowner can do is to maintain or replant a natural strip of shoreline vegetation. Shoreline vegetation helps prevent erosion, traps sediment, removes pollution from runoff, and provides valuable wildlife habitat.

Want to enhance your shoreline with vegetation?

Below are some different approaches on how to get started.

Stop Mowing: This method is the least labor intensive and can provide quick results and a natural "up-north" style. Native grasses and wildflowers are some of the first plants to appear. This method is low-cost and effective.

Designed and Formal: A formally designed garden can still be an effective shoreline vegetation strip. The most effective design will utilize plants of different heights and adequate ground covers and mulch to prevent soil loss.

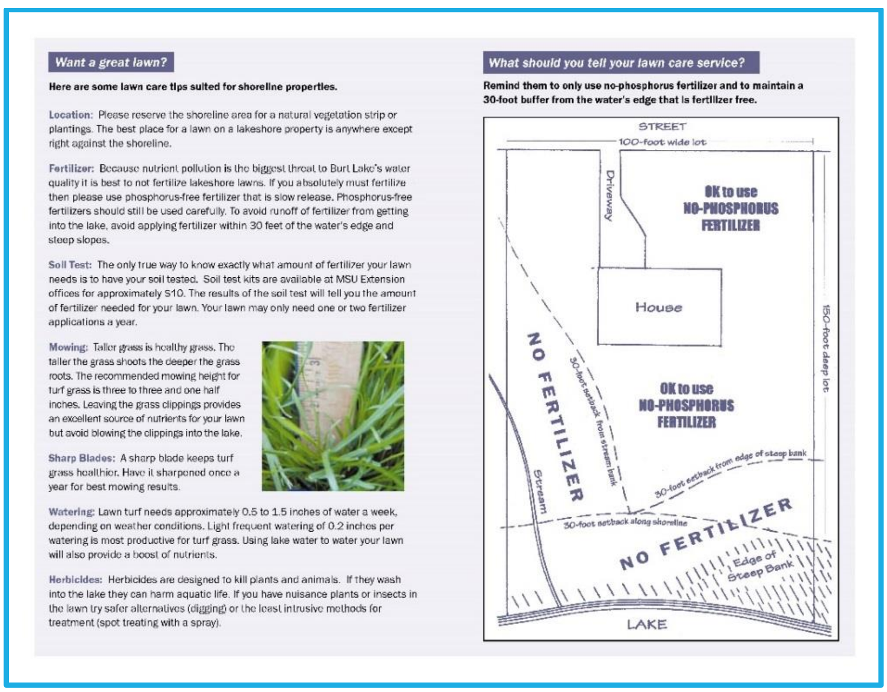
Sideburns: Stop mowing or add plantings 10-20 feet on each side of your shoreline. This method allows you to enhance the shoreline in phases and adjust accordingly.

Happy Birthday: Give your shoreline a birthday present every year by planting one new tree, shrub, or perennial along the shoreline. It might take a few years, but before you know it your shoreline will be greatly enhanced with beautiful plants.

Size: How big should my shoreline vegetation strip be? A shoreline vegetation strip that will provide the most water quality benefits should cover 75% of the shoreline frontage (e.g., 75 feet of a 100 foot property) and be a minimum of 20 feet deep.

photo by Al Sickinger

Figure 135: Front and back cover shoreline landscape maintenance tips



Want a great lawn?

Here are some lawn care tips suited for shoreline properties.

Location: Please reserve the shoreline area for a natural vegetation strip or plantings. The best place for a lawn on a lakeshore property is anywhere except right against the shoreline.

Fertilizer: Because nutrient pollution is the biggest threat to Burt Lake's water quality it is best to not fertilize lakeshore lawns. If you absolutely must fertilize then please use phosphorus-free fertilizer that is slow release. Phosphorus-free fertilizers should still be used carefully. To avoid runoff of fertilizer from getting into the lake, avoid applying fertilizer within 30 feet of the water's edge and steep slopes.

Soil Test: The only true way to know exactly what amount of fertilizer your lawn needs is to have your soil tested. Soil test kits are available at MSU Extension offices for approximately $10. The results of the soil test will tell you the amount of fertilizer needed for your lawn. Your lawn may only need one or two fertilizer applications a year.

Mowing: Taller grass is healthy grass. The taller the grass shoots the deeper the grass roots. The recommended mowing height for turf grass is three to three and one half inches. Leaving the grass clippings provides an excellent source of nutrients for your lawn but avoid blowing the clippings into the lake.

Sharp Blades: A sharp blade keeps turf grass healthier. Have it sharpened once a year for best mowing results.

Watering: Lawn turf needs approximately 0.5 to 1.5 inches of water a week, depending on weather conditions. Light frequent watering of 0.2 inches per watering is most productive for turf grass. Using lake water to water your lawn will also provide a boost of nutrients.

Herbicides: Herbicides are designed to kill plants and animals. If they wash into the lake they can harm aquatic life. If you have nuisance plants or insects in the lawn try safer alternatives (digging) or the least intrusive methods for treatment (spot treating with a spray).

What should you tell your lawn care service?

Remind them to only use no-phosphorus fertilizer and to maintain a 30-foot buffer from the water's edge that is fertilizer free.

Figure 136: Inside shoreline landscape maintenance tips

Appendix E: Water Quality Data

Biological Indices - Total Taxa, EPT, and Sensitive Taxa							
Water Body	Location	Total Taxa*	EPT Taxa*	Sensitive Taxa*	Count*	Data Source	Time Period
McPhee Creek	Valley Rd.	25.0	11.0	5.0	2	MDEQ	2005
Minnehaha Creek	Pickerel Lake Rd.	21.0	9.0	4.0	1	MDEQ	2005
Maple River East Branch	Douglas Lake Rd.	38.0	13.0	4.0	1	MDEQ	2005
Maple River Main Branch	Brutus Rd.	23.3	11.1	6.0	8	TOMWC	2012-2015
Maple River Main Branch	Maple River Rd.	39.5	19.0	9.5	2	MDEQ	2005-2010
Maple River Main Branch	Woodland Rd.	25.1	10.4	3.7	7	TOMWC	2011-2015
Maple River West Branch	Pleasantview Rd.	18.0	6.8	1.3	6	TOMWC	2011-2015
Maple River West Branch	Robinson Rd.	22.4	9.7	4.4	7	TOMWC	2011-2015
Club Stream	Fontinalis Club	30.0	15.0	8.0	1	MDEQ	2005
Club Stream	Sturgeon Valley Rd.	15.0	8.0	4.0	1	MDEQ	2000
Sturgeon River	Cornwall Grade Launch	31.0	14.5	6.0	2	MDEQ	2000-2005
Sturgeon River	Fisher Woods Rd.	35.0	16.0	9.0	1	MDEQ	2005
Sturgeon River	Fisher Woods Rd.	21.3	10.3	6.8	4	TOMWC	2013-2015
Sturgeon River	M68	17.7	9.0	5.7	3	TOMWC	2011-2012
Sturgeon River	Old Vanderbilt Rd.	20.0	11.0	7.0	1	TOMWC	2015
Sturgeon River	Poquette Rd.	25.0	13.5	6.5	2	MDEQ	2000-2005
Sturgeon River	Rondo Rd.	30.5	14.0	8.5	2	MDEQ	1991-2005
Sturgeon River	Scott Rd.	31.0	14.0	8.0	1	MDEQ	1991
Sturgeon River	Sturgeon Valley Rd.	26.0	12.0	7.0	1	MDEQ	2005
Sturgeon River	Sturgeon Valley Rd.	19.3	10.6	6.0	9	TOMWC	2011-2014
Sturgeon River	Trowbridge Rd.	33.0	13.0	7.0	1	MDEQ	1991
Sturgeon River	Whitmarsh Rd.	21.0	9.0	6.0	1	MDEQ	2000
Sturgeon River	Wolverine	21.3	11.1	7.3	9	TOMWC	2011-2015
Sturgeon River West Branch	M27 Roadside Park	26.4	13.8	8.9	12	TOMWC	2009-2015
Sturgeon River West Branch	M27 Wolverine	26.0	14.0	9.0	1	MDEQ	1991
Sturgeon River West Branch	McGregor Rd.	31.0	16.0	8.5	2	MDEQ	2001-2005
Sturgeon River West Branch	Shire Rd.	29.5	13.0	7.5	2	MDEQ	2000-2005

*Values in number of family-level taxa. Total taxa: total number of macroinvertebrate taxa; EPT taxa: taxa from pollution-sensitive insect orders (mayflies, stoneflies, and caddisflies); sensitive taxa: taxa most intolerant of pollution. Count = number of measurements at the site.

E. Coli								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 300 *E. coli*/ 100mL	Data Sources	Time Period
Burt Lake	0.00	2419.60	26.02	160	192.70	2	HDNWM	2002-2008
Crooked Lake	1.00	231.93	18.32	215	35.57	0	HDNWM	2001-2014
Pickerel Lake	1.00	131.91	12.29	66	20.27	0	HDNWM	2006-2014
Weber Lake	0.00	6.48	4.14	6	2.07	0	HDNWM	2002
Douglas Lake	0.00	11.50	4.83	6	3.99	0	HDNWM	2002
Larks Lake	1.00	141.84	7.89	47	23.13	0	HDNWM	2006-2013
Huffman Lake	1.26	66.90	10.56	12	17.36	0	HDNWM	2004
Pickerel Lake (Otsego)	1.00	40.48	3.91	38	6.77	0	HDNWM	2006-2010
Thumb Lake	0.00	157.57	6.12	108	17.60	0	HDNWM	2001-2014
Sturgeon River West Branch	12.87	166.60	55.83	4	64.16	0	HDNWM	2013

*Values in number of *E. coli*bacteria per 100mL. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.

**Count = number of measurements. # Above 300 *E. coli*/ 100mL = number of measurements above 300 *E. coli*/ 100mL, a numerical standard in R323.1062, Part 4 Water Quality Standards, Part 31 of PA 451 for all Michigan waters protected for total body contact recreation.

Chlorophyll-a								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 56 µg/L**	Data Sources	Time Period
Burt Lake	0.00	5.60	1.10	356	0.88	0	MDEQ, TOMWC, USGS	1979-2015
Crooked Lake	0.04	7.40	1.87	157	1.28	0	EPA, LTBB, MDEQ, TOMWC, UMBS, USGS	1974-2015
Mud Lake	0.20	18.00	2.09	33	3.02	0	LTBB	2001-2014
Pickerel Lake	0.00	4.96	1.32	158	1.01	0	MDEQ, TOMWC, USGS	1980-2015
Round Lake	0.10	11.00	2.06	46	1.93	0	MDEQ, LTBB, TOMWC, USGS	1980-2014
Spring Lake	0.20	8.33	2.26	33	1.98	0	LTBB	2001-2014
Douglas Lake	0.07	5.00	2.39	151	1.00	0	TOMWC	1991-2015
Lancaster Lake	0.49	2.00	1.23	9	0.55	0	MDEQ, TOMWC, USGS	1980-2007
Larks Lake	0.00	10.79	1.56	69	2.12	0	LTBB, MDEQ, TOMWC, UMBS, USGS	1974-2015
Munro Lake	0.13	24.10	3.85	101	4.43	0	TOMWC	1995-2014
Huffman Lake	0.00	14.60	0.63	100	1.54	0	MDEQ, TOMWC, USGS	1979-2015
Pickerel Lake (Otsego)	1.40	2.20	1.80	2	0.40	0	MDEQ, USGS	2005
Silver Lake	0.10	1.10	0.73	3	0.45	0	MDEQ, USGS	1980-2010
Thumb Lake	0.03	6.40	1.15	172	0.89	0	MDEQ, TOMWC, USGS	1979-2015
Sturgeon River	1.00	5.00	1.67	9	1.25	0	MDEQ	1990

*Values in µg/L. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.

**Count = number of measurements. # Above 56 µg/L = number of measurements above 56 µg/L, considered hypereutrophic by the North American Lake Management Society.

Secchi Disc Depth								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Below 0.5 Meters **	Data Sources	Time Period
Burt Lake	5.91	33.00	16.14	662	4.83	0	MDEQ, TOMWC, USGS	1967-2015
Crooked Lake	4.59	24.50	9.82	266	3.23	0	EPA, MDEQ, TOMWC, USGS	1980-2015
Pickerel Lake	3.94	19.00	9.57	373	2.88	0	MDEQ, TOMWC, USGS	1980-2015
Round Lake	3.61	15.00	10.29	119	2.26	0	MDEQ, LTBB, TOMWC, USGS	1980-2014
Douglas Lake	8.50	25.00	12.37	323	1.81	0	MDEQ, TOMWC	1967-2015
Lancaster Lake	8.50	12.00	10.11	10	1.19	0	MDEQ, TOMWC, USGS	1980-2007
Larks Lake	4.92	10.00	7.78	95	1.25	0	LTBB, MDEQ, TOMWC	1972-2015
Munro Lake	5.50	16.00	11.37	214	2.15	0	TOMWC	1995-2014
Huffman Lake	2.00	14.25	7.01	226	1.99	0	MDEQ, TOMWC, USGS	1979-2015
Pickerel Lake (Otsego)	11.15	19.03	15.09	4	3.94	0	MDEQ, USGS	2005
Silver Lake	9.00	46.50	26.98	238	6.87	0	MDEQ, TOMWC, USGS	1980-2010
Thumb Lake	7.00	41.50	19.43	330	5.67	0	MDEQ, TOMWC, USGS	1973-2015

*Values in feet. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.

**Count = number of measurements. # Below 0.5 Meters = number of measurements below 0.5 meters (1.64 feet), considered hypereutrophic by the North American Lake Management Society.

Nitrate Nitrogen								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 10 mgN/L**	Data Sources	Time Period
Burt Lake	51.0	150.0	105.7	35	24.7	0	MDEQ, TOMWC	1967-2013
Carp Creek	35.1	127.6	62.3	11	23.2	0	TOMWC	2011-2015
Hasler Creek	69.6	437.8	252.9	9	98.7	0	TOMWC	2014-2015
Maple Bay Creek	2.3	23.0	12.9	4	7.4	0	TOMWC	2014-2015
Unnamed Creek W Burt Lk Rd	16.0	196.1	70.0	9	55.4	0	TOMWC	2014-2015
White Goose Creek	30.7	396.3	174.1	10	119.8	0	TOMWC	2011-2015
Crooked Lake	0.0	510.0	231.4	37	129.3	0	EPA, LTBB, MDEQ, TOMWC	1957-2014
Mud Lake	627.8	649.0	638.4	2	10.6	0	TOMWC	2013
Pickerel Lake	19.0	510.0	194.6	32	123.7	0	TOMWC, UMBS	1974-2013
Round Lake	16.7	88.0	54.5	12	23.1	0	TOMWC	1998-2013
Spring Lake	811.0	1396.8	1021.9	8	219.2	0	TOMWC	2004-2013
Crooked River	46.1	280.0	141.6	17	65.3	0	TOMWC	2004-2015
Douglas Lake	13.0	510.0	113.0	31	153.5	0	MDEQ, TOMWC	1967-2013
Lancaster Lake	3.5	173.0	81.3	10	50.5	0	TOMWC	2004-2013
Larks Lake	10.0	149.0	57.3	20	38.0	0	TOMWC, USGS	1973-2013
Munro Lake	10.0	83.0	57.4	12	26.0	0	TOMWC	1998-2013
Maple River Main Branch	65.5	405.6	200.7	15	91.8	0	TOMWC	2004-2015
Huffman Lake	10.0	88.0	59.4	13	27.1	0	TOMWC	1998-2013
Silver Lake	18.0	90.0	42.5	18	17.9	0	TOMWC	1998-2013
Thumb Lake	7.8	510.0	119.0	30	134.8	0	MDEQ, TOMWC, USGS	1973-2013
Wildwood Lake	0.1	1.0	0.6	4	0.4	0	TOMWC	2004-2013
Sturgeon River	39.0	542.0	215.6	23	112.0	0	MDEQ, TOMWC	1990-2015
Sturgeon River West Branch	113.0	226.0	169.5	2	56.5	0	USGS	1966-1971

*Values in µgN/L. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.

**Count = number of measurements. # Above 10 mgN/L = number of measurements above 10,000µgN/L. Although there is no numerical surface water quality standard for nitrate, the Michigan Safe Drinking Water Act requires nitrate in drinking water be under 10mgN/L.

Total Nitrogen								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 400 µg/L (lakes) and 440 µg/L (streams)**	Data Sources	Time Period
Burt Lake	217	1800	392	57	256	16	MDEQ, TOMWC, USGS	1973-2013
Carp Creek	123	378	190	11	77	0	TOMWC	2011-2015
Hasler Creek	309	946	516	9	199	6	TOMWC	2014-2015
Maple Bay Creek	461	1109	654	11	226	11	TOMWC	2014-2015
Unnamed Creek W Burt Lk Rd	341	1212	577	9	289	5	TOMWC	2014-2015
White Goose Creek	309	1758	623	12	386	7	TOMWC	2011-2015
Crooked Lake	82	2300	528	164	326	104	EPA, LTBB, MDEQ, TOMWC, USGS	1957-2014
Mud Lake	540	2770	1119	52	370	52	LTBB, TOMWC	2001-2014
Pickerel Lake	125	1500	496	45	234	27	MDEQ, TOMWC, USGS	1980-2013
Round Lake	185	2790	672	105	304	97	MDEQ, LTBB, TOMWC, USGS	1980-2014
Spring Lake	513	2818	1119	58	491	58	LTBB, TOMWC	2001-2014
Cedar Creek	430	430	430	1	0	0	MDEQ	2005
Crooked River	191	693	396	17	140	5	TOMWC	2004-2015
McPhee Creek	650	650	650	1	0	1	MDEQ	2005
Minnehaha Creek	610	980	795	2	185	2	MDEQ	2005
Oden Creek	900	900	900	1	0	1	MDEQ	2005
Douglas Lake	298	1170	572	27	229	21	TOMWC	1987-2013
Lancaster Lake	410	682	550	18	84	18	MDEQ, TOMWC, USGS	1980-2013
Larks Lake	299	1520	680	90	228	86	LTBB, MDEQ, TOMWC, USGS	1980-2014
Munro Lake	470	1022	785	12	192	12	TOMWC	1998-2013
Maple River Main Branch	268	1025	521	16	157	12	MDEQ, TOMWC	2004-2015
Maple River East Branch	570	570	570	1	0	1	MDEQ	2005
Maple River West Branch	359	1420	745	76	251	73	LTBB, MDEQ	2001-2013
Van Creek	260	1875	583	33	352	19	LTBB	2011-2014

Huffman Lake	165	390	270	25	61	0	MDEQ, TOMWC, USGS	1979-2013
Pickerel Lake (Otsego)	250	1200	541	10	400	3	MDEQ, USGS	2005
Silver Lake	247	1203	475	26	208	15	MDEQ, TOMWC, USGS	1980-2013
Thumb Lake	246	2400	589	73	396	42	MDEQ, TOMWC, USGS	1973-2013
Wildwood Lake	297	439	363	8	46	2	TOMWC	2004-2013
Club Stream	222	530	376	2	154	1	MDEQ	2005
Sturgeon River	155	3214	491	30	529	12	MDEQ, TOMWC	1990-2015
Sturgeon River West Branch	303	500	401	3	80	1	MDEQ	2005

*Values in μg/L. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.
**Count = number of measurements. Although there is no numerical surface water quality standard for total nitrogen, a total nitrogen concentration of 400 μg/L for lakes and 440 μg/L for streams in Aggregate Nutrient Ecoregion VIII Subecoregion 50 are considered reference conditions by the EPA.

Total Phosphorus								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 9.69 µg/L (lakes) and 12 µg/L (streams)**	Data Sources	Time Period
Burt Lake	1.00	20.00	6.68	60	3.96	12	MDEQ, TOMWC, USGS	1973-2013
Carp Creek	0.26	29.00	8.31	11	9.17	3	TOMWC	2011-2015
Hasler Creek	4.50	23.00	10.34	9	6.55	2	TOMWC	2014-2015
Maple Bay Creek	20.60	43.00	31.43	11	7.79	11	TOMWC	2014-2015
Unnamed Creek W Burt Lk Rd	10.00	39.00	24.17	9	10.22	8	TOMWC	2014-2015
White Goose Creek	9.20	54.00	22.46	12	11.21	9	TOMWC	2011-2015
Crooked Lake	2.80	30.00	7.26	174	3.69	35	EPA, LTBB, MDEQ, TOMWC, USGS	1957-2014
Mud Lake	0.00	21.90	10.66	54	4.62	33	LTBB, TOMWC	2001-2014
Pickerel Lake	1.90	16.00	6.40	48	3.60	11	MDEQ, TOMWC, USGS	1980-2013
Round Lake	0.00	22.00	7.69	108	3.76	26	MDEQ, LTBB, TOMWC, USGS	1980-2014
Spring Lake	1.30	25.20	9.18	58	4.69	24	LTBB, TOMWC	2001-2014
Crooked River	3.40	29.00	8.22	17	8.10	3	TOMWC	2004-2015
Minnehaha Creek	10.00	10.00	10.00	1	0.00	0	MDEQ	2005
Oden Creek	20.00	20.00	20.00	1	0.00	1	MDEQ	2005
Douglas Lake	4.90	42.80	11.04	30	7.52	14	TOMWC	1987-2013
Lancaster Lake	4.90	74.00	19.28	19	15.79	14	MDEQ, TOMWC, USGS	1980-2013
Larks Lake	3.30	43.80	9.96	81	5.46	9	LTBB, MDEQ, TOMWC, UMBS, USGS	1973-2014
Munro Lake	4.50	13.30	8.97	12	2.97	4	TOMWC	1998-2013
Certon Creek	10.00	10.00	10.00	1	0.00	0	MDEQ	2005
Maple River Main Branch	3.00	56.00	12.61	16	12.49	4	MDEQ, TOMWC	2004-2015
Maple River East Branch	0.00	20.00	10.00	2	10.00	1	MDEQ	1967-2005
Maple River West Branch	2.50	20.70	10.05	76	4.13	22	LTBB, MDEQ	2001-2013
Van Creek	7.20	100.80	23.42	32	16.99	26	LTBB	2011-2014

Huffman Lake	2.00	11.00	6.54	27	2.77	5	MDEQ, TOMWC, USGS	1979-2013
Pickerel Lake (Otsego)	4.00	16.00	8.67	6	3.90	2	MDEQ, USGS	2005
Silver Lake	1.00	21.00	7.88	30	5.73	9	MDEQ, TOMWC, USGS	1980-2013
Thumb Lake	2.40	340.00	21.47	78	39.71	52	MDEQ, TOMWC, USGS	1973-2013
Wildwood Lake	5.30	11.90	8.29	8	1.90	1	TOMWC	2004-2013
Club Stream	7.00	9.00	8.00	2	1.00	0	MDEQ	2005
Sturgeon River	1.00	29.00	9.51	30	6.60	11	MDEQ, TOMWC	1990-2015
Sturgeon River West Branch	1.90	11.00	8.33	11	2.46	0	MDEQ	2005-2013

*Values in µg/L. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.
**Count = number of measurements. Although there is no numerical standard for phosphorus, a total phosphorus concentration of 9.69 µg/L for lakes and 12 µg/L for streams in Aggregate Nutrient Ecoregion VIII Subecoregion 50 are considered reference conditions by the EPA.

Total Hardness								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 180 mg/L CaCO3**	Data Sources	Time Period
Burt Lake	165.0	165.0	165.0	1	0.0	0	MDEQ	1967
Crooked Lake	150.0	186.5	168.3	2	18.3	1	MDEQ	1967-2005
Douglas Lake	130.0	130.0	130.0	1	0.0	0	MDEQ	1967
Lancaster Lake	166.0	166.0	166.0	1	0.0	0	MDEQ	2005
Larks Lake	126.9	126.9	126.9	1	0.0	0	MDEQ	2005
Maple River East Branch	145.0	145.0	145.0	1	0.0	0	MDEQ	1967
Pickerel Lake (Otsego)	168.9	168.9	168.9	1	0.0	0	MDEQ	2005
Thumb Lake	118.7	131.8	127.0	3	5.9	0	MDEQ	2005
Sturgeon River	175.0	200.0	192.4	14	7.5	12	MDEQ	1990-1996
Sturgeon River West Branch	188.0	207.0	199.3	8	7.1	8	MDEQ	2008

*Values in mg/L CaCO3. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.

**Count = number of measurements. # Above 180 mg/L CaCO3 = number of measurements above 180 mg/L CaCO3. Though there is no standard for hardness, the USGS Water Quality Information considers values over 180 as very hard.

pH								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Outside 6.5 to 9.0**	Data Sources	Time Period
Burt Lake	7.05	8.60	8.09	117	0.37	0	MDEQ, TOMWC, USGS	1967-2013
Carp Creek	7.95	8.68	8.25	10	0.29	0	TOMWC	2011-2015
Hasler Creek	7.78	8.31	8.08	9	0.14	0	TOMWC	2014-2015
Maple Bay Creek	7.40	7.98	7.69	11	0.21	0	TOMWC	2014-2015
Unnamed Creek W Burt Lk Rd	7.39	8.15	7.71	9	0.23	0	TOMWC	2014-2015
White Goose Creek	7.38	7.93	7.66	12	0.17	0	TOMWC	2011-2015
Crooked Lake	6.79	8.60	8.03	429	0.37	0	EPA, LTBB, MDEQ, TOMWC, UMBS, USGS	1957-2014
Mud Lake	6.90	8.38	8.02	58	0.26	0	LTBB, TOMWC	2001-2014
Pickerel Lake	7.10	8.45	8.05	74	0.31	0	MDEQ, TOMWC, UMBS, USGS	1974-2013
Round Lake	6.77	8.99	8.32	148	0.45	0	MDEQ, LTBB, TOMWC, USGS	1980-2014
Spring Lake	7.08	8.65	8.13	64	0.25	0	LTBB, TOMWC	2001-2014
Crooked River	7.46	8.72	8.53	142	0.19	0	TOMWC	2004-2015
Mud Creek	8.00	8.00	8.00	1	0.00	0	TOMWC	2004
Douglas Lake	7.08	9.40	7.96	31	0.45	1	MDEQ, TOMWC	1967-2013
Lancaster Lake	7.00	8.30	7.40	62	0.32	0	MDEQ, TOMWC, USGS	1980-2013
Larks Lake	7.18	9.31	8.49	137	0.40	9	LTBB, MDEQ, TOMWC, UMBS, USGS	1972-2014
Munro Lake	6.95	8.87	8.44	29	0.49	0	TOMWC	1998-2013
Maple River Main Branch	7.63	8.47	8.09	14	0.20	0	MDEQ, TOMWC	2004-2015
Maple River East Branch	8.20	8.20	8.20	1	0.00	0	MDEQ	1967
Maple River West Branch	5.50	8.28	7.90	75	0.37	1	LTBB	2001-2013
Van Creek	7.19	8.31	7.70	33	0.30	0	LTBB	2011-2014
Huffman Lake	7.45	8.43	8.11	37	0.30	0	MDEQ, TOMWC, USGS	1979-2013
Pickerel Lake (Otsego)	7.20	8.30	7.93	38	0.32	0	MDEQ, USGS	2005

Silver Lake	7.19	8.60	8.07	48	0.34	0	MDEQ, TOMWC, USGS	1980-2013
Thumb Lake	6.60	9.40	7.88	247	0.56	7	MDEQ, TOMWC, USGS	1973-2013
Wildwood Lake	6.60	8.46	7.91	16	0.64	0	Lakeshore Env., TOMWC	2004-2013
Sturgeon River	7.30	8.90	8.18	58	0.23	0	MDEQ, TOMWC, USGS	1966-2015
Sturgeon River West Branch	7.36	8.36	8.02	19	0.29	0	MDEQ, USGS	1966-2013

*Values in units. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.

**Count = number of measurements. # Outside 6.5 to 9.0 = number of measurements below 6.5 or above 9.0, a numerical standard in R323.1053, Part 4 Water Quality Standards, Part 31 of PA 451 for all Michigan waters.

Alkalinity								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Below 20 mg/L**	Data Sources	Time Period
Burt Lake	135.0	158.0	143.9	11	6.6	0	MDEQ, USGS	1973-2010
Crooked Lake	137.0	158.6	143.9	7	7.8	0	MDEQ, UMBS, USGS	1974-2005
Pickerel Lake	136.4	163.8	146.6	7	10.3	0	MDEQ, UMBS, USGS	1974-2010
Round Lake	103.0	121.0	109.3	3	8.3	0	MDEQ, USGS	1980-2010
Cedar Creek	174.0	174.0	174.0	1	0.0	0	MDEQ	2005
McPhee Creek	159.0	159.0	159.0	1	0.0	0	MDEQ	2005
Minnehaha Creek	180.0	180.0	180.0	1	0.0	0	MDEQ	2005
Lancaster Lake	125.0	197.0	165.8	4	26.9	0	MDEQ, USGS	1980-2005
Larks Lake	95.0	216.0	121.0	13	32.7	0	MDEQ, UMBS, USGS	1972-2005
Maple River Main Branch	144.0	144.0	144.0	1	0.0	0	MDEQ	2005
Maple River East Branch	112.0	140.0	126.0	2	14.0	0	MDEQ	1967-2005
Huffman Lake	140.0	166.0	153.7	7	11.0	0	MDEQ, USGS	1979-2010
Pickerel Lake (Otsego)	133.0	133.0	133.0	1	0.0	0	USGS	2005
Silver Lake	98.0	124.0	108.0	4	9.9	0	MDEQ, USGS	1980-2010
Thumb Lake	89.0	145.0	112.3	18	16.9	0	MDEQ, USGS	1973-2005
Wildwood Lake	120.0	148.0	133.8	6	10.1	0	Lakeshore Env.	2010
Club Stream	181.0	182.0	181.5	2	0.5	0	MDEQ	2005
Sturgeon River	138.0	218.0	181.4	28	17.7	0	MDEQ, USGS	1966-2005
Sturgeon River West Branch	188.0	190.0	189.3	3	0.9	0	MDEQ, USGS	1971-2005

*Values in mg/L $CaCO_3$. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.
**Count = number of measurements. # Below 20 mg/L = number of measurements below 20 mg/L, the EPA Water Quality Criteria recommended minimum value for aquatic life except where alkalinity is naturally lower, in which case the criterion cannot be lower than 25% of the natural level.

Specific Conductance								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 1000 uS/cm**	Data Sources	Time Period
Burt Lake	206.9	481.1	314.8	125	33.5	0	MDEQ, TOMWC, USGS	1973-2013
Carp Creek	257.0	316.8	292.1	11	20.0	0	TOMWC	2011-2015
Hasler Creek	286.2	492.3	450.6	9	60.1	0	TOMWC	2014-2015
Maple Bay Creek	267.9	369.3	320.5	11	36.5	0	TOMWC	2014-2015
Unnamed Creek W Burt Lk Rd	165.8	309.3	239.5	9	46.6	0	TOMWC	2014-2015
White Goose Creek	248.6	373.0	321.2	12	40.9	0	TOMWC	2011-2015
Crooked Lake	250.0	531.8	316.4	412	27.6	0	EPA, LTBB, MDEQ, TOMWC, UMBS, USGS	1957-2014
Mud Lake	448.7	819.4	524.4	58	66.8	0	LTBB, TOMWC	2001-2014
Pickerel Lake	230.0	351.0	296.7	60	27.2	0	MDEQ, TOMWC, UMBS, USGS	1974-2013
Round Lake	225.0	623.3	321.6	148	57.1	0	MDEQ, LTBB, TOMWC, USGS	1980-2014
Spring Lake	388.9	1190.0	538.3	61	134.3	1	LTBB, TOMWC	2001-2014
Cedar Creek	362.0	362.0	362.0	1	0.0	0	MDEQ	2005
Crooked River	258.5	319.4	307.2	143	9.4	0	TOMWC	2004-2015
McPhee Creek	339.0	339.0	339.0	1	0.0	0	MDEQ	2005
Minnehaha Creek	378.0	378.0	378.0	1	0.0	0	MDEQ	2005
Douglas Lake	178.0	247.1	219.0	30	16.7	0	TOMWC	1987-2013
Lancaster Lake	174.1	429.0	329.9	62	60.9	0	MDEQ, TOMWC, USGS	1980-2013
Larks Lake	33.0	425.0	216.3	140	67.0	0	LTBB, MDEQ, TOMWC, UMBS, USGS	1973-2014
Munro Lake	186.5	279.4	204.7	29	23.3	0	TOMWC	1998-2013

Maple River Main Branch	181.6	314.0	252.0	16	31.5	0	MDEQ, TOMWC	2004-2015
Maple River East Branch	256.0	256.0	256.0	1	0.0	0	MDEQ	1967-2005
Maple River West Branch	193.0	402.3	303.1	75	41.4	0	LTBB	2001-2013
Van Creek	205.9	439.0	350.0	33	69.9	0	LTBB	2011-2014
Huffman Lake	275.2	353.1	308.3	37	18.1	0	MDEQ, TOMWC, USGS	1981-2010
Pickerel Lake (Otsego)	251.0	338.0	282.4	38	26.6	0	MDEQ, USGS	2005
Silver Lake	186.6	327.4	226.7	51	26.1	0	MDEQ, TOMWC, USGS	1980-2013
Thumb Lake	142.0	435.0	215.7	228	31.8	0	MDEQ, TOMWC, USGS	1973-2013
Wildwood Lake	246.4	321.0	281.6	16	20.6	0	Lakeshore Env., TOMWC	2004-2013
Club Stream	395.0	411.0	403.0	2	8.0	0	MDEQ	2005
Sturgeon River	265.0	505.0	374.0	55	39.8	0	MDEQ, TOMWC, USGS	1966-2015
Sturgeon River West Branch	330.0	820.0	414.6	21	132.6	0	MDEQ, USGS	1966-2013

*Values in uS/cm. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.

**Count = number of measurements. # Above 1000 uS/cm = number of measurements exceeding 1000 uS/cm. Although there is no state standard for specific conductance, higher values signify an increased likelihood of other impairments.

Chloride								
Water Body	Low*	High*	Mean*	Count**	Standard Deviation*	# Above 125 mg/L**	Data Sources	Time Period
Burt Lake	3.0	65.0	10.2	47	11.9	0	MDEQ, TOMWC, USGS	1973-2013
Carp Creek	2.5	10.1	5.9	11	1.7	0	TOMWC	2011-2015
Hasler Creek	13.7	47.0	22.5	9	9.2	0	TOMWC	2014-2015
Maple Bay Creek	11.5	24.5	16.5	11	4.5	0	TOMWC	2014-2015
Unnamed Creek W Burt Lk Rd	2.1	6.4	4.6	9	1.2	0	TOMWC	2014-2015
White Goose Creek	12.9	34.6	17.8	12	5.7	0	TOMWC	2011-2015
Crooked Lake	1.0	12.5	7.6	156	2.2	0	EPA, LTBB, MDEQ, TOMWC, UMBS, USGS	1957-2014
Mud Lake	0.0	105.7	51.6	55	16.3	0	LTBB, TOMWC	2001-2014
Pickerel Lake	0.7	10.9	4.9	39	2.3	0	MDEQ, TOMWC, USGS, UMBS	1974-2013
Round Lake	8.1	35.8	25.0	90	4.6	0	MDEQ, LTBB, TOMWC, USGS	1980-2014
Spring Lake	24.9	214.0	59.6	58	29.9	2	LTBB, TOMWC	2001-2014
Cedar Creek	3.0	3.0	3.0	1	0.0	0	MDEQ	2005
Crooked River	7.2	18.1	9.8	17	2.4	0	TOMWC	2004-2015
McPhee Creek	7.0	7.0	7.0	1	0.0	0	MDEQ	2005
Minnehaha Creek	4.0	4.0	4.0	1	0.0	0	MDEQ	2005
Douglas Lake	1.0	8.4	5.5	30	1.9	0	TOMWC	1987-2013
Lancaster Lake	2.9	10.1	6.7	16	2.0	0	MDEQ, TOMWC, USGS	1980-2013
Larks Lake	1.0	9.4	4.2	70	1.6	0	LTBB, MDEQ, TOMWC, USGS	1980-2014
Munro Lake	3.1	4.9	3.9	12	0.6	0	TOMWC	1998-2013
Maple River Main Branch	3.2	11.6	6.6	16	2.2	0	MDEQ, TOMWC	2004-2015
Maple River East Branch	0.0	5.0	2.5	2	2.5	0	MDEQ	1967-2005
Maple River West Branch	0.0	8.7	5.4	75	1.7	0	LTBB	2001-2013
Van Creek	0.9	5.2	2.0	33	1.0	0	LTBB	2011-2014
Huffman Lake	1.7	4.7	3.5	17	1.0	0	MDEQ, TOMWC, USGS	1981-2010
Pickerel Lake (Otsego)	1.0	1.0	1.0	2	0.0	0	MDEQ, USGS	2005
Silver Lake	1.2	6.0	3.7	22	1.2	0	MDEQ, TOMWC, USGS	1980-2013
Thumb Lake	1.0	10.2	3.3	48	2.0	0	MDEQ, TOMWC, USGS	1973-2013

Wildwood Lake	9.8	16.0	13.5	8	2.3	0	TOMWC	2004-2013
Club Stream	9.0	12.0	10.5	2	1.5	0	MDEQ	2005
Sturgeon River	0.0	26.0	9.3	44	5.8	0	MDEQ, TOMWC, USGS	1966-2015
Sturgeon River West Branch	1.0	3.2	2.4	12	0.6	0	MDEQ, USGS	1966-2013

*Values in mg/L. Mean = sum of measurements / number of measurements. Standard Deviation calculated based on the entire population given as arguments.
**Count = number of measurements. # Above 125 mg/L = number of measurements exceeding 125 mg/L, a numerical standard in R323.1051 (2), Part 4 Water Quality Standards, Part 31 of PA 451 for Michigan waters designated as a public water supply source.

Dissolved Oxygen								
Water Body	Low*	High*	Mean*	Count	Standard Deviation**	# Below 7 mg/L***	Data Sources	Time Period
Burt Lake	0.1	13.1	8.7	124	3.5	24	MDEQ, TOMWC, USGS	1973-2013
Carp Creek	8.0	11.1	10.0	10	0.9	0	TOMWC	2011-2015
Hasler Creek	9.3	11.9	10.2	9	0.8	0	TOMWC	2014-2015
Maple Bay Creek	6.6	9.1	7.7	11	0.8	3	TOMWC	2014-2015
Unnamed Creek W Burt Lk Rd	7.9	10.1	8.9	9	0.7	0	TOMWC	2014-2015
White Goose Creek	6.6	9.2	8.3	12	0.9	1	TOMWC	2011-2015
Crooked Lake	0.0	12.3	7.8	414	3.4	97	EPA, LTBB, MDEQ, TOMWC, USGS	1957-2014
Mud Lake	1.0	15.7	9.9	58	2.8	5	LTBB, TOMWC	2001-2014
Pickerel Lake	0.1	12.2	8.0	70	3.2	17	MDEQ, TOMWC, USGS	1980-2013
Round Lake	0.1	17.6	9.2	148	2.4	13	MDEQ, LTBB, TOMWC, USGS	1980-2014
Spring Lake	1.3	16.8	11.3	64	2.7	3	LTBB, TOMWC	2001-2014
Crooked River	8.4	13.3	10.4	143	0.9	0	TOMWC	2004-2015
Douglas Lake	0.2	13.1	10.0	30	2.6	4	TOMWC	2004-2013
Lancaster Lake	0.0	11.5	3.6	59	3.6	43	MDEQ, TOMWC, USGS	1980-2013
Larks Lake	1.8	15.5	10.1	132	1.9	4	LTBB, MDEQ, TOMWC, USGS	1972-2014
Munro Lake	2.8	12.5	9.6	29	2.4	3	TOMWC	2004-2013
Maple River Main Branch	8.3	14.4	10.3	15	1.4	0	TOMWC	2004-2015
Maple River East Branch	10.6	10.6	10.6	1	0.0	0	MDEQ	1967
Maple River West Branch	4.3	12.1	8.7	75	1.3	5	LTBB, MDEQ, TOMWC	2001-2013
Van Creek	1.8	10.5	7.1	33	2.2	12	LTBB	2011-2014
Huffman Lake	6.4	11.7	9.4	37	1.7	5	MDEQ, TOMWC, USGS	1979-2013
Pickerel Lake (Otsego)	3.0	11.6	8.7	38	2.1	6	MDEQ, USGS	2005
Silver Lake	0.2	13.8	8.8	48	3.6	13	MDEQ, TOMWC, USGS	1980-2013
Thumb Lake	0.0	12.6	7.4	245	3.7	79	MDEQ, TOMWC, USGS	1973-2013
Wildwood Lake	1.2	11.4	8.8	16	2.4	1	Lakeshore Env., TOMWC	2007-2014
Sturgeon River	8.4	14.4	10.8	29	1.5	0	MDEQ, TOMWC	1990-2015
Sturgeon River West Branch	10.0	14.2	11.7	16	1.6	0	MDEQ	2008-2013

*Values in mg/L.

**Values in mg/L. Standard Deviation calculated based on the entire population given as arguments.

***Environmental conditions, such as anoxic zones at the bottom of lakes, can cause values below 7 mg/L that are not necessarily indicative of impairment.

Tributary Monitoring Data (2014/2015)

Total Phosphorus Concentrations

Sample Site	Avg. (µg/L)	Min (µg/L)	Max (µg/L)	St. Dev (µg/L)
Carp Creek, Mouth	9.7	0.3	29.0	10.3
Crooked River, Mouth	9.1	3.4	29.0	8.8
Hasler Creek, Ellinger Rd	10.8	4.5	23.0	6.8
Maple Bay Creek, Mouth	32.2	20.6	43.0	7.1
Maple River, Brutus Rd	16.1	4.4	56.0	15.9
Sturgeon River, Mouth	9.2	1.8	29.0	9.0
Unnamed Creek, Mouth	24.9	10.0	39.0	10.6
White Goose Creek, Mouth	26.5	11.7	54.0	11.2
ALL MONITORED TRIBS	17.3	0.3	56.0	10.0

Total Phosphorus Loads

Sample Site	Avg. (lbs/day)	Min (lbs/day)	Max (lbs/day)	RSD (%)	Percent of Total
Carp Creek, Mouth	1.04	0.02	3.20	110%	2.72%
Crooked River, Mouth	9.06	1.01	31.53	116%	23.63%
Hasler Creek, Ellinger Rd	0.07	0.02	0.18	75%	0.18%
Maple Bay Creek, Mouth	0.16	0.04	0.52	97%	0.42%
Maple River, Brutus Rd	13.80	2.47	56.52	124%	36.00%
Sturgeon River, Mouth	13.60	2.15	37.07	98%	35.49%
Unnamed Creek, Mouth	0.17	0.03	0.37	76%	0.43%
White Goose Creek, Mouth	0.43	0.01	0.84	61%	1.13%
TOTAL OF MONITORED TRIBS	38.33	n/a	n/a	n/a	100.00%

Nitrate-Nitrogen Concentrations

Sample Site	Avg. (µg/L)	Min (µg/L)	Max (µg/L)	St. Dev (µg/L)
Carp Creek, Mouth	56.7	35.1	69.0	11.0
Crooked River, Mouth	99.3	46.1	160.7	47.8
Hasler Creek, Ellinger Rd	253.1	69.6	437.8	104.6
Maple Bay Creek, Mouth	12.7	2.3	23.0	6.7
Maple River, Brutus Rd	181.6	65.5	301.6	73.6
Sturgeon River, Mouth	151.9	62.2	212.0	42.5
Unnamed Creek, Mouth	74.8	16.0	196.1	57.0
White Goose Creek, Mouth	162.9	30.7	358.0	97.1
ALL MONITORED TRIBS	124.1	2.3	437.8	55.0

Nitrate-Nitrogen Loads

Sample Site	Avg. (lbs/day)	Min (lbs/day)	Max (lbs/day)	RSD (%)	Percent of Total
Carp Creek, Mouth	5.42	3.87	9.01	31%	1.33%
Crooked River, Mouth	70.50	33.98	158.84	68%	17.34%
Hasler Creek, Ellinger Rd	1.47	0.59	2.07	34%	0.36%
Maple Bay Creek, Mouth	0.11	0.01	0.28	97%	0.03%
Maple River, Brutus Rd	117.57	60.46	168.93	35%	28.92%
Sturgeon River, Mouth	208.06	119.99	270.97	21%	51.19%
Unnamed Creek, Mouth	0.47	0.08	2.04	127%	0.12%
White Goose Creek, Mouth	2.88	0.10	11.38	126%	0.71%
TOTAL OF MONITORED TRIBS	406.48	n/a	n/a	n/a	100.00%

Tributary Monitoring Data (2014/2015): continued

Total Nitrogen Concentrations

Sample Site	Avg. (µg/L)	Min (µg/L)	Max (µg/L)	St. Dev (µg/L)
Carp Creek, Mouth	200	123	378	87.1
Crooked River, Mouth	361	191	682	159.0
Hasler Creek, Ellinger Rd	521	309	946	210.3
Maple Bay Creek, Mouth	635	461	1109	197.8
Maple River, Brutus Rd	511	268	1025	214.9
Sturgeon River, Mouth	714	188	3214	952.2
Unnamed Creek, Mouth	605	341	1212	294.2
White Goose Creek, Mouth	676	309	1758	458.0
ALL MONITORED TRIBS	528	123	3214	321.7

Total Nitrogen Loads

Sample Site	Avg. (lbs/day)	Min (lbs/day)	Max (lbs/day)	RSD (%)	Percent of Total
Carp Creek, Mouth	19.5	7.9	35.7	50%	1.00%
Crooked River, Mouth	312.0	74.5	741.5	72%	16.02%
Hasler Creek, Ellinger Rd	3.4	1.3	8.1	59%	0.17%
Maple Bay Creek, Mouth	2.8	0.7	7.2	75%	0.14%
Maple River, Brutus Rd	401.2	116.3	1034.5	70%	20.59%
Sturgeon River, Mouth	1192.4	272.3	6204.4	159%	61.20%
Unnamed Creek, Mouth	3.6	1.3	10.9	80%	0.19%
White Goose Creek, Mouth	13.3	0.3	36.0	96%	0.68%
TOTAL OF MONITORED TRIBS	1948.2	n/a	n/a	n/a	100.00%

Dissolved Oxygen

Sample Site	Avg. (mg/L)	Min (mg/L)	Max (mg/L)	St. Dev (mg/L)
Carp Creek, Mouth	9.9	8.0	11.1	0.9
Crooked River, Mouth	9.4	8.4	11.1	0.9
Hasler Creek, Ellinger Rd	10.2	9.3	11.9	0.8
Maple Bay Creek, Mouth	7.8	6.6	9.1	0.8
Maple River, Brutus Rd	9.9	8.6	11.5	0.8
Sturgeon River, Mouth	10.6	9.1	13.7	1.4
Unnamed Creek, Mouth	9.0	7.9	10.1	0.7
White Goose Creek, Mouth	8.0	6.6	9.0	0.8
ALL MONITORED TRIBS	9.4	6.6	13.7	0.9

pH

Sample Site	Avg.	Min	Max	St. Dev
Carp Creek, Mouth	8.2	8.0	8.7	0.3
Crooked River, Mouth	8.1	7.5	8.3	0.3
Hasler Creek, Ellinger Rd	8.1	7.8	8.3	0.1
Maple Bay Creek, Mouth	7.7	7.4	8.0	0.2
Maple River, Brutus Rd	8.0	7.6	8.4	0.2
Sturgeon River, Mouth	8.2	7.8	8.6	0.2
Unnamed Creek, Mouth	7.7	7.4	8.2	0.2
White Goose Creek, Mouth	7.6	7.4	7.9	0.2
ALL MONITORED TRIBS	8.0	7.4	8.7	0.2

Tributary Monitoring Data (2014/2015): continued

Chloride Concentrations

Sample Site	Avg. (mg/L)	Min (mg/L)	Max (mg/L)	St. Dev (mg/L)
Carp Creek, Mouth	6.4	5.3	10.1	1.5
Crooked River, Mouth	11.1	8.8	18.1	2.7
Hasler Creek, Ellinger Rd	23.1	13.7	47.0	9.6
Maple Bay Creek, Mouth	17.3	11.6	24.5	4.8
Maple River, Brutus Rd	7.2	5.6	11.0	1.5
Sturgeon River, Mouth	15.1	12.0	25.7	4.5
Unnamed Creek, Mouth	4.4	2.1	6.4	1.2
White Goose Creek, Mouth	18.0	12.9	34.6	6.4
ALL MONITORED TRIBS	12.8	2.1	47.0	4.0

Chloride Loads

Sample Site	Avg. (lbs/day)	Min (lbs/day)	Max (lbs/day)	RSD (%)	Percent of Total
Carp Creek, Mouth	618.0	342.2	1117.2	35%	1.65%
Crooked River, Mouth	8787.7	3043.5	17448.3	49%	23.41%
Hasler Creek, Ellinger Rd	152.0	75.6	401.1	67%	0.40%
Maple Bay Creek, Mouth	92.3	16.6	298.9	97%	0.25%
Maple River, Brutus Rd	5233.5	2005.1	10371.3	47%	13.94%
Sturgeon River, Mouth	22256.3	15354.7	49567.9	49%	59.28%
Unnamed Creek, Mouth	28.6	8.8	57.8	66%	0.08%
White Goose Creek, Mouth	376.8	8.2	797.7	73%	1.00%
TOTAL OF MONITORED TRIBS	37545.3	n/a	n/a	n/a	100.00%

Suspended Sediment Concentrations

Sample Site	Avg. (mg/L)	Min (mg/L)	Max (mg/L)	St. Dev (mg/L)
Carp Creek, Mouth	15.1	1.4	49.8	17.0
Crooked River, Mouth	9.0	0.6	44.4	14.3
Hasler Creek, Ellinger Rd	29.2	1.2	100.4	34.8
Maple Bay Creek, Mouth	5.7	0.4	16.0	5.4
Maple River, Brutus Rd	7.0	0.8	34.4	10.8
Sturgeon River, Mouth	19.8	2.2	69.9	24.2
Unnamed Creek, Mouth	7.7	0.4	18.1	5.5
White Goose Creek, Mouth	8.1	0.9	29.6	8.9
ALL MONITORED TRIBS	12.7	0.4	100.4	15.1

Suspended Solid Loads

Sample Site	Avg. (lbs/day)	Min (lbs/day)	Max (lbs/day)	RSD (%)	Percent of Total
Carp Creek, Mouth	1482.7	132.2	4341.6	111%	3.26%
Crooked River, Mouth	7239.9	172.5	27361.9	135%	15.91%
Hasler Creek, Ellinger Rd	194.9	6.6	628.5	120%	0.43%
Maple Bay Creek, Mouth	43.3	0.4	138.9	123%	0.10%
Maple River, Brutus Rd	4693.9	336.7	19282.8	135%	10.32%
Sturgeon River, Mouth	31512.3	2588.9	101485.9	127%	69.26%
Unnamed Creek, Mouth	62.1	1.0	184.0	101%	0.14%
White Goose Creek, Mouth	266.3	2.5	948.5	125%	0.59%
TOTAL OF MONITORED TRIBS	45495.4	n/a	n/a	n/a	100.00%

Tributary Monitoring Data (2014/2015): continued

Discharge (cfs)

Sample Site	Avg. (cfs)	Min (cfs)	Max (cfs)	RSD (%)	Percent of Total
Carp Creek, Mouth	17.68	11.97	24.66	20%	3.13%
Crooked River, Mouth	142.85	53.47	201.58	33%	25.32%
Hasler Creek, Ellinger Rd	1.16	0.72	1.58	27%	0.21%
Maple Bay Creek, Mouth	0.87	0.18	2.26	76%	0.15%
Maple River, Brutus Rd	132.84	58.45	187.11	34%	23.55%
Sturgeon River, Mouth	263.54	221.71	357.90	15%	46.71%
Unnamed Creek, Mouth	1.14	0.41	1.93	51%	0.20%
White Goose Creek, Mouth	4.10	0.10	11.46	84%	0.73%
TOTAL OF MONITORED TRIBS	564.18	n/a	n/a	43%	100.00%

RSD = St. Dev / avg. volume

Watershed Area

Sample Site	Acres	Percent of Total
Carp Creek, Mouth	1799	0.53%
Crooked River, Mouth	97334	28.85%
Hasler Creek, Ellinger Rd	1038	0.31%
Maple Bay Creek, Mouth	567	0.17%
Maple River, Brutus Rd	107620	31.90%
Sturgeon River, Mouth	125991	37.34%
Unnamed Creek, Mouth	1798	0.53%
White Goose Creek, Mouth	1231	0.36%
TOTAL OF MONITORED TRIBS	337378	100.00%

TOTAL WATERSHED AREA	371,173	
PERCENT OF AREA MONITORED		0.90895125

Conductivity

Sample Site	Avg. (uS/cm)	Min (uS/cm)	Max (uS/cm)	St. Dev (uS/cm)
Carp Creek, Mouth	296	257	317	16.6
Crooked River, Mouth	296	281	313	11.2
Hasler Creek, Ellinger Rd	447	286	492	62.7
Maple Bay Creek, Mouth	318	268	369	33.0
Maple River, Brutus Rd	252	221	284	22.8
Sturgeon River, Mouth	380	367	402	11.3
Unnamed Creek, Mouth	231	166	309	41.9
White Goose Creek, Mouth	338	269	373	30.1
ALL MONITORED TRIBS	319	166	492	28.7

Appendix F: Stakeholder Engagement

Burt Lake Watershed
Stakeholder Survey April 1, 2016

The primary purpose of a watershed management plan is to guide all stakeholders toward restoration and protection of the lakes, rivers, streams, and wetlands in a given watershed. The plan is intended to be a practical tool with specific recommendations on practices to improve and sustain water quality.

Stakeholders provide critical input into the watershed planning process that help identify issues of concern, develop goals, and propose management strategies for implementation. In other words:

WE NEED YOU!

Purpose of this survey is to help identify water quality and resource issues within the Watershed and the necessary implementation steps to address them.

The Watershed Council presented information regarding the below monitoring data and resource inventories at the April 1, 2016 meeting. Given that information and your personal knowledge, please respond to the topics below. If you were not able to attend the April meeting, yet still want to provide input, please do! Also, please forward to any individuals, business owners, organizations, etc. that you feel would have an interest in providing their input.

You can access additional surveys at: **www.watershedcouncil.org**

Water Quality:

- Applies to Burt Lake, Maple River, Douglas Lake, Crooked River, Round Lake, Sturgeon River, Wildwood Lake, Lance Lake, Silver Lake, and Huffman Lake

Do you have any water quality concerns? Consider if you have noticed heavy algal blooms, excessive sedimentation, significant changes in water clarity over a short period of time, or other measured or observable conditions that could indicate a water quality problem. Has your recreational use or aesthetic appreciation of any of these water bodies been affected by perceived problems?

Road/Stream Crossings:

- Applies to any crossing over the following: Maple River (West Branch & East Branch), Sturgeon River (Main Branch & West Branch), Crooked River, or any of their tributaries.

Do you have any concerns about any one road/stream crossing, crossings on a particular stream, within a certain jurisdiction, etc.? Consider if you have noted excessive erosion, undersized or failing structures, fish passage barriers, or other factors that are likely influencing habitat, water quality, stream hydrology, etc.

Streambank Erosion:

- Applies to: Maple River (West Branch & East Branch), Sturgeon River (Main Branch & West Branch), Crooked River, or any of their tributaries.

Do you have any concerns about any erosion on a particular stream, within a specific geographic area, etc.? Consider if you have not only noted excessive erosion, but can see a direct correlation with a land use, such as riparian vegetation removal or recreational access.

Shorelines:

- Applies to any inland lake within the Watershed.

Do you have concerns about shorelines throughout the Watershed in general or are there specific lakes or areas of concern? Do you think erosion, lack of shoreline vegetation, signs of nutrient pollution, or altered shorelines (seawalls, oversized rip rap, etc.) is of particular concern?

Stormwater:

- Applies to: Indian River, Alanson, Pellston, Wolverine, Vanderbilt, and partial areas of Petoskey and Gaylord, as well as non-urban settings such as lawns, golf course, roads, public access sites, etc.

Do you have any concerns about stormwater management in the above listed municipalities? Consider if you believe decision-makers are investing enough in stormwater infrastructure, if residents are knowledgeable about where their stormwater goes, or if there are enough local examples of best management practices, etc.

Agriculture:

- Applies to the entire Burt Lake Watershed.

Do you have any concerns about agricultural land use within the Watershed? Consider if you believe there are specific examples (e.g. livestock in streams) or just a general lack of understanding and practice of best management practices.

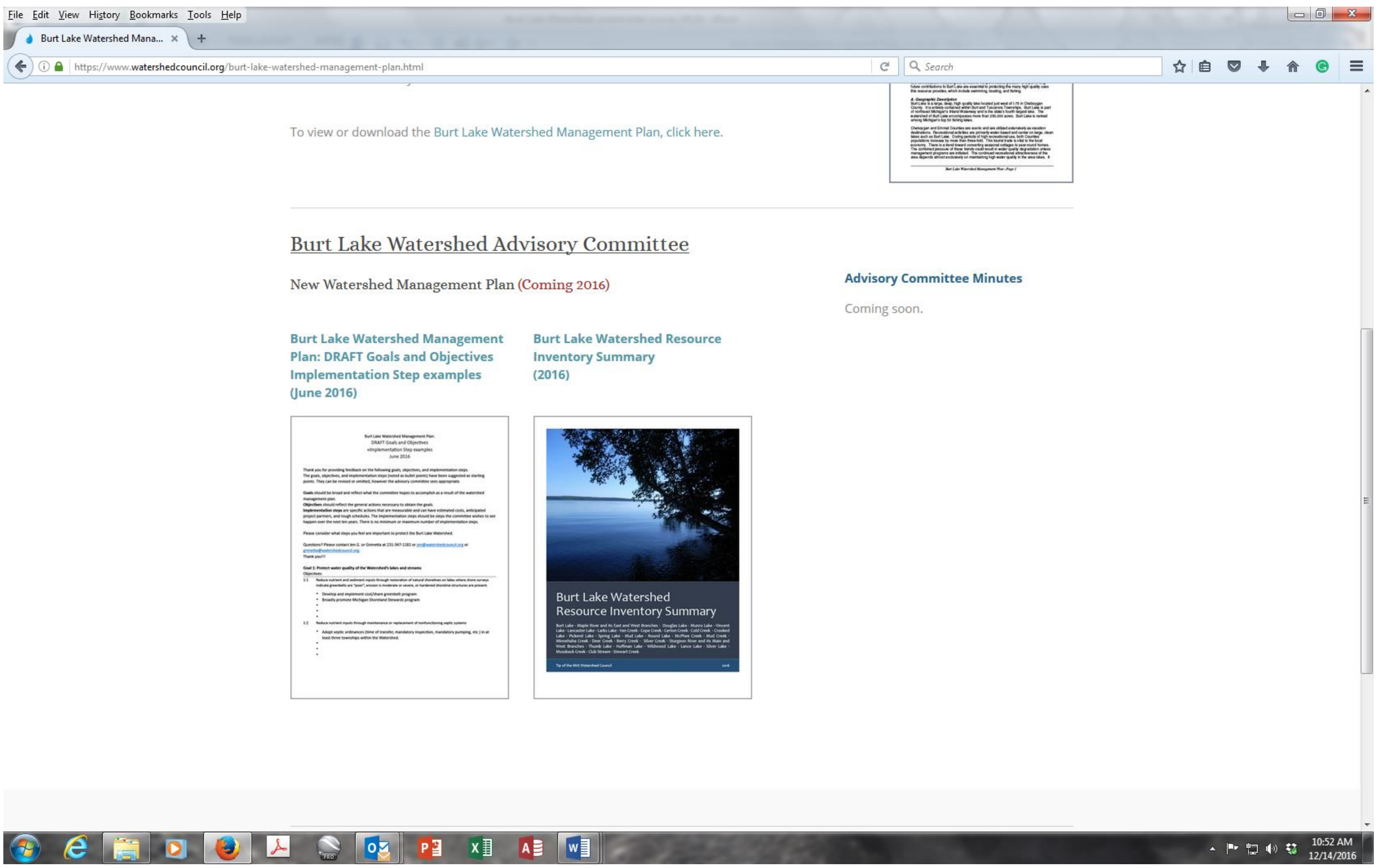
Forestry:

- Applies to any the entire Burt Lake Watershed.

Do you have any concerns about forestry land use within the Watershed? Consider if you best management practices are employed by the industry or if there is enough enforcement, etc.

Please share any historical or current knowledge you may have about an issue that may be influencing water quality within the Watershed. Consider information you may have that you believe is not reflected through the information you provided above, or simply needs to be prioritized for some reason. These observations will help formulate implementation steps:

Example: J.Q. Public allows his cattle to access the Stream X all year long and is not practicing any best management practices (BMPs). Consequently, the streambank is eroding and nutrients are reaching the stream.



Burt Lake Watershed Management Plan:

DRAFT Goals and Objectives
+Implementation Step examples
June 2016

Thank you for providing feedback on the following goals, objectives, and implementation steps. The goals, objectives, and implementation steps (noted as bullet points) have been suggested as starting points. They can be revised or omitted, however the advisory committee sees appropriate.

Goals should be broad and reflect what the committee hopes to accomplish as a result of the Watershed Management Plan.
Objectives should reflect the general actions necessary to obtain the goals.
Implementation steps are specific actions that are measurable and can have estimated costs, anticipated project partners, and rough schedules. The implementation steps should be steps the committee wishes to see happen over the next ten years. There is no minimum or maximum number of implementation steps.

Please consider what steps you feel are important to protect the Burt Lake Watershed.

Questions? Please contact Jen B. or Grenetta at 231-347-1181 or jen@watershedcouncil.org or grenetta@watershedcouncil.org.
Thank you!!!

Goal 1: Protect water quality of the Watershed's lakes and streams
Objectives:

1.1 Reduce nutrient and sediment inputs through restoration of natural shorelines on lakes where shore surveys indicate greenbelts are "poor," erosion is moderate or severe, or hardened shoreline structures are present.

- Develop and implement cost/share greenbelt program
- Broadly promote Michigan Shoreland Stewards program

1.2 Reduce nutrient inputs through maintenance or replacement of nonfunctioning septic systems

- Adopt septic ordinances (time of transfer, mandatory inspection, mandatory pumping, etc.) in at least three townships within the Watershed.

1.3 Balance the management of lake levels, where applicable, to reduce the risk of erosion due to widely fluctuating water levels.

- Convene Watershed-wide lake level working group to evaluate current management efforts and the potential need for more thorough review

1.4 Broadly implement riparian property best management practices throughout the Watershed

1.5 Manage stormwater in developed areas

- Install stormwater best management practices, including rain gardens, oil/grit separators, and other structures in Alanson (East St.), Indian River (drainage basin to Sturgeon River), and Spring Lake (near M-119).

1.6 Conduct resource inventories and monitor water quality on a regular basis to assess conditions that may be affecting water quality.

- Continue comprehensive water quality monitoring program (TOMWC)
- Expand volunteer lake monitoring program (TOMWC)
- Expand volunteer stream monitoring program (TOMWC)

Goal 2: Protect and restore aquatic and riparian habitats

Objectives:

2.1 Retain or install natural shorelines

- Develop and implement cost/share greenbelt program
- Broadly promote Michigan Shoreland Stewards program

2.2 Manage priority invasive species throughout the Watershed

- Work with both Northeast Michigan Cooperative Invasive Species Management Area (CISMA) and C.A.K.E CISMA to inventory, prioritize, and manage invasives species throughout the Watershed.

2.3 Protect wetlands from future development through low-impact development techniques

- Review DEQ Part 303 Wetland Permit Applications to evaluate proposed wetland impacts. Submit comments to DEQ regarding anticipated wetland impacts when appropriate.

2.4 Implement permanent land protection strategies (e.g. conservation easements, etc.) in priority Watershed

- Identify and fundraise priority resource areas on the Sturgeon River downstream of Wolverine.

Goal 3: Sustain tourism, recreational opportunities, and industry in a manner consistent with water quality protection

Objectives:

3.1 Expand low-impact recreational opportunities
- Water trails, etc.

3.2 Collaborate with resource managers on recreational planning efforts

3.3 Minimize impacts from forestry by adhering to best management practices
- Conduct Better Back Roads workshops for logging contractors.
- Enroll private property owners in forest management programs, such as State of Michigan's Forest Stewardship Program or Natural Resource Conservation Service's Environmental Quality Incentives Program.

3.4 Minimize impacts from boating
- Promote clean boating practices at marinas, events, and other public venues

Goal 4: Protect regional and local hydrology

Objectives:

4.1 Limit impacts to wetlands and groundwater recharge areas

- Protect wetlands from future development through implementation of low-impact development (LID) techniques
    - Promote LID to architects, engineers, developers, builders, and associated professionals through workshops, trainings, and publications.
- Review DEQ Part 303 Wetland Permit Applications to evaluate proposed wetland impacts. Submit comments to DEQ regarding anticipated wetland impacts when appropriate.

4.2 Manage stormwater throughout the Watershed

- Install stormwater best management practices, including rain gardens, oil/grit separators, and other structures in Alanson (East St.), Indian River (drainage basin to Sturgeon River), and Spring Lake (near M-119).

4.3 Restore areas where local hydrology has been altered

- Improve priority road/stream crossings that have been identified as aquatic organism barriers at most flows.
- Maintain roadside ditches.

Goal 5: Protect the Burt Lake Watershed from future threats/emerging issues
Objectives:

5.1 Line 5 and other pipelines
- Conduct education and outreach to local government officials, lake associations, and other community groups and members about Line 5.

5.2 Ensure climate change vulnerable areas are healthy for future resiliency
- Identify climate change vulnerable areas and strategies for resiliency.

Goals - Objectives - Implementation Steps – Milestones – Oh My

→ Goals are big, broad-brush ideas of what we hope for the Watershed.
→ Objectives are the ways we hope to go about achieving the goals.
→ Implementation Steps build upon the objectives, but also detail the when, who, how, etc.
→ Milestones serve as indicators for whether or not progress is being made on an individual implementation step.

Example scenario:
Goal: Protect the excellent trout fishery of the Maple and Sturgeon Rivers
→ **Objective**: Restore severe road/stream crossings within the subwatersheds (could be reduced in geographic scope if certain area was found to have a concentration of severe sites) to reduce sediment loading (because sedimentation impacts trout habitat/fishery)
    → **Implementation Step:** Develop and distribute best management practices brochure for Sturgeon and Maple River riparian property owners
        → **Milestone:** Print and distribute 1,000 brochures by year 4
    → **Implementation Step**: Promote riparian best management practices to property owners in areas where streambank erosion is severe
        → **Milestone**: Conduct 50 site assessments to riparian property owners on the Sturgeon River and distribute outreach and education materials (listed above) by year 5

Using this framework, what goals, objectives, and implementation steps do you think will yield the OVERALL goal of why we are creating this Watershed Management Plan to protect the water resources within the Burt Lake Watershed?

If you can only think of some broad goals, that is OK! What if you can only come up with a few objectives or a couple of implementation steps? That is fine, too. What if you have some ideas but don't know if they are a goal, objective, or implementation step? No problem! We will take in everyone's comments and suggestions and begin synthesizing them into some clear goals, objectives, and implementation steps. We will review them at the June meeting followed by a prioritization process.

List any goals, objectives, and implementation steps below:

Additional Comments or Questions:

Completing the below information is **optional**

Name:

Organization/agency:

Phone:

Email:

Geographic area most familiar with:

Return surveys to:
Tip of the Mitt Watershed Council.
426 Bay St, Petoskey, MI 49770
Fax: 231-347-5928
jen@watershedcouncil.org
Or call to discuss: 231-347-1181 x 1112

Thank you!

Burt Lake Watershed Management Plan
Advisory Committee Meeting
April 1, 2016
Tuscarora Township Hall
3546 S Straits Highway
Indian River, MI 49749
1:00-3:00 pm

Purpose of the meeting:

- Introduce the project
- Present results from resource inventories and water quality monitoring
- Form Advisory Committee of watershed stakeholders
- Development of draft watershed management plan
- Confirm next steps

AGENDA

1:00-1:30
Welcome and introductions
Watershed 101 – Grenetta Thomassey, TOMWC

1:30-2:30
Overview of the watersheds covered by the project – Kevin Cronk, TOMWC
Field surveys: Road/stream crossings, streambank erosion, stormwater, shore surveys, agriculture, forestry, priority parcels,
Water Quality Monitoring results

2:30-2:50
Watershed Management Plans – Jen Buchanan Gelb, TOMWC
What a plan includes and how it is developed
Role of the Advisory Committee

2:50-3:00
Timeline for project (draft plan distributed, feedback returned, submitted to DEQ/EPA)
What to expect at next meeting

Dates of future meetings:
June 17, 1-3pm
August 26, 1-3pm
October 28, 1-3pm

3:00 Adjourn

Burt Lake Watershed Management Plan Advisory Committee Meeting
Tuscarora Township Hall
3546 S Straits Highway
Indian River, MI 49749
June 17, 2016 - 1:00-3:00 pm

Purpose of the meeting:

- Continue to inform area stakeholders about development of draft watershed management plan
- Re-cap results from resource inventories and water quality monitoring
- Get additional feedback regarding development of draft plan
- Form Advisory Committee of watershed stakeholders and share info about related projects
- Confirm next steps

AGENDA

1:00-1:10
Welcome and introductions

1:10-1:30
Video Presentation – Sturgeon: Little Traverse Bay Bands Odawa Indians

1:30-1:40
Maple River Update – Kira Davis, Conservation Resource Alliance (CRA)

1:40-2:40
Watershed Plan Development – Jen Buchanan Gelb, Matt Claucherty, TOMWC
Re-cap of resource inventories and water quality monitoring
Survey compilation/feedback/keep this open through July
Goals/Objectives
Partner List – role of the Advisory Committee

2:40-3:00
Timeline for project (draft plan distributed, feedback returned, submitted to DEQ/EPA)
What to expect at next meeting

Dates of future meetings:
August 26, 1-3 pm
October 28, 1-3 pm

3:00 **Adjourn**

Burt Lake Watershed Management Plan Advisory Committee Meeting
Tuscarora Township Hall
3546 S Straits Highway
Indian River, MI 49749
August 26, 2016 - 1:00-3:00 pm

Purpose of the meeting:
- The new watershed plan will be submitted for DEQ/EPA approval in upcoming weeks. Before that happens, this meeting provides a final opportunity for stakeholders to learn about what is in the plan, and provide additional feedback.
- Confirm the partner list
- Confirm next steps

AGENDA

1:00-1:10
Welcome and introductions

1:10-2:00
Watershed Plan Development – Jen Buchanan, TOMWC
1. Goals/Objectives
2. Critical Areas
3. Priority Areas
4. Implementation Steps
5. Recent watershed activities and contributions

2:00-2:30
Partner List – role of the Advisory Committee

Dates of future meetings:
October 28, 1-3 pm

Adjourn

Burt Lake Watershed Management Plan Advisory Committee Meeting
Tuscarora Township Hall
3546 S Straits Highway
Indian River, MI 49749
October 28, 2016 - 1:00-3:00 pm

Purpose of the meeting:

- The new watershed plan will be submitted for DEQ/EPA approval in upcoming weeks. Before that happens, this meeting provides a final opportunity for stakeholders to review the draft plan, and provide final comments.
- Confirm the partner list
- Meet our Watershed Plan grant manager from DEQ
- Confirm next steps

AGENDA

1:00-1:10
Welcome and introductions

1:10-1:40
PRESENTATION: Paradise Lake Boat Washing Station
Little Traverse Bay Bands of Odawa Indians

1:40-2:10
PRESENTATION:
Introduction to the Michigan Shoreland Stewards Program
Eli Baker, Tip of the Mitt Watershed Council

2:10-2:40
Watershed Plan Development – Jen Buchanan, TOMWC
1. Goals/Objectives
2. Critical Areas
3. Priority Areas
4. Implementation Steps
5. Recent watershed activities and contributions
6. Any additional questions and feedback?

2:10-2:40
Partner List – role of the Advisory Committee
Dates of future meetings:
We will be emailing you a survey link, to find the best times for us to meet next year. We will meet once a quarter.

Adjourn