Elk River Chain of Lakes
Watershed Management Plan

April 18th, 2016 | Final Draft

Authors: Lauren Silver, Elliot Nelson, Brandon List, Kevin Peterson, Stephanie Miller – Advisor: Allen Burton, Ph.D.

TABLE OF CONTENTS

TABLES

FIGURES

Chapter 5

Chapter 7

FOREWORD

The Elk River Chain of Lakes (ERCOL) is an extremely important natural resource in Northern Michigan that warrants the utmost protection due to its ecological, recreational, and economic value. Despite continual efforts to protect them, emerging issues such as invasive species and general development pressures threaten to impair these waters and degrade their ecological treasures.

The Elk River Chain of Lakes Watershed Implementation Team (ERCOL-WPIT) is a diverse set of stakeholders that first convened in 2010 with the primary focus of implementing projects coming out of the Grand Traverse Bay Watershed Protection Plan. These individuals and organizations serve as ambassadors for the watershed and the development of the ERCOL watershed plan helps substantiate their current momentum in protecting the region's water resources. The organizations listed below have worked closely to install best management practices (BMPs), educate residents and visitors on watershed stewardship, and work with businesses and local government toward management and regulatory reform. In many ways this plan simply helps organize and articulate many of the impressive efforts currently underway in helping the ERCOL remain one of the crown jewels of northern Michigan's natural wonders.

ERCOL-WPIT MEMBERS:

Antrim County
Antrim Upper Chain of Lakes Association
Conservation Resource Alliance (CRA)
Elk-Skegemog Lakes Association (ESLA)
Elk Rapids Planning Commission
Friends of Cedar River
Friends of Clam Lake (FOCL)
Friends of Rapid River (FORR)
Grand Traverse Regional Conservancy
Grass River Natural Area (GRNA)
Helena Township
Intermediate Lake Association (ILA)
Kalkaska Soil & Water Conservation District
Michigan Dept. of Environmental Quality (DEQ)
Northern Michigan Envir. Action Council
Paddle Antrim
Six-Mile Lake Association
Thayer Lake Association
The Watershed Center Grand Traverse Bay
Three Lakes Association (TLA)
Tip of the Mitt Watershed Council (TOMWC)
Torch Lake Protection Alliance (TLPA)
Township Neighbors Network
White Pine Associates
Whitewater Township

The master's project team from University of Michigan's School of Natural Resources and Environment completed a comprehensive first draft of the management plan. Following their eighteen month engagement, which included data organization, extensive fieldwork and stakeholder engagement, and data analysis, TOMWC and TWC will finalize the plan. This will include engagement with the broader ERCOL-WPIT to populate implementation priorities and tasks. Social indicator and shoreline survey work currently scheduled to take place in 2016 will also be incorporated into the plan. Submission of the final watershed plan to EPA will take place once all the constituent parts have been finalized.

ABSTRACT

The Elk River Chain of Lakes (ERCOL) watershed is located in northwestern Michigan in the Lower Peninsula. It is the largest sub-watershed of the Grand Traverse Bay watershed and covers over 500 square miles of land, has over 60 square miles of open water, and 200 miles of shoreline. The lakes and streams found in this watershed are some of the most pristine inland waterbodies in the entire country and provide a multitude of recreational and economic benefits for both full time residents and tourist. Despite continual efforts to protect the watershed, emerging issues such as land development pressures, invasive species, failing septic systems, and barriers to hydrologic connectivity threaten to impair these waters and degrade their ecological and economic treasures.

The SNRE team developed a comprehensive watershed management plan under the guidance of Tip of the Mitt Watershed Council and in conjunction with local lake associations and the ERCOL Watershed Plan Implementation Team (ERCOL-WPIT). The team's efforts included: conducting road stream crossing and streambank erosion surveys across the watershed, leading town hall meetings, performing a priority parcel analysis, and generating spatial analysis reference sets and maps.

Ultimately, the ERCOL Watershed Protection Plan will be submitted for approval by the Michigan Department of Environmental Quality (DEQ) and the US Environmental Protection Agency (EPA).The lessons learned on restoration and protection can be carried over to similar geographies throughout the Great Lakes region, to cumulatively protect and enhance Great Lakes' water quality and ecosystems.

INTRODUCTION

Watershed plans exist at a variety of forms and scales, and the Environmental Protection Agency (EPA) has identified nine key elements that are critical for achieving improvements in water quality. The EPA requires that these nine elements be addressed in watershed plans and projects funded with incremental Clean Water Act section 319 funds and strongly recommends that they be included in all other watershed plans intended to address water quality impairments. State water quality or natural resource agencies and the EPA will review watershed plans that provide the basis for section 319-funded projects.

Considerable resources are allocated to restoration of degraded water bodies, particularly large water bodies in the Great Lakes region, while few resources are devoted to protecting those waters that remain intact. The ERCOL Watershed Plan Project approach addresses both restoration and protection of lakes and streams draining into Lake Michigan.

Currently, the ERCOL is included in the existing Grand Traverse Bay Watershed Management Plan, written by The Watershed Center Grand Traverse Bay (TWC). Tip of the Mitt Watershed Council (TOMWC) and TWC have a service area overlap in Antrim County and often partner on projects. While the Grand Traverse Bay Watershed Management Plan has been proven to be a powerful organizing tool, this ERCOL specific plan helps address the unique needs to the Chain of Lakes and connecting waterways.

CHAPTER 1
WATERSHED CHARACTERIZATION

CHAPTER 1: WATERSHED CHARACTERIZATION

1.1 INTRODUCTION

The Elk River Chain of Lakes (ERCOL) watershed is the largest contributor to the Grand Traverse Bay watershed, covering over half of the total basin area. Home to 14 interconnected lakes, this is a unique area with a significant impact on the region. Characterized by a generally rural population and large portions of natural land cover relative to other areas in the Lower Peninsula of Michigan, the ERCOL possesses a wealth of natural resources that contribute to the health of local human and wildlife communities. Understanding the physical and demographic attributes of this area is an important prerequisite to implementing any effective management actions. The following sections detail some of the components of the ERCOL watershed that make it such a valuable resource and critical area for protection.

1.2 GEOGRAPHY AND HYDROGRAPHY

LOCATION AND SIZE

The Elk River Chain of Lakes watershed is located in the northwestern region of Michigan's Lower Peninsula. It is the largest sub-watershed of the Grand Traverse Bay watershed, covering over 500 square miles of land and encompassing parts of Antrim, Grand Traverse, Kalkaska, Charlevoix, and Otsego counties (Table 1). Within the watershed, Antrim County accounts for the largest land area and largest number of municipalities within the ERCOL. These towns and villages include Bellaire, Kalkaska, Elk Rapids, Ellsworth, Central Lake, Mancelona, Rapid City, Alden, Kewadin, Williamsburg, and Atwood (Figure 1).

TABLE 1: COUNTIES LOCATED IN THE WATERSHED

County	Area (mi^2)	Area in Watershed (mi^2)	% County in Watershed	% Watershed per County
Antrim	524.60	346.77	66.1 %	69.13 %
Grand Traverse	489.90	30.14	6.15 %	6.01 %
Kalkaska	570.13	103.37	18.13 %	20.61 %
Otsego	525.89	3.22	0.61 %	0.64 %
Charlevoix	453.56	18.14	4.0 %	3.62 %
Total	**2,564.08**	**501.64**		

WATER BODIES

The lakes, rivers, and streams of this watershed provide ample opportunities for recreation, offer stunning views, support abundant fisheries, and help sustain local economies. The ERCOL watershed contains nearly 60 square miles of water and over 200 miles of shoreline, and is unique in that it is comprised of 14 interconnected lakes and rivers in Antrim and Kalkaska counties and encompasses over 200 streams, 138 miles of which are designated Blue Ribbon trout streams. Starting at the headwaters near East Jordan, water flows 55 miles through the chain, drops 40 feet in elevation as it travels into Elk River and finally into Grand Traverse Bay where it provides approximately 60% of the bay's tributary flow inputs (Tip of the Mitt Watershed Council, 2005).

14 lakes make up the Chain of Lakes (Table 2), however many more lakes can be found within the watershed including: Mud Lake, Carpenter Lake, Little Torch Lake, Eaton Lake, Thayer Lake, Harwood Lake, and a number of other small lakes. The Chain of Lakes begins at Beals Lake and flows north into Scotts Lake. Water then continues north through Six Mile Lake and onto St. Clair Lake. Near the town of Ellsworth, it turns south through Ellsworth, Wilson, Ben-way, Hanley and Intermediate Lakes. South of the town of Bellaire, the chain opens into larger bodies of water, flowing south through Lake Bellaire, west through Clam Lake, and cutting through southern Torch Lake to the Torch River. This main channel then flows west through Lake Skegemog, north through Elk Lake and out of the Elk River into Lake Michigan. The combined surface area of all fourteen lakes in the chain is 34,420 acres (TOMWC, 2010). The largest lakes found within the ERCOL are Torch Lake, Elk Lake, and Skegemog Lake (Table 2). With a maximum depth of 302 feet, Torch Lake is by far the deepest of all the lakes, followed by Elk Lake with a maximum depth of 195 feet.

There are seven sub-watersheds within the ERCOL defined by their watershed course (Table 3, Figure 2). The largest sub-watershed within the ERCOL is the Rapid River stretching across the southern quadrant and parts of Kalkaska, Antrim, and Otsego counties (Figure 3). The Rapid River is the longest and fastest flowing river within the watershed. Following close behind in flow velocity and size are the Grass and Cedar Rivers. There are many smaller rivers and streams throughout each sub-watershed of the Chain. Barker Creek, Battle Creek, and Williamsburg Creek are located in the southwestern Elk River sub-watershed. Eastport Creek and Wilkinson Creek are on the north side of Torch Lake while Spencer Creek connects with Torch Lake on its southwestern side. River managers and residents describe several of the streams on the north side of Torch Lake as flashy and occasionally causing floods in developed areas such as Eastport and upper Torch Lake. Many more small streams are concentrated in the Hanley Lake Outlet sub-watershed located, including Ogletree Creek, King Creek, Toad Creek, and Skinner Creek.

TABLE 2: LAKES WITHIN THE ELK RIVER CHAIN OF LAKES

Lake	Surface Area (acres)	Shoreline (mi)	Maximum Depth (ft)	Primary Inflows
Beals Lake	39	1.2	16	Intermediate River
Scotts Lake	63.3	1.6	35	Intermediate River
Six Mile Lake	370	8.7	31	Dingman River, Liscon Creek, Vance Creek
Saint Clair Lake	60	2.4	32	Sinclair River
Ellsworth Lake	106	3.7	42	Intermediate River
Wilson Lake	89	3.4	48	Intermediate River, Von Stratten Creek
Ben-way Lake	127	2.8	42	Intermediate River
Hanley Lake	91	3.4	27	Green River
Intermediate Lake	1,569	14.6	70	Intermediate River
Lake Bellaire	1,789	12	95	Intermediate River
Clam Lake	437	9.6	27	Grass River
Torch Lake	18,473	41	302	Clam River, Eastport Creek
Lake Skegemog	2,766	15	29	Torch River
Elk Lake	8,194	28	195	Torch River, Upper Chain via Lake Skegemog

TABLE 3: SUBWATERSHEDS IN THE ELK RIVER CHAIN OF LAKES WATERSHED

Subwatershed	Area (mi^2)	Percent of Watershed
St. Clair Lake Outlet	42.1	8.39 %
Hanley Lake Outlet	46.2	8.49 %
Intermediate River	56.9	11.34 %
Clam Lake	53.6	10.68 %
Torch Lake Outlet	76.4	15.23 %
Rapid River	142.7	28.45 %
Elk River	83.9	16.73 %

ELK RIVER CHAIN OF LAKES WATERSHED BOUNDARY

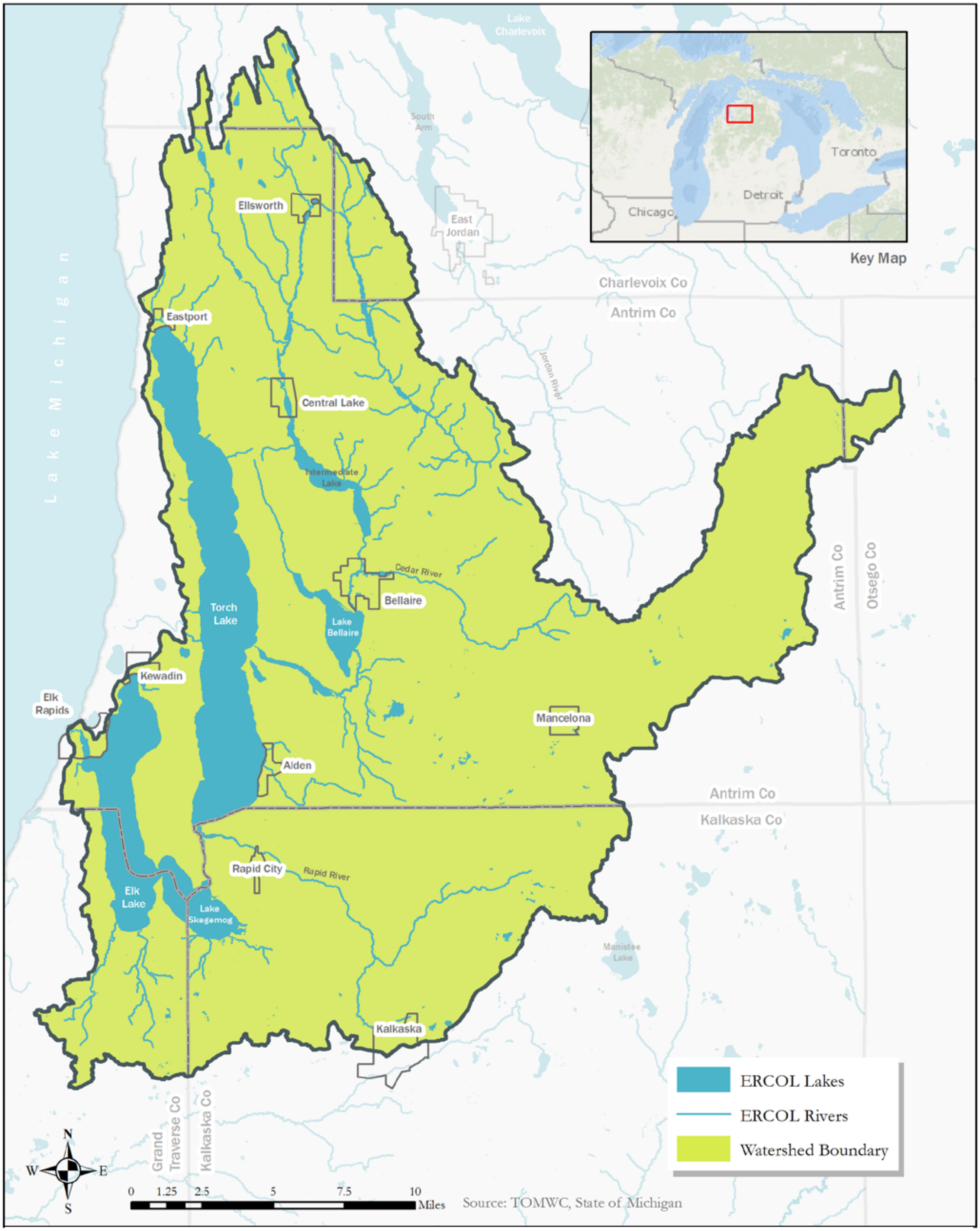


Figure 1: The Elk River Chain of Lakes watershed boundary and general location within Northern Michigan.

ELK RIVER CHAIN OF LAKES SUBWATERSHED BOUNDARIES

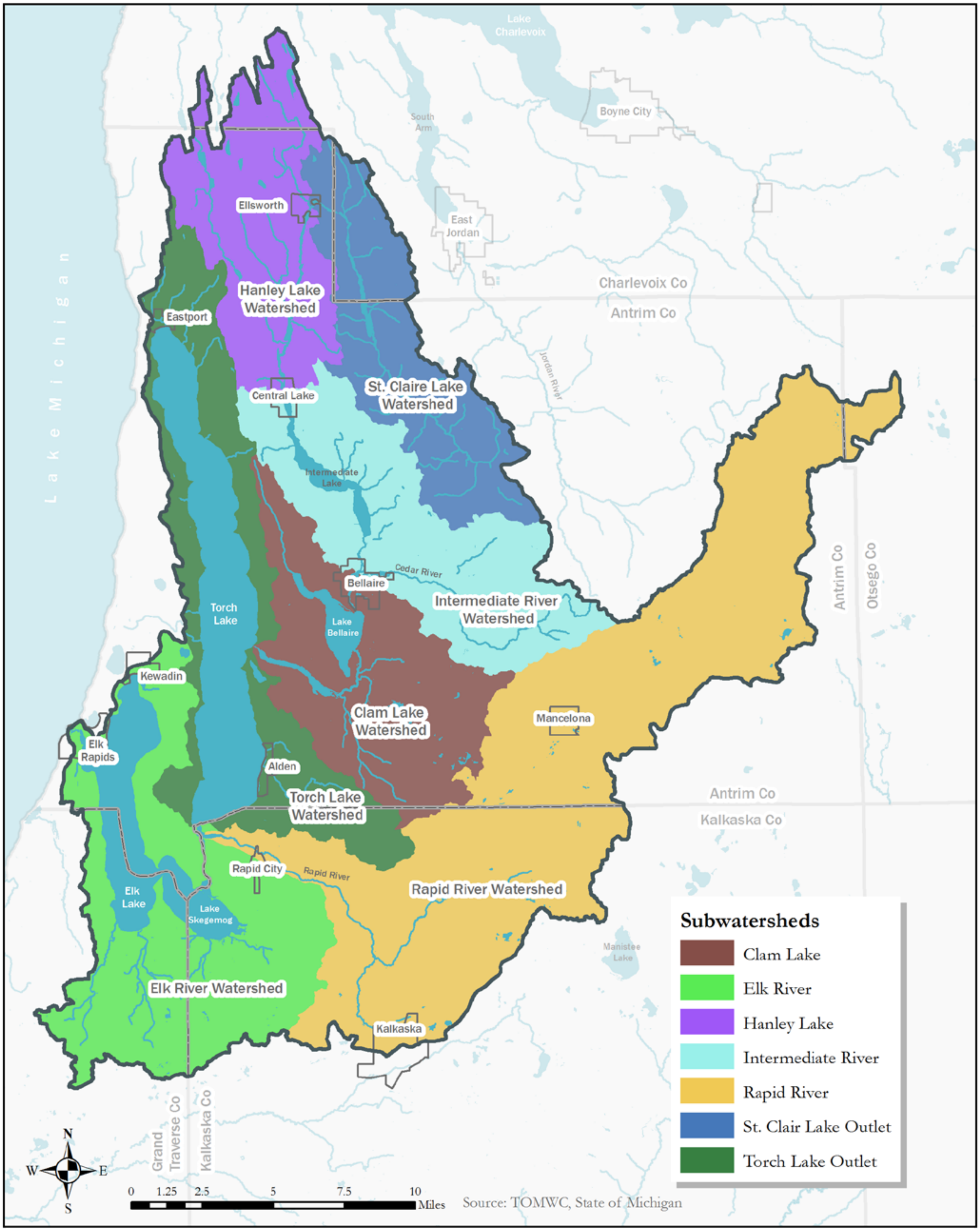


Figure 2: The subwatersheds that compose the ERCOL with major towns, villages and water bodies labeled.

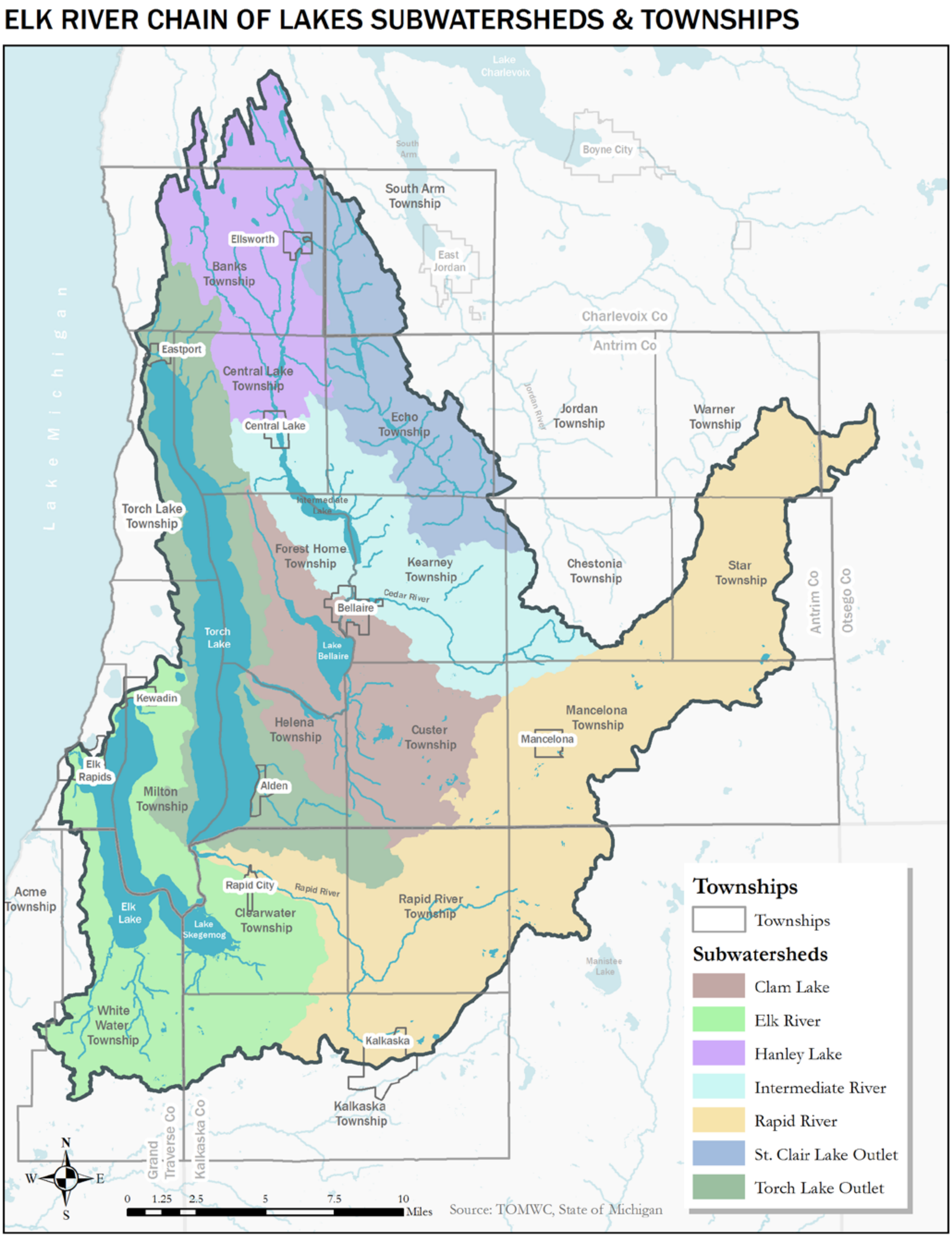


Figure 3: ERCOL subwatersheds overlap across multiple counties and townships.

ELK RIVER CHAIN OF LAKES MAJOR WATER BODIES

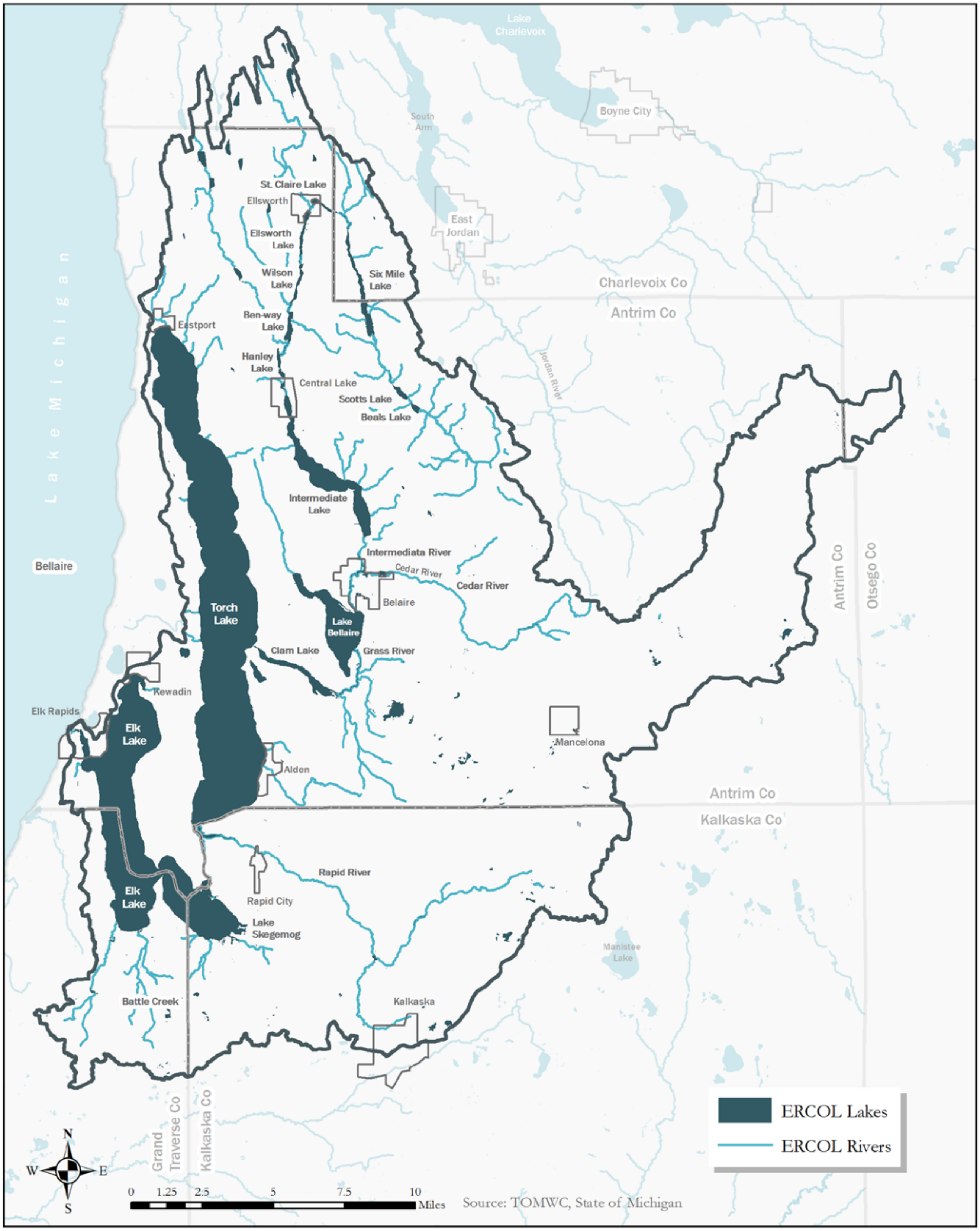


Figure 4: The major surface water bodies of the ERCOL watershed.

TOPOLOGY

Elevations ranges from 535 feet above sea level to 1,561 feet above sea level throughout the watershed. The highest elevations can be found in the easternmost part of the ERCOL watershed at the border of Antrim and Otsego Counties. Lower elevations occur toward the west near Lake Michigan and in the north toward Charlevoix County, with the lowest of elevations surrounding the lower chain lakes such: Torch Lake, Elk Lake, Lake Bellaire, and Lake Skegemog (Figure 5).

1.3 LOCAL CLIMATE

The typical weather for the ERCOL region can be described using data from the weather station at the Antrim County Airport in Bellaire. The climate of the watershed is humid continental, a climate type that typically occurs at mid-latitudes and is characterized by variable weather conditions. The ERCOL experiences relatively warm summers but no dry season (Ritter, 2006; Weatherspark, n.d.). The Great Lakes significantly impact climate in this region, particularly in areas nearest the coast. In general terms, lake effects cause temperatures to be variable within the Great Lakes basin due to differential heating of air over water compared to over land. This phenomenon can cause warmer mean minimum temperatures in all seasons (relative to regions of similar latitude not experiencing lake effect). However, mean maximum temperatures are cooler in spring and summer due to the presence of the lakes. Additionally, due to the presence of the Great Lakes, precipitation is generally much greater during the fall and winter than in the spring and summer (Scott & Huff, 1997).

Despite notable variation in temperature through the year, the overall pattern can be described as having a warm season and a cold season. The warm season typically lasts from late-May through mid-September, and the cold season lasts from early-December to early-March. During the warm season, the average daily high temperature is above 70º F. The highest temperatures of the year typically occur in late July with an average high temperature of 81º F and an average low temperature of 58º F. During the cold season, the average daily high temperature is below 38º F. The coldest day of the year is typically around mid- to late-January with an average low temperature of 15º F and an average high temperature of 28º F. On average, the shortest day of the year is December 21 with 8 hours and 46 minutes of daylight and the longest day of the year is June 20 with 15 hours and 37 minutes of daylight (Weatherspark, n.d.).

These seasonal variations bring precipitation in a range of intensity and form. During a typical year, 31% of precipitation events consist of light snow, 25% consist of moderate rain, and the other forms of precipitation occur less frequently (Weatherspark, n.d.). Table 4 provides a snapshot of climate patterns.

TABLE 4: LOCAL CLIMATE FOR THE ELK RIVER CHAIN OF LAKES AREA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average High (°F)	26°	29°	38°	52°	65°	74°	78°	76°	68°	55°	42°	30°
Average Low (°F)	10°	9°	16°	30°	40°	50°	55°	53°	45°	36°	27°	17°
Average Precipitation (in)	1.89	1.46	1.69	2.52	2.95	3.39	3.27	3.35	3.94	3.66	2.83	2.13
Average Snowfall (in)	37	25	14	6	1	0	0	0	0	1	17	35

Climate history values based on the weather station located in Kalkaska, Michigan (US Climate Data, 2015).

CLIMATE CHANGE IN THE GREAT LAKES REGION

An international consensus on climate change has been reached by the world's leading natural and social scientists, assembled by the Intergovernmental Panel on Climate Change (IPCC), jointly established by the World Meteorological Organization and the United Nations Environment Programme. The IPCC and the National Academy of Sciences have concluded that human-induced global climate change is occurring and global average temperatures could increase from 2 to 11º F in the coming century (Kling et al., 2003).

There have been numerous efforts to predict how climate change will impact the Great Lakes region. According to the Great Lakes Integrated Sciences Assessment (GLISA, 2014), the Great Lakes region has experienced many changes in general climate patterns over the past century. GLISA (2014) identified several climate variables that have undergone major alterations between 1900 and the present. Annual average air temperature has increased by 2º F in the Great Lakes region since 1900 and is projected to increase by an additional 1.8º to 5.4º F by 2050 and by an additional 3.6º to 11.2º F by 2100. Lake temperatures have also increased in the region and Great Lakes ice coverage was seen to decline by 71% between 1973 and 2010. It is projected that lake ice coverage as well as land snow cover will continue to decrease in the coming years. Precipitation in the region has increased by 10.8% from 1900 to 2012 and this trend is expected to continue with some variability. The reduction in lake ice coverage will, in fact, contribute to this increase due to increased water exposure and subsequent lake-effect precipitation. Severe storms have become increasingly frequent and intense with heavy storm precipitation increasing by 37% from 1958 to 2012. Such severe storms can have major economic consequences due to costly clean up and damage repair as well as the disruption of daily business operations. Aside from projected economic impacts, the increased risk of extreme weather events such as droughts, severe storms, and flood events may increase the risk of erosion and sewage overflow in some areas, posing a potential serious threat to water quality in the region (GLISA, 2014).

Although precipitation is expected to increase, water availability will likely change and most climate change models have projected long-term declines in lake levels with large variations in the short-term. Great Lakes region land surfaces are expected to become drier due to increasing temperatures and evaporation rates. If summer droughts become more frequent then soil moisture, surface waters, and groundwater supplies could be greatly impacted. Increasing surface temperatures of lakes have the potential to increase lake stratification and reduce vertical mixing. This effect compounded with increasing intensity and frequency of storms are expected to increase runoff and nutrient loading (from impervious surfaces, agricultural areas, and sewer systems) into the lakes, consequently producing more toxic algal blooms and hypoxic dead zones. This has the potential to put major stress on fish and wildlife species, in particular populations that are better adapted to colder temperatures. Similarly, species living in wetlands may experience a reduction in available habitat due to increased evaporation rates that decrease wetland area (GLISA, 2014).

TOPOLOGY / DIGITAL ELEVATION MODEL

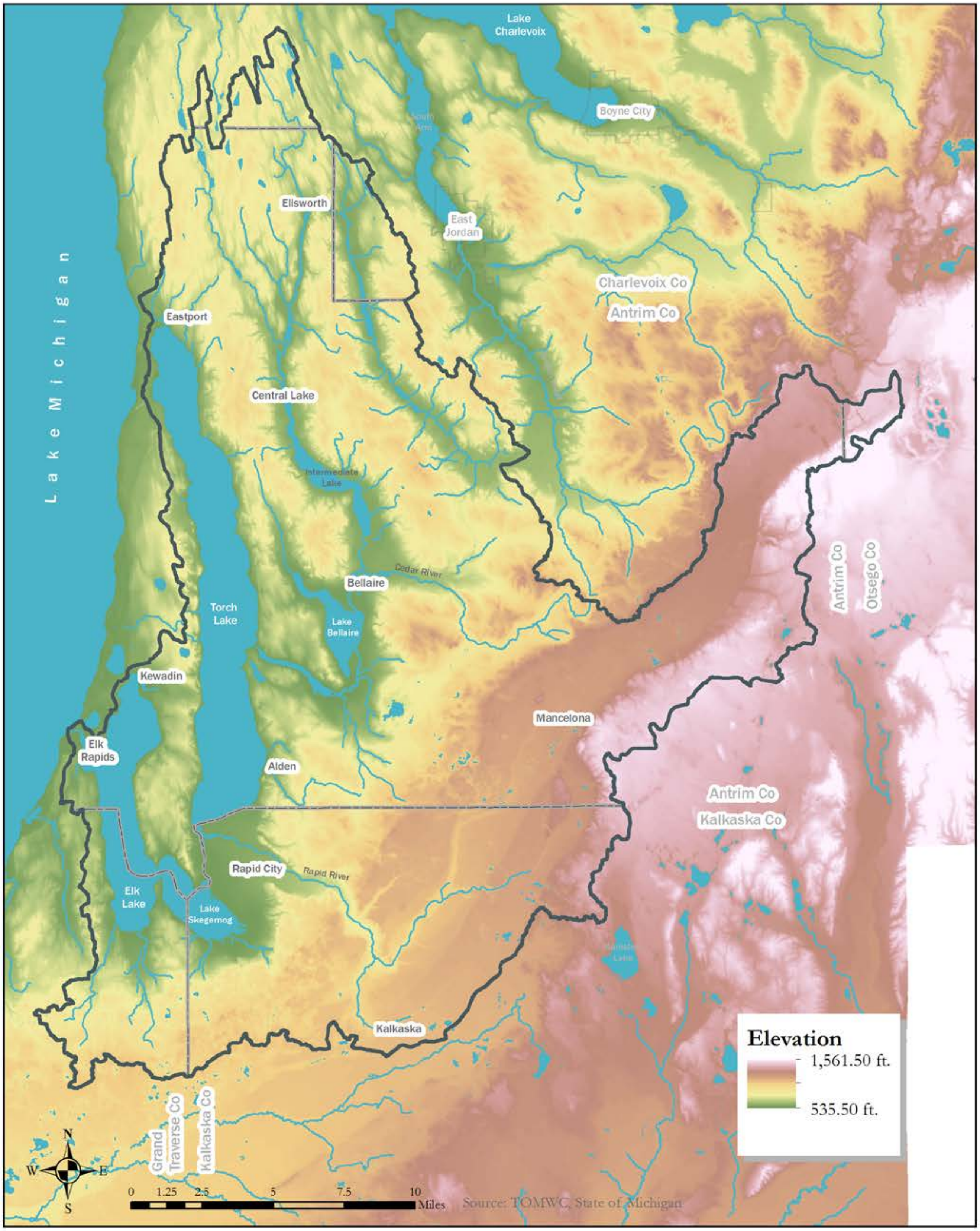


Figure 5: ERCOL watershed topography, depicted via a digital elevation model.

1.4 NATURAL FEATURES

The ERCOL watershed provides 1.5 million acres of bountiful resources and habitat for a wide variety of plant and animal species. Thousands of notable species inhabit the rivers, lakes, streams, wetlands, forests, and grasslands within the watershed including white-tailed deer, black bear, coyotes, rainbow trout, beavers, morel mushrooms, trillium, spring beauty, and maidenhair ferns. Much like the human residents of the watershed, the plants and animals rely on high quality water resources to thrive. Natural resource agencies, environmental organizations, universities, and other institutions work diligently to identify and protect species as well as their habitats (TOMWC, 2016).

THREATENED AND ENDANGERED SPECIES

The ERCOL watershed it is also home to threatened and endangered species, making it a vital task to protect the resources and habitat that allow them to flourish. Using the Michigan Natural Resource Inventory and the U.S. Fish and Wildlife Service Threatened and Endangered Species List, several species within the Elk River Chain of Lakes Watershed have been identified as in critical need of our protection (Table 5, Table 6, and Table 7).

TABLE 5: FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN THE WATERSHED

Species	Federal Status	County
Northern long-eared bat *Myotis septentrionalis*	Threatened	Antrim, Charlevoix, Grand Traverse, Kalkaska, Otsego
Kirtland's warbler *Setophaga kirtlandii*	Endangered	Antrim, Grand Traverse, Kalkaska, Otsego
Rufa Red knot *Calidris canutus rufa*	Threatened	Antrim, Charlevoix, Grand Traverse
Eastern massasauga *Sistrurus catenatus*	Proposed as Threatened	Antrim, Grand Traverse, Kalkaska
Pitcher's thistle *Cirsium pitcheri*	Threatened	Antrim, Grand Traverse
Piping plover *Charadrius melodus*	Endangered	Charlevoix
Dwarf lake iris *Iris lacustris*	Threatened	Charlevoix
Houghton's goldenrod *Solidago houghtonii*	Threatened	Charlevoix, Kalkaska
Michigan monkey-flower *Mimulus michiganensis*	Endangered	Charlevoix

Data from U.S. Fish and Wildlife Service (2015).

TABLE 6: STATE LISTED ENDANGERED AND THREATENED SPECIES IN THE WATERSHED

Species	State Status	County
Pumpelly's bromegrass *Bromus pumpellianus*	Threatened	Antrim, Charlevoix
Red-shouldered hawk *Buteo lineatus*	Threatened	Antrim, Charlevoix, Grand Traverse, Kalkaska, Otsego
Calypso or fairy-slipper *Calypso bulbosa*	Threatened	Antrim, Charlevoix
Pitcher's thistle *Cirsium pitcheri*	Threatened	Antrim, Charlevoix, Grand Traverse
Lake herring or Cisco *Coregonus artedi*	Threatened	Antrim, Charlevoix, Grand Traverse, Kalkaska
False violet *Dalibarda repens*	Threatened	Antrim, Charlevoix
Common loon *Gavia immer*	Threatened	Antrim, Charlevoix, Grand Traverse, Kalkaska, Otsego
Ginseng *Panax quinquefolius*	Threatened	Antrim, Kalkaska
Pine-drops *Pterospora andromedea*	Threatened	Antrim, Grand Traverse
Lake Huron tansy *Tanacetum huronense*	Threatened	Antrim, Charlevoix, Grand Traverse
Lake Huron locust *Trimerotropis huroniana*	Threatened	Antrim, Charlevoix
Piping Plover *Charadrius melodus*	Endangered	Charlevoix
Merlin *Falco columbarius*	Threatened	Charlevoix
Common moorhen *Gallinula chloropus*	Threatened	Charlevoix
Limestone oak fern *Gymnocarpium robertianum*	Threatened	Charlevoix
Dwarf lake iris *Iris lacustris*	Threatened	Charlevoix

TABLE 6 CONTINUED: STATE LISTED ENDANGERED AND THREATENED SPECIES

Species	State Status	County
Michigan monkey flower *Mimulus michiganensis*	Endangered	Charlevoix
Broomrape *Orobanche fasciculata*	Threatened	Charlevoix
Hill's pondweed *Potamogeton hillii*	Threatened	Charlevoix, Otsego, Kalkaska
Seaside crowfoot *Ranunculus cymbalaria*	Threatened	Charlevoix
Houghton's goldenrod *Solidago houghtonii*	Threatened	Charlevoix, Kalkaska
Hine's emerald dragonfly *Somatochlora hineana*	Endangered	Charlevoix
Deepwater pondsnail *Stagnicola contracta*	Endangered	Charlevoix
Caspian tern *Sterna caspia*	Threatened	Charlevoix
Common tern *Sterna hirundo*	Threatened	Charlevoix
Trumpeter swan *Cygnus buccinator*	Threatened	Grand Traverse
Kirtland's warbler *Dendroica kirtlandii*	Endangered	Grand Traverse, Kalkaska, Otsego
Least bittern *Ixobrychus exilis*	Threatened	Grand Traverse
Migrant loggerhead shrike *Lanius ludovicianus migrans*	Endangered	Grand Traverse
King rail *Rallus elegans*	Endangered	Grand Traverse
Spotted turtle *Clemmys guttata*	Threatened	Kalkaska
Whorled pogonia *Isotria verticillata*	Threatened	Kalkaska
Vasey's rush *Juncus vaseyi*	Threatened	Kalkaska
Canada rice grass *Oryzopsis canadensis*	Threatened	Kalkaska
New England violet *Viola novae-angliae*	Threatened	Kalkaska
Prairie or pale agoseris *Agoseris glauca*	Threatened	Otsego
Goblin moonwort *Botrychium mormo*	Threatened	Otsego
Rough fescue *Festuca scabrella*	Threatened	Otsego
Yellow pitcher plant *Sarracenia purpurea f. heterophylla*	Threatened	Otsego

Data from Michigan Natural Features Inventory (n.d.).

FISHERIES

The robust water resources of the ERCOL watershed also provide habitat for a multitude of fish species. There are a total of 154 different fish species found within the waters of Michigan. The Michigan Department of Natural Resources (MDNR) works to ensure that there is adequate high quality habitat for fish species to reproduce and grow. Fish are ecologically, culturally, and economically important in the state of Michigan. Anglers have significant positive impacts on Michigan's economy and angler participation in Michigan is ranked 5th in the nation (MDNR, 2015). In 2011, anglers spent $2.4 billion on fishing trip-related expenses and equipment. During that same year, 1.1 million fishing licenses were issued contributing another $11.2 million in public funds that are used for further conservation of fish species and aquatic habitat. The DNR raises and stocks a variety of fish species in order to provide anglers with more fishing opportunities (MDNR, 2015). The lakes, rivers, and streams within the ERCOL Watershed have varied biological communities and several of the lakes within the Chain support abundant recreational fisheries.

Between January of 2010 and December of 2015, there have been a variety of stocking activities within the lakes, rivers, and streams of the ERCOL watershed. According to the MDNR Fish Stocking Database, the following ERCOL water bodies have been stocked with various fish species over the past five years (MDNR, 2016):

- Elk River - Brown trout (60,235 individuals) and rainbow trout (48,900)
- Intermediate Lake – Walleye (156,464)
- Torch Lake - Atlantic Salmon (217,935)
- Lake Bellaire – Walleye (166,050)
- Six Mile Lake - Walleye (22,912)
- Green Lake - Rainbow trout (15,595)
- Blue Lake - Lake trout (4,880)

A variety of habitat characteristics drive the type of species present within the major lakes. The following passages move through the chain and outline the predominate fish populations.

Along a majority the shoreline of Six Mile Lake, out to a depth of approximately one to four feet, the substrate is comprised of firm, sandy sediment. Past this depth, the substrate transitions into mucky sand and then to muck at greater depths. In the past, it is likely that trunks and branches of trees commonly fell into the water around the shore, providing important habitat for fish and other aquatic organisms. However, with increased development of residences along the shoreline, much of this woody debris has been removed and is now only found primarily along undeveloped stretches of shoreline. Despite this reduction in woody debris habitat, there are still many fish species present, including smallmouth and largemouth bass, northern pike, muskellunge, rock bass, black crappie, yellow perch, bluegill, walleye, and pumpkinseed. Northern pike, walleye, largemouth bass, yellow perch, and bluegills are reported to be the mainstay of the sport fishery in Six Mile Lake. Further downstream from Six Mile Lake is St. Clair Lake, a relatively long and narrow lake that supports several fish species. These species include rock bass, black crappie, northern pike, smallmouth and largemouth bass, bluegill, yellow perch, pumpkinseed, green sunfish, and mimic shiner (TOMWC, 2016).

Ellsworth Lake is a popular destination for anglers, located just downstream from St. Clair Lake within the Upper Chain. Reported fish species include black, yellow, and brown bullhead, longnose gar, longear sunfish, white sucker, bluegill, yellow perch, northern pike, black crappie, smallmouth and largemouth bass, rock bass, pumpkinseed, and walleye. A short section of the Intermediate River feeds Wilson Lake from Ellsworth Lake. Wilson Lake supports populations of largemouth bass, bluegill, and longnose gar, among other species. Another short section of the Intermediate River flows from Wilson Lake into Ben-Way Lake. Ben-Way Lake supports a healthy warmwater fishery which includes species such as northern pike, black crappie, yellow perch, yellow bullhead, black bullhead, smallmouth bass, walleye, Iowa darter, johnny darter, bluntnose minnow, common shiner, bluegill, cisco, rock bass, pumpkinseed, longnose gar, and white sucker (TOMWC, 2016).

Hanley Lake is a small, narrow lake situated in the middle of the ERCOL. Species that have been identified in this lake include muskellunge, northern pike, rock bass, yellow perch, black crappie, bluegill, largemouth bass, longear sunfish, black, yellow, and brown bullhead, blackchin shiner, common shiner, bluntnose minnow, johnny darter, longnose gar, white sucker, and walleye (TOMWC, 2016).

Further downstream of Hanley Lake is the larger Intermediate Lake. Intermediate Lake is characterized by a sand or gravelly sand bottom nearshore, with an intermittent rocky zones and some muck. This lake supports a number of coldwater and warmwater fish species: walleye, bluegill, logperch, yellow perch, large- and smallmouth bass, pumpkinseed, longnose gar, white sucker, rock bass, whitefish, cisco, muskellunge, northern pike, rainbow trout, lake trout, brown trout, and sunfish (TOMWC, 2016).

Due to its depth, cold temperature, and oxygen-rich water in the summer months, Lake Bellaire fosters an abundant coldwater fishery and some of the shallower areas support a variety of warmwater fish species. The fish species within Lake Bellaire include whitefish, yellow perch, northern pike, rock bass, smallmouth bass, largemouth bass, bluegill, lake trout, longnose gar, white sucker, brook silverside, bluntnose minnow, walleye, brook trout, black crappie, yellow perch, white sucker, brown trout, splake, pumpkinseed, brown bullhead, cisco, smelt, rainbow trout, and brown trout. Because of its considerable size, it is unusual that Lake Bellaire does not have natural rocky shorelines. This can pose potential issues for the spawning success of some fish species. The nearshore substrate of Lake Bellaire primarily consists of sand or gravelly-sand while the remainder consists of muck or marl-sand bottom (TOMWC, 2016).

Similar to Lake Bellaire, Clam Lake provides ample fishing opportunities for both coldwater and warmwater species. Clam Lake fish species include mudminnow, longnose gar, northern pike, yellow perch, brown, black, and yellow bullhead, smallmouth and largemouth bass, bluegill, rock bass, white sucker, pumpkinseed, longear sunfish, muskellunge, blacknose, spottail, blackchin, emerald and sand shiners, bluntnose minnow, banded killifish, logperch, johnny darter, Iowa darter, walleye, and black crappie (TOMWC, 2016).

Torch Lake is characterized by a wide, sandy, shallow region that parallels the shore and ends in a steep drop-off. The deepest lake in the watershed, Torch Lake is also designated as a coldwater fishery, including lake trout and whitefish, both of which are self-sustaining through natural reproduction. Burbot are common in a deep-water community association with the trout, whitefish, and deep-water sculpin. Smallmouth bass, yellow perch, rock bass, and muskellunge are commonly fished for in Torch Lake and this lake is particularly well-known for its large muskellunge and whitefish. However, Fish Consumption Advisories have been listed for five species of Torch Lake fish: brown trout, lake trout, lake whitefish, smallmouth bass, and yellow perch due to high concentrations of mercury, PolyChlorinated Biphenyls (PCBs), and dioxins. It has recently been advised that even those in good health never consume lake trout from Torch Lake (TOMWC, 2016).

The nearshore substrate of Skegemog Lake is primarily sand, with a smaller proportion being comprised of a mixture of rocks, gravel, and sand. Some areas, primarily in the eastern end, have soft muck or marl bottoms. Several fish species can be found within Skegemog Lake including walleye, bullhead, rock bass, small- and largemouth bass, white sucker, yellow perch, bluegill, brown and rainbow trout, bullhead, channel catfish, northern pike, longnose gar, muskellunge, cisco, pumpkinseed, rosyface shiner, and golden shiners (TOMWC, 2016).

Elk Lake is the second deepest lake in the Chain and is classified as oligotrophic, meaning that it has low biological productivity, is nutrient poor, but has abundant dissolved oxygen levels. Elk Lake supports an abundant fishery and was recently found to possess a unique strain of lake trout (TOMWC, 2016).

Data from the Michigan Fish Atlas (Michigan Geographic Data Library, 2002) was used to compile a table of fish species found within the lakes, streams, and rivers of the ERCOL watershed. The list here-in is not comprehensive, but speaks to the wide array of fish species that reside within the watershed (Table 7).

TABLE 7: FISH SPECIES OF THE ELK RIVER CHAIN OF LAKES WATERSHED

Common Name	Scientific Name	Common Name	Scientific Name
American brook lamprey	*Lampetra appendix*	Longnose dace	*Rhinichthys cataractae*
Atlantic salmon*	*Salmo salar*	Longnose gar	*Lepisosteus osseus*
Black bullhead	*Ameeurus melas*	Mimic shiner	*Notropis volucellus*
Black crappie	*Pomoxis nigromaculatus*	Mottled sculpin	*Cottus bairdii*
Blackchin shiner	*Notropis heterodon*	Muskellunge	*Esox masquinongy*
Blacknose shiner	*Notropis heterolepis*	Ninespine stickleback	*Pungitius pungitius*
Bluegill	*Lepomis macrochirus*	Northern logperch	*Percina caprodes semifasciata*
Bluntnose minnow	*Pimephales notatus*	Northern longear sunfish	*Lepomis peltastes*
Brook silverside	*Labidesthes sicculus*	Northern pearl dace	*Northern pearl dace*
Brook trout*	*Salvelinus fontinalis*	Northern pike	*Esox lucius*
Brown bullhead	*Ameiurus nebulosus*	Northern redbelly dace	*Phoxinus eos*
Brown trout	*Salmo trutta*	Pumpkinseed	*Lepomis gibbosus*
Burbot	*Lota lota*	Rainbow smelt*	*Osmerus mordax*
Central mudminnow	*Umbra limi*	Rainbow trout*	*Oncorhynchus mykiss*
Common shiner	*Luxilus cornutus*	Rock bass	*Ambloplites rupestris*
Creek chub	*Semotilus atromaculatus*	Rosyface shiner	*Notropis rubellus*

TABLE 7 CONTINUED: FISH SPECIES OF THE ELK RIVER CHAIN OF LAKES WATERSHED

Common Name	Scientific Name	Common Name	Scientific Name
Deepwater sculpin	*Myoxocephalus thompsonii*	Sand shiner	*Notropis stramineus*
Emerald shiner	*Notropis atherinoides*	Sea lamprey*	*Petromyzon marinus*
Finescale dace	*Phoxinus neogaeus*	Slimy sculpin	*Cottus cognatus*
Golden shiner	*Notemigonus crysoleucas*	Smallmouth bass	*Micropterus dolomieu*
Green sunfish	*Lepomis cyanellus*	Trout-perch	*Percopsis omiscomaycus*
Iowa darter	*Etheostoma exile*	Walleye	*Sander vitreus*
Johnny darter	*Etheostoma nigrum*	Western banded killifish	*Fundulus diaphanus menona*
Lake herring	*Coregonus artedi*	Western blacknose dace	*Rhinichthys obtusus*
Lake trout	*Salvelinus namaycush*	White sucker	*Catostomus commersonii*
Lake whitefish	*Coregonus clupeaformis*	Yellow bullhead	*Ameiurus natalis*
Largemouth bass	*Micropterus salmoides*	Yellow perch	*Perca flavescens*

Data from Michigan Fish Atlas (Michigan Geographic Data Library).
* Non-native species to the Great Lakes region.

FISH HABITAT STRUCTURES

An ongoing initiative has been undertaken by the Three Lakes Association, The Watershed Center Grand Traverse Bay, Friends of Clam Lake, Antrim Conservation District, Tip of the Mitt Watershed Council, Elk-Skegemog Lakes Association, and Intermediate Lake Association to improve the recreational fisheries of the watershed's lakes. Beginning in 2012, this five-year program deployed fish shelters at 80 sites at a depth of 15 to 20 across five of the watershed's lakes: Torch Lake, Clam Lake, Lake Bellaire, Intermediate Lake, and Elk Lake. Positive results have already been seen at fish shelter sites as a variety of fish species are rapidly colonizing many of the structures (Varga, 2012).

LAND USE AND LAND COVER

Land use and land cover greatly influence the health and quality of a watershed catchment. Land cover refers to physical land types or surface cover (i.e. wetlands, forest, row crops, etc.) and land use refers to how people are using the land (i.e. development, state park, etc.). Different types of land cover and land uses surrounding a water body impact its water chemistry and quality, flow regimes, habitat complexity and connectivity, as well as the biological diversity. Urban land use can have disproportionate impacts (compared to other land use types) on the health of a watershed as it increases impervious surfaces, which can lead to issues with storm water runoff as well as reduce groundwater recharge. Agricultural land can also have significant impacts as it can also increase storm water runoff, alter stream flows, and lead to increases in nonpoint source pollution into surrounding waterbodies. Studies have shown that forested river catchments support more species of aquatic organisms when compared to catchments with a large proportion of agricultural land (Allan, 2004).

The Elk River Chain of Lakes watershed is characterized by a wide variety of land cover types and land uses. Forested land makes up the vast majority of land cover (42.96%), which contributes to the high quality nature of the ERCOL region. Other land cover types found within the watershed include urban, agriculture, grassland/herbaceous, scrub-shrub, wetland, water, and barren (Table 8, Figure 4).

Agriculture is the second most extensive land use type within the ERCOL watershed. Of the total agricultural land found within the watershed, 68.32 square miles is cultivated cropland and 11.59 square miles is pasture and hay. The top crop items grown in the Elk River Chain of Lakes watershed vary between counties. According to the 2012 Census of Agriculture, top crop items grown in ERCOL counties include hay, tart cherries, corn, potatoes, soybeans, wheat, and the top livestock items include cattle, hogs, and pigs (Census of Agriculture 2012).

Water and wetland areas together make up just over 20% of the ERCOL watershed. Urban and developed areas make up a relatively small percentage of the land area (4.25%). The primary urban centers include Ellsworth, Central Lake, Bellaire, Mancelona, Elk Rapids, and Kalkaska.

TABLE 8: LAND USE/LAND COVER IN THE WATERSHED

Land Use/Cover Type	Square Miles	Percent of Watershed
Urban	21.3	4.25 %
Agriculture	79.91	15.93 %
Grassland/Herbaceous	57.81	11.52 %
Forest	215.52	42.96 %
Scrub/Shrub	20.87	4.16 %
Wetland	48.29	9.63 %
Barren	1.11	0.22 %
Water	56.83	11.33 %

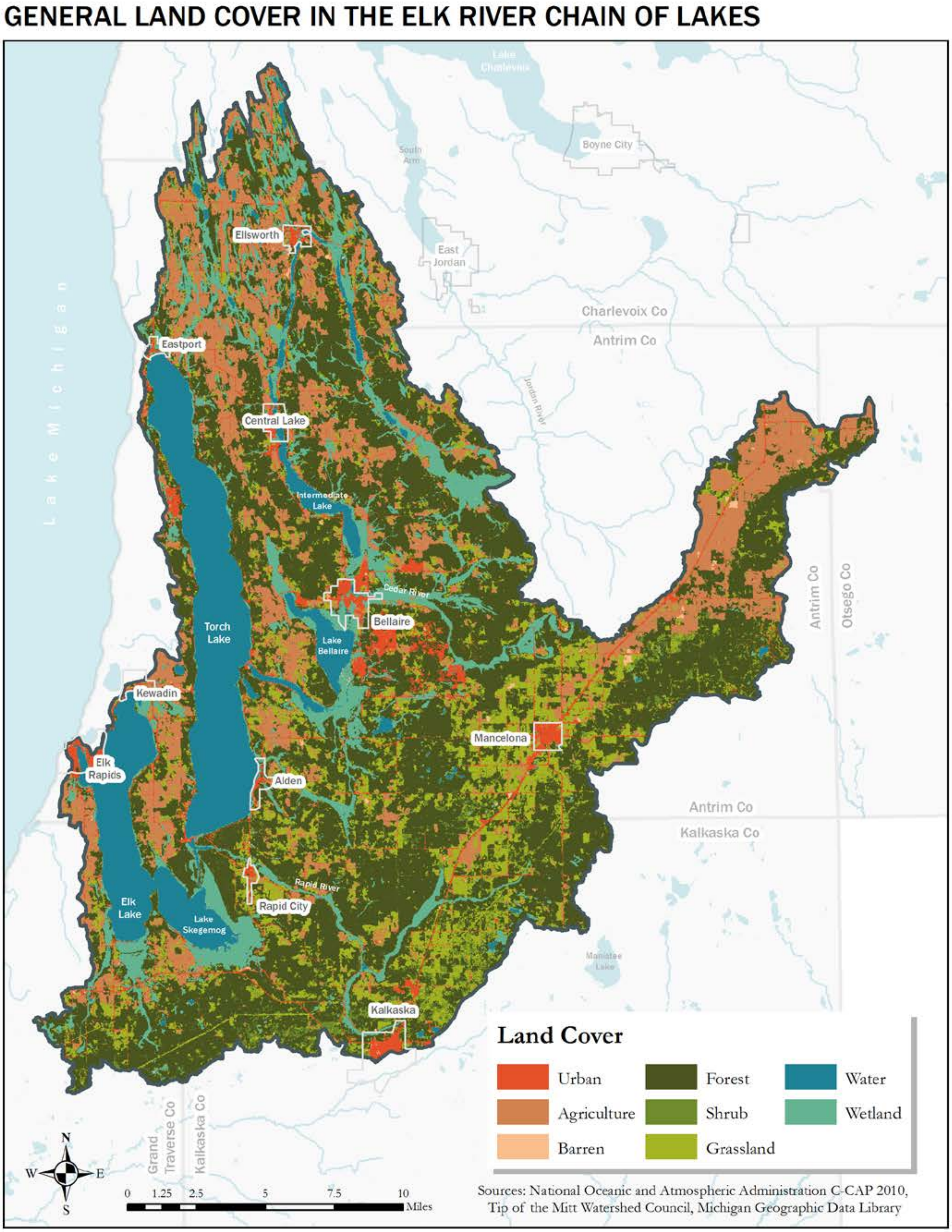


Figure 6: The generalized land cover types for the ERCOL watershed.

Wetlands are an essential element of any watershed as they perform important ecological functions. These important transition zones clean and purify water by filtering out sediments and pollutants. They also recycle nutrients in the environment and regulate nitrogen and carbon cycles. (Mao & Cui, 2012). Wetlands retain or remove nutrients in four ways: uptake by plant life, adsorption onto sediments, deposition of detritus (organic material), and chemical precipitation (TOMWC, 2016). They also influence river and stream flows by storing water and helping to prevent flooding. Wetland vegetation provides erosion control as well as food for aquatic organisms (Mao & Cui, 2012).

Aside from providing food resources, wetlands also provide an essential network of complex habitat for a wide variety of organisms. In fact, most freshwater fish depend on wetlands during parts of their life cycle, making these areas nursery grounds of sorts. Nearly all of Michigan's amphibians are wetland dependent, especially for breeding. Many scientists have found correlations between wetland degradation and declines in amphibian populations on a global scale. Bird species also depend on wetland habitats during their migratory activities, as they serve as excellent resting places, providing food and cover from predators. Some bird species exclusively breed in wetland areas. Mammals such as muskrat, beaver, otter, mink, and raccoon prefer wetland habitat over other habitat types. White-tailed deer also utilize cedar swamps for browsing and thermal cover during harsh winter month (TOMWC, 2016).

The different types of wetlands and their percent composition of total wetland area within the watershed are shown in Table 9. Forested wetlands make up the vast majority of wetland area within the watershed (83.61%), followed by scrub-shrub wetland (7.46%) and emergent wetland (7.15%).

TABLE 9: WETLAND AREAS IN THE WATERSHED

Wetland Type	Percent in Watershed
Aquatic Bed	0.001 %
Emergent	7.15 %
Forested	83.61 %
Open Water/Unknown Bottom	0.50 %
Scrub-Shrub	7.46 %
Unconsolidated Bottom	1.03 %
Other	0.01 %

1.5 GEOLOGY AND SOILS

Past glacial movement through the region was the greatest driver influencing the current geology and soils of northwestern Michigan (Farrand, 1988). Quaternary (the most recent period in the Cenozoic era) glacial advances and retreats, particularly the Wisconsinan Glaciation, carved into Michigan's limestone and shale bedrock and created deep valleys (Farrand, 1988; Boutt et al., 2001). Glaciers deposited till and sediment across the region during this process, and the resulting sediment types persist in the Elk River Chain of Lakes region today (Boutt et al., 2001).

BEDROCK GEOLOGY

The bedrock geology underlying the ERCOL is characterized by six classifications: Antrim Shale, Ellsworth Shale, Berea Sandstone and Bedford, Coldwater Shale, Sunbury Shale, and Traverse Group (Figure 8). The bedrock geology types that make up the majority of the watershed are Ellsworth Shale and Coldwater Shale. Ellsworth Shale is unique to the western part of Michigan and, in fact, only occurs within Antrim and Charlevoix counties. This bedrock type originated in the Late Devonian era between approximately 382 and 372 million years ago. Ellsworth Shale in the westernmost parts of these counties is about 152 meters thick on average, and ranges between 91 and 152 meters thick elsewhere in the region. This shale is commonly green, but can also have a grayish hue. Ellsworth Shale is typically overlain by Coldwater Shale. Coldwater Shale originates from the Mississippian geologic time period which occurred between 358 and 323 million years ago. Coldwater Shale is of a bluish-gray color and consists of clay minerals, primarily illite, kaolinite, and chlorite. In the western part of Michigan where the ERCOL lies, Coldwater Shale is about 168 meters thick and is much more coarse and calcareous than in the eastern part of state (USGS, n.d.).

GLACIAL TOPOLOGY AND SOILS

Glacial topology within the watershed consists of eight different glacial feature types. The southern and eastern parts of the watershed are primarily characterized by moraine ridges with few kettle lakes, broad and flat outwash plains with few lakes, and pitted outwash plain. Closer to the 14-lake chain in the western and northern parts of the watershed, the glacial topology is predominantly composed of broad moraine ridges, till plains, or drumlins. Around the major lakes are sandy flat lake plains (Figure 9).

The watershed is characterized by 10 different soil associations that vary throughout the landscape (Figure 10). In the north and western portions, the majority of the soils are of the Emmet-Montcalm-Kalkaska soil association. This soil association typically consists of sandy loams and loamy sands that range from neutral to acidic. They are found on gently sloping to steep land and are well-drained. In the eastern part of the watershed, Kalkaska-Leelanau-Emmet and Kalkaska-Rubicon-Duel soil associations are more common.

The Kalkaska-Leelanau-Emmet soils are well-drained sands and loamy sands that persist on level to steep areas. They are typically slightly acidic or neutral. The Kalkaska-Rubicon-Duel soil association shares similar characteristics to the Kalkaska-Leelanau-Emmet soils, but the sand is very droughty (dry) (USDA, 1966).

GROUNDWATER

The groundwater system of the Great Lakes watershed is composed of aquifers and relatively impermeable rocks and sediments called confining units. Groundwater discharge into lakes, streams, and wetlands can greatly impacts flows, water temperatures, and water quality. Groundwater recharge is the process of adding water to the groundwater system. This typically takes place where soils are permeable such as in the land area between streams. Water that makes its way into the groundwater system is stored for a period of time until it reaches discharge areas. A variety of environmental factors, such as soil type, precipitation, and the amount of impervious surface, impact the quantity and rate of groundwater recharge. Urban development often reduces groundwater recharge because impervious surfaces such as paved roads, buildings, and compacted soils reduce the amount of water that infiltrates the ground, which consequently increases surface runoff (USGS, 2013).

Within the watershed, most groundwater recharge occurs in the southwestern corner where the watershed intersects with Grand Traverse County and in the eastern-most portions of the watershed. Recharge rates in these areas ranges from 15 to 20 inches per year. Groundwater recharge is lowest in the northern part of the watershed near Ellsworth and Eastport, with a rate of 5 to 8 inches per year. Near major lakes such as Torch Lake, Elk Lake, and Lake Skegemog, recharge is between 5 and 8 inches year (Figure 10).

DELINEATED WETLANDS IN THE ELK RIVER CHAIN OF LAKES

Figure 7: The delineated wetlands of the ERCOL watershed.

BEDROCK GEOLOGY IN THE ELK RIVER CHAIN OF LAKES

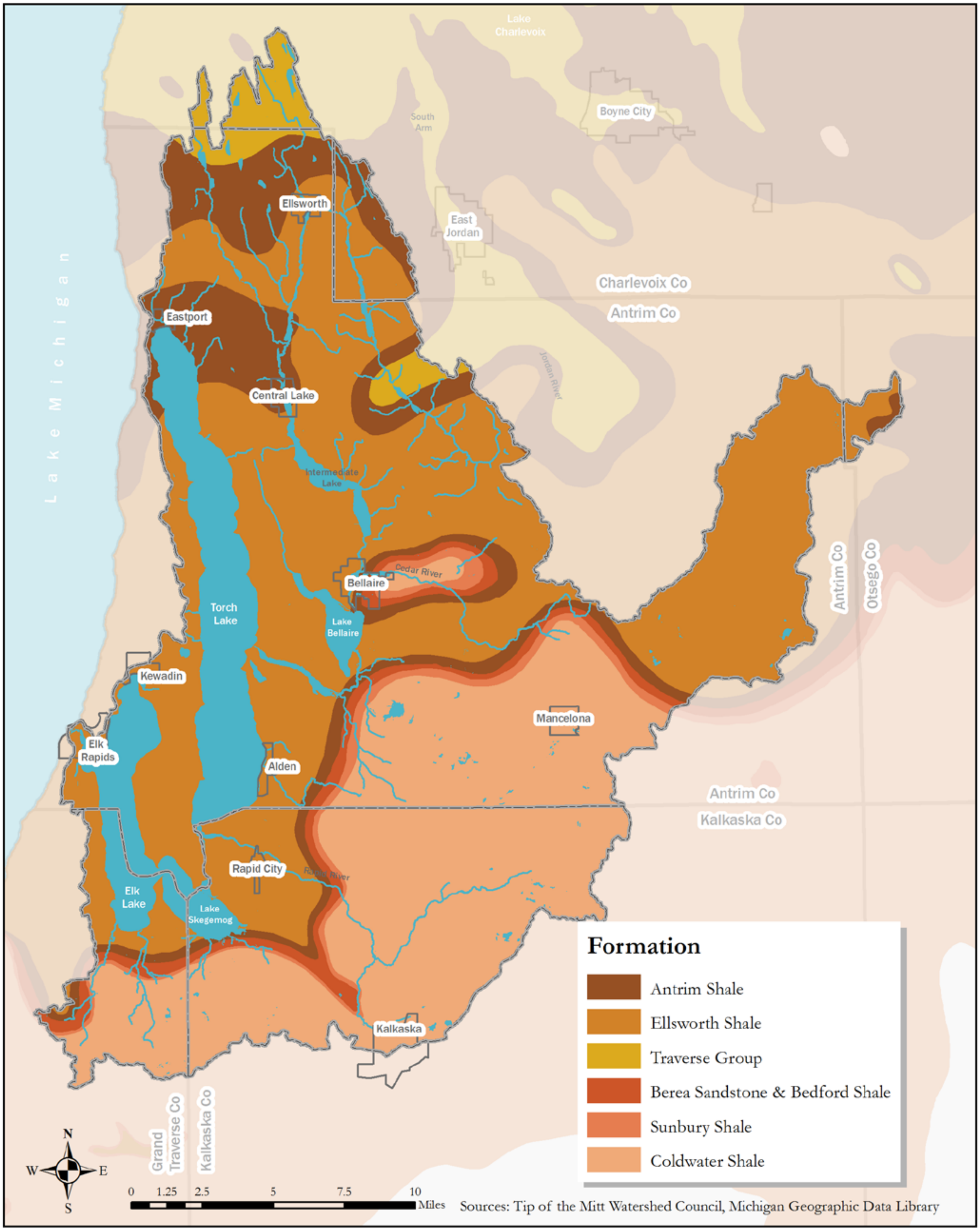


Figure 8: The underlying bedrock geology of the ERCOL watershed.

GLACIAL TOPOLOGY IN THE ELK RIVER CHAIN OF LAKES

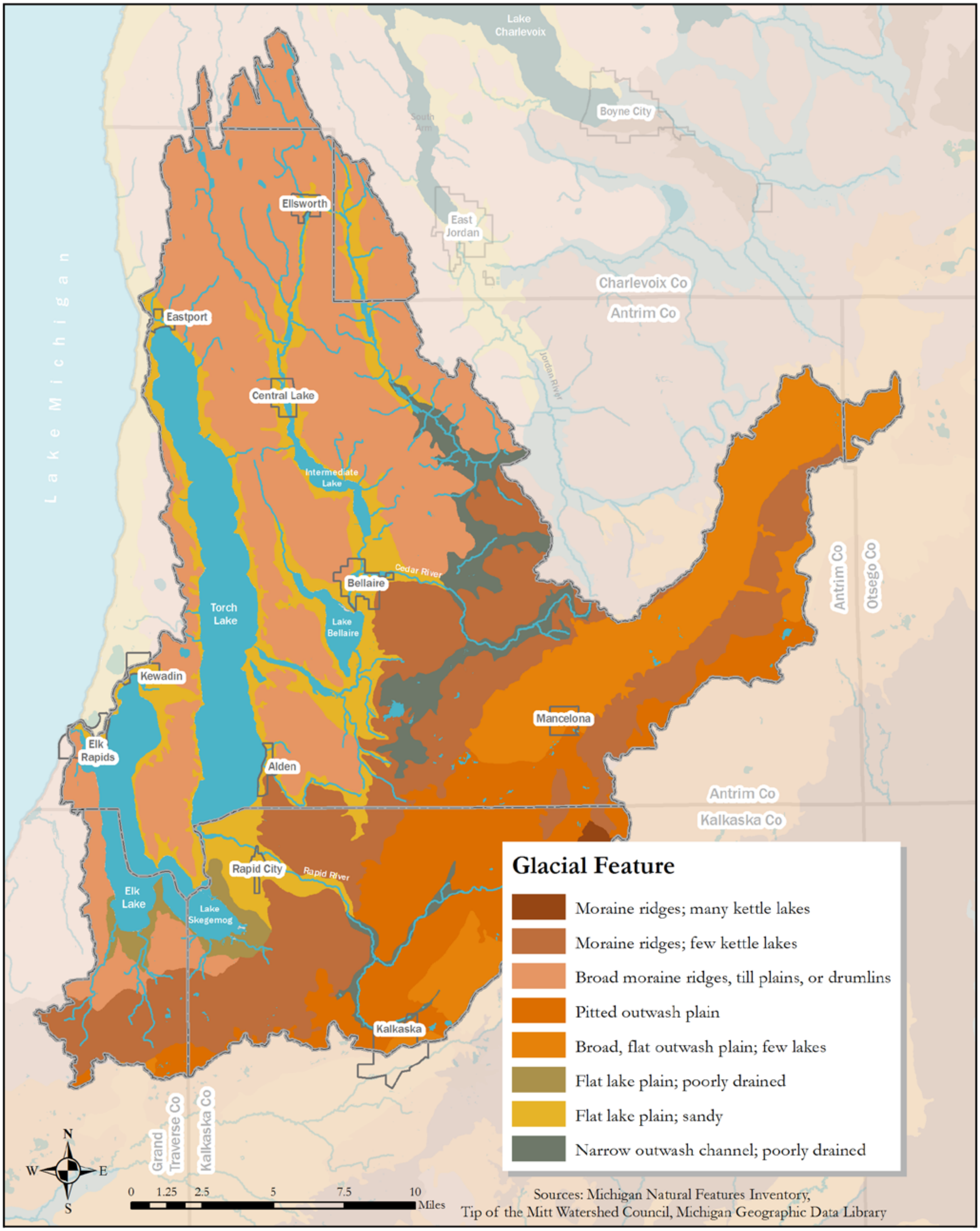


Figure 9: The glacial typology classification of the ERCOL watershed.

SOIL ASSOCIATIONS IN THE ELK RIVER CHAIN OF LAKES

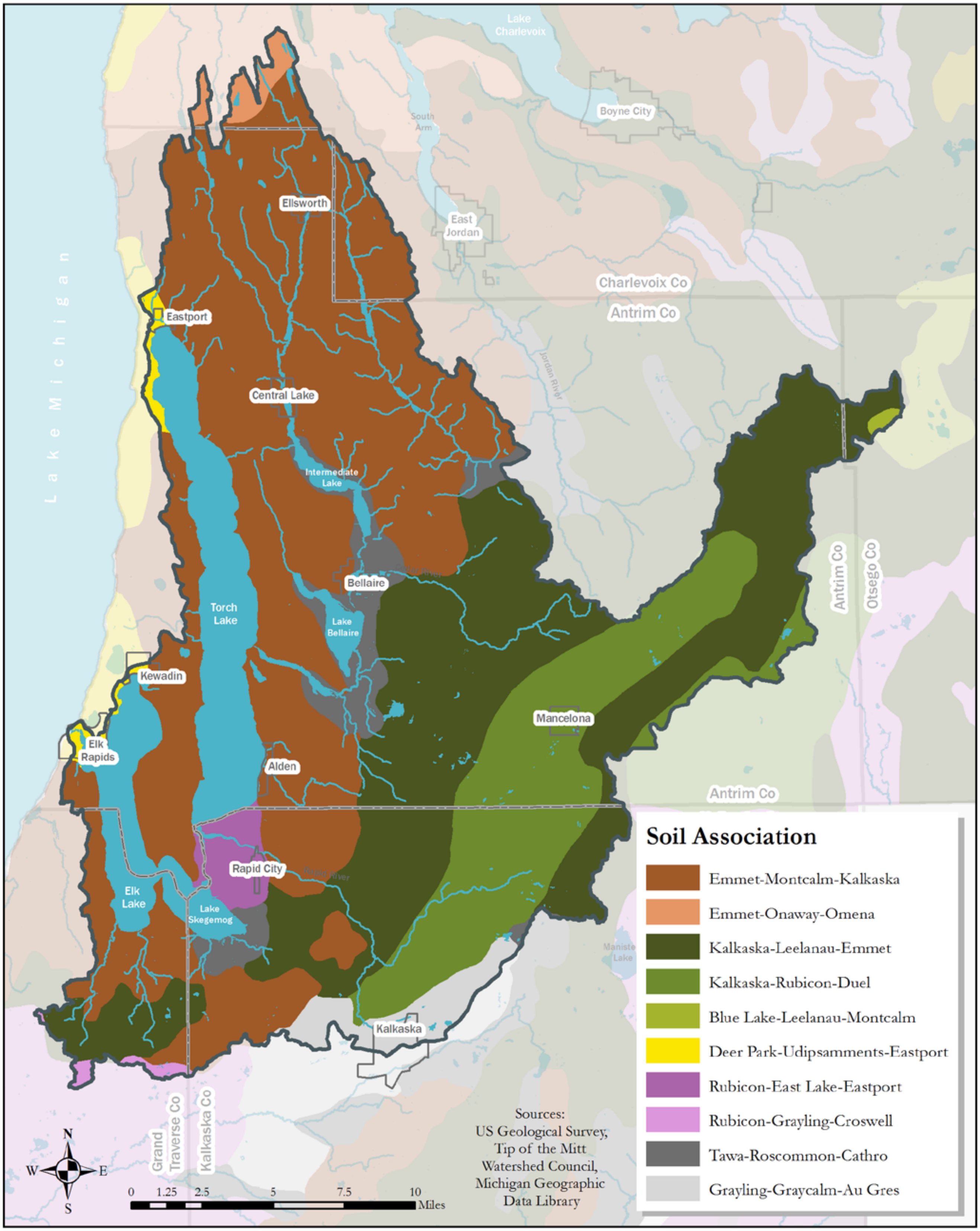


Figure 10: The USGS soil associations of the ERCOL watershed.

GROUNDWATER RECHARGE

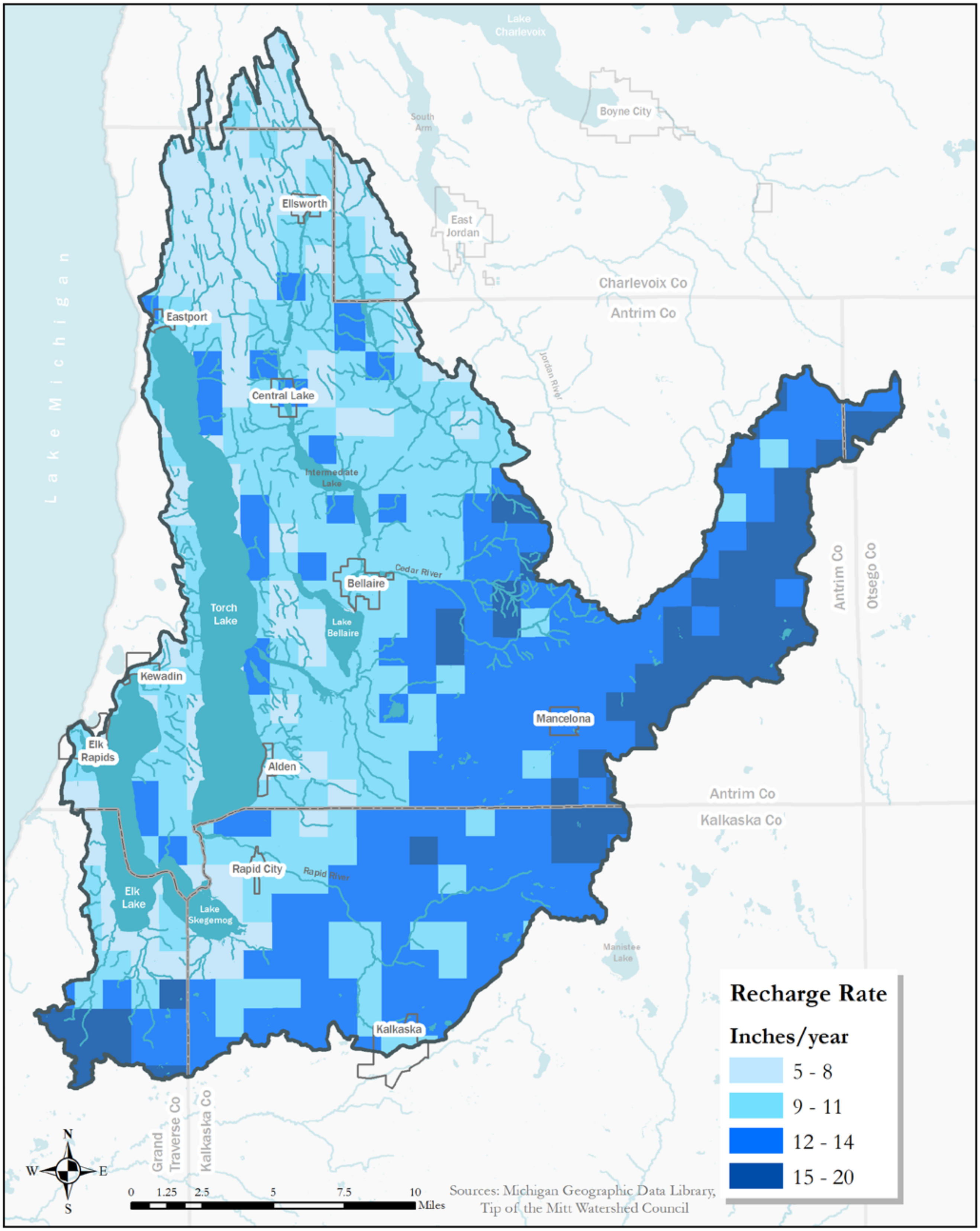


Figure 11: The groundwater recharge rate for the ERCOL watershed, utilizing a groundwater model.

1.6 PEOPLE

The ERCOL provides an immense amount of resources to its residents. This area is home to over 45,000 people who live side by side with the natural wonders including diverse floral and faunal communities. Population densities have changed over time on county, township, and municipality levels with the most significant increases for many counties occurring between the 1950s and the 1990s (Table 10).

DEMOGRAPHICS AND POPULATION TRENDS

A vast majority of the watershed population resides in Antrim County, with the majority of this county's population residing in the southernmost portion (Figure 12). Most residents of Antrim County live in incorporated villages (Antrim County Planning Commission, 2012). Elk Rapids Township has the greatest population density with 371.6 people per square mile. Population densities in all other Antrim County townships in the ERCOL watershed are below 100 people per square mile. The three Charlevoix County townships, four Kalkaska County townships, and the one Otsego County Township within the ERCOL watershed all have population densities of under 100 people per square mile. Acme Township and Whitewater Township in the Grand Traverse county portion of the watershed have population densities of 175 people per square mile and 54.3 people per square mile, respectively (U.S. Census Bureau, 2015; Michigan Department of Technology, Management and Budget, 2016).

The most recent 2010 census data shows that populations within ERCOL municipalities have declined between 2000 and 2010. However, the majority of townships have seen a moderate increase in population during this same time period, with Star Township having the largest increase (24%) and Banks Township having the largest decrease (11.3%) (Table 12, Figure 13). With the exception of Charlevoix County, populations of counties within the ERCOL have seen an increase in population between 2000 and 2010. The 2014 population estimates by county show an increase in population for Grand Traverse, Kalkaska, and Charlevoix counties, but a decline for Antrim and Otsego counties (Table 10). Data for the following tables was retrieved from the U.S. Census Bureau (2015) and the Michigan Department of Technology, Management and Budget (DTMB) (2016).

TABLE 10: CURRENT AND HISTORIC POPULATION BY COUNTY

County	1900	1950	1970	1990	2000	2010	2014 Estimate
Antrim	16,568	10,721	12,612	18,185	23,102	23,580	23,267
Grand Traverse	20,479	28,598	39,175	64,273	77,655	86,986	90,782
Kalkaska	7,133	4,597	5,272	13,497	16,565	17,153	17,394
Otsego	6,175	6,435	10,422	17,957	23,310	24,164	24,158
Charlevoix	13,956	13,475	16,541	21,468	26,087	25,949	26,949

TABLE 11: POPULATION CHANGE BY COUNTY (2000-2010)

County	Percent Change (2000-2010)
Antrim	2.1 %
Grand Traverse	12.0 %
Kalkaska	3.5 %
Otsego	3.7 %
Charlevoix	-0.5 %
Total	20.8 %

TABLE 12: POPULATION OF TOWNSHIPS (2000-2010)

Township	2000	2010	Percent Change (2000-2010)
Antrim County			
Banks	1,813	1,609	-11.3 %
Central Lake	2,254	2,198	-2.5 %
Torch Lake	1,159	1,194	3.0 %
Echo	928	877	-5.5 %
Jordan	875	992	13.4 %
Forest Home	1,858	1,720	-7.4 %
Kearney	1,764	1,765	0.1 %
Custer	988	1,136	15.0 %
Mancelona	4,100	4,400	7.3 %
Chestonia	546	511	-6.4 %
Star	745	926	24.3 %
Warner	389	416	6.9 %
Milton	2,072	2,204	6.4 %
Elk Rapids	2,741	2,631	-4.0 %
Helena	878	1,001	14.0 %
Grand Traverse			
Acme	4,361	4,375	0.3 %
White Water	2,438	2,597	6.5 %
Otsego			
Elmira	1,598	1,687	5.6 %
Kalkaska			
Kalkaska	4,830	4,722	-2.2 %
Clearwater	2,382	2,444	2.6 %
Rapid River	1,005	1,145	13.9 %
Cold Springs	1,449	1,464	1.0 %
Charlevoix			
Marion	1,492	1,714	14.9 %
South Arm	1,844	1,873	1.6 %
Norwood	714	723	1.3 %

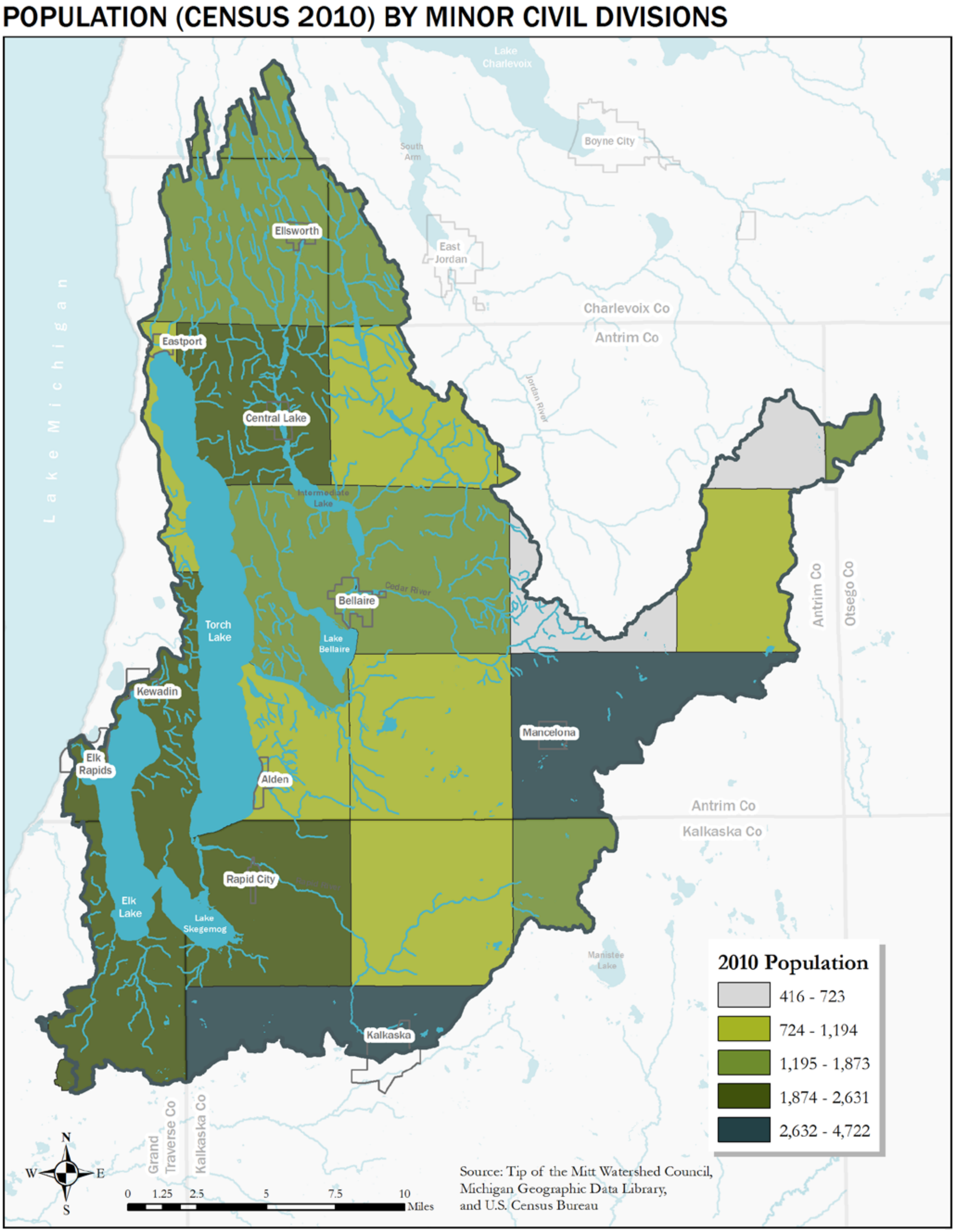


Figure 12: Population within minor civil division for the ERCOL watershed, data from 2010 census.

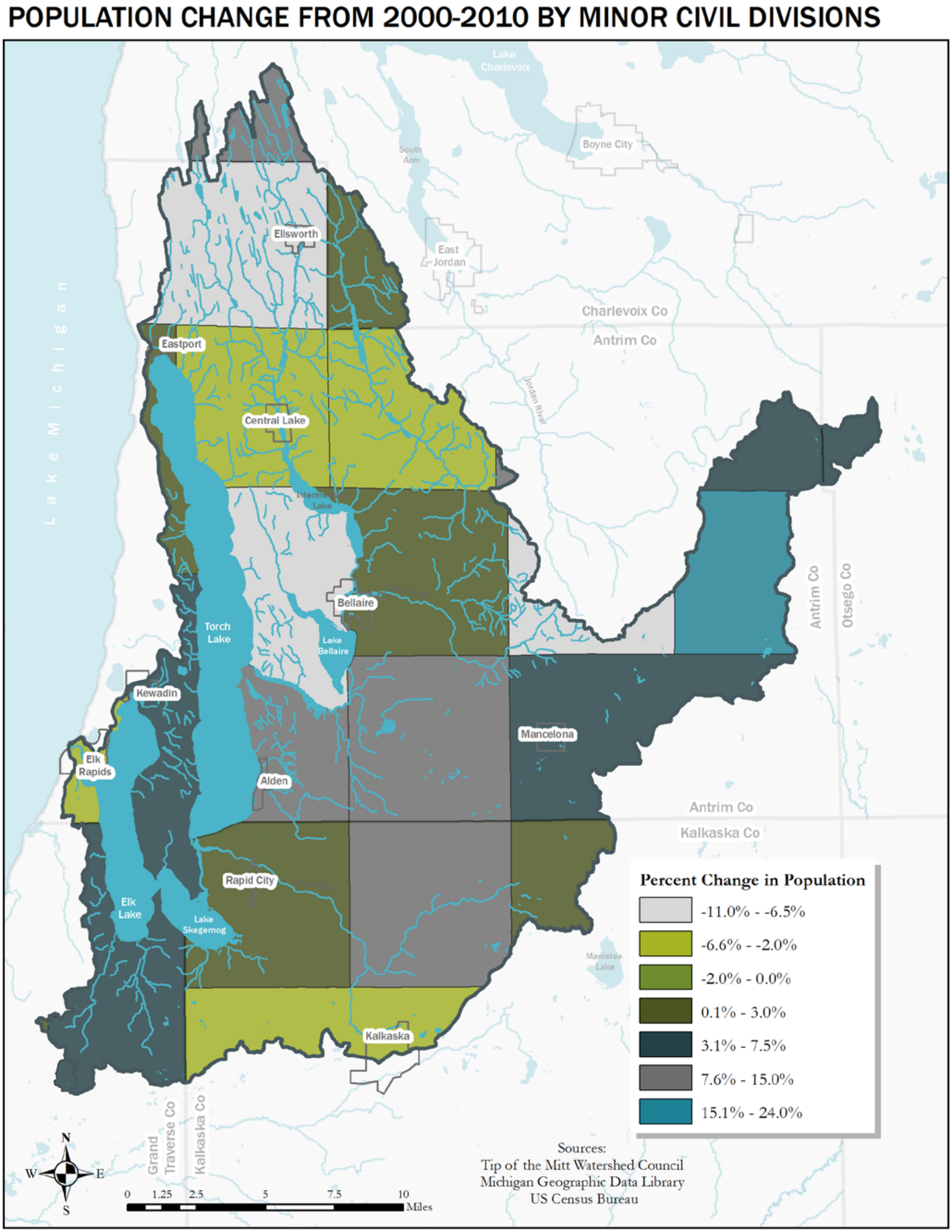


Figure 13: Population change in the ERCOL watershed by townships, data from 2000 and 2010 censuses.

HOUSEHOLDS

According to 2010 Census data, Antrim County has the largest number of occupied households within the ERCOL. The total number of occupied households within townships that are partially or completely within the watershed: 9,980 occupied households in Antrim County townships, 1,889 occupied households in Charlevoix County Townships, 2,818 occupied household in Grand Traverse County townships, 3,963 occupied household in Kalkaska County townships, and 646 occupied households in Otsego County townships (Michigan DTMB, 2016).

Between 2009 and 2013, the median household income for Michigan residents was $48,411. In comparison, the median household incomes for representative counties are as follows: Antrim County ($45,362), Charlevoix County ($45,949), Grand Traverse County ($51,766), Kalkaska County ($40,140), and Otsego County ($47,584) (U.S. Census Bureau, 2015).

SOCIOECONOMIC OVERVIEW

The state of Michigan has experienced broad scale economic changes over the past several decades, transitioning from a manufacturing-based economy to a service-based economy. The northwestern region of the Lower Peninsula is not exempt from the effects of these economic shifts – greatly influencing development and land use activities within population centers, forest lands, agricultural areas, and near lakes and riverfront areas. These development and land use changes directly influence the use of water resources and the overall watershed health and quality (Antrim County Planning Commission, 2012).

According to county business patterns, Antrim County had a total of 547 business establishments as of 2013. A wide variety of establishment types were included in this count but major categories include: construction; manufacturing; retail trade; food and beverage stores; gasoline stations; finance and insurance; real estate and rental/leasing; professional, scientific, and technical services; healthcare and social assistance; and accommodation and food services (Networks Northwest, 2015). Thirteen percent of the population in Antrim County is self-employed. The majority of self-employed residents work in the professional, scientific management, and administrative services industry (22%) or construction industry (18%) (TownCharts, 2016). The median earnings per worker in Michigan as a whole is $44,567, slightly above the national median. Median earnings per worker is $36,803 in Antrim County, $32,940 in Kalkaska County, $37,177 in Charlevoix County, $40,048 in Grand Traverse County, and $39,984 in Otsego County (TownCharts, 2016). According to the Northern Lakes Economic Alliance which includes Antrim, Charlevoix, Cheboygan, and Emmet counties, unemployment decreased from 13.5% in January of 2014 to

10.9% in January of 2015. The most recent data show that as of October 2015, the unemployment rate declined to 4.7% (Networks Northwest (B), 2015).

1.7 GOVERNMENTS

JURISDICTIONS

Watershed management requires the knowledge and collaboration of the political entities that pertain to the watershed. It is essential for local governments, on county, township, and municipality levels, to understand watershed boundaries and develop watershed scale plans in collaboration with neighboring municipalities and townships. A total of five counties are partially found within the ERCOL watershed including Antrim, Grand Traverse, Kalkaska, Otsego, and Charlevoix counties (Table 13). There are 25 townships (Table 14) and 6 municipalities (Table 15) whose boundaries are either entirely or partially found within the ERCOL watershed (Figure 12).

TABLE 13: NUMBER OF TOWNSHIPS AND MUNICIPALITIES IN THE WATERSHED

County	Townships	Municipalities
Antrim	15	4
Grand Traverse	2	0
Kalkaska	4	2
Otsego	1	0
Charlevoix	3	0
Total	**25**	**6**

TOWNSHIPS, TOWNS, AND VILLAGES

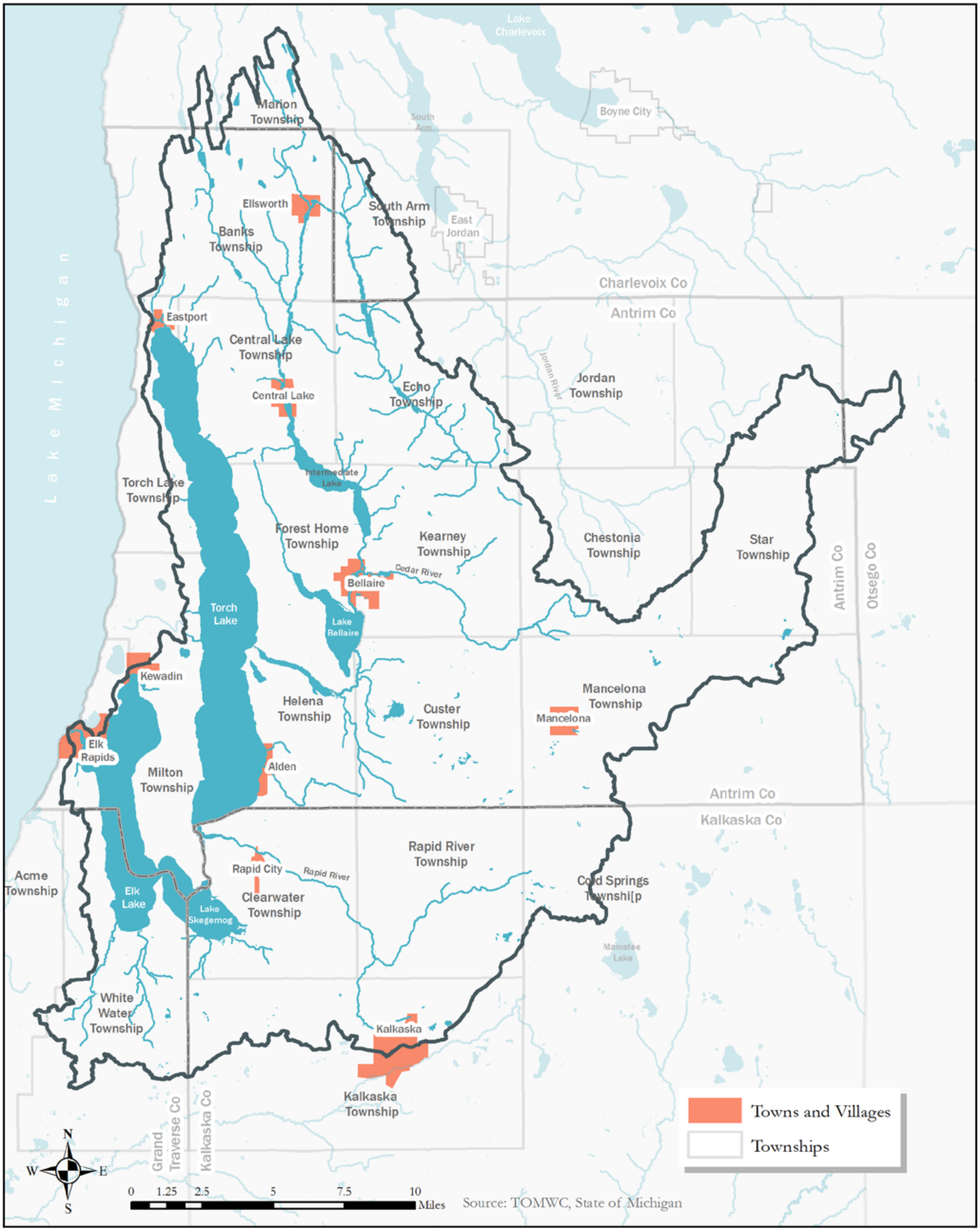


Figure 14: Towns and villages in the ERCOL watershed.

TABLE 14: TOWNSHIPS WITHIN THE WATERSHED

Township	Total Area (mi^2)	Total Area in Watershed (mi^2)	Percent of Township in Watershed
Antrim County			
Banks	45.83	34.88	76.1 %
Central Lake	31.28	31.28	100 %
Torch Lake	21.09	11.56	54.81 %
Echo	31.28	31.28	100 %
Jordan	35.20	0.52	1.48 %
Forest Home	33.51	33.51	100 %
Kearney	35.23	34.99	99.32 %
Custer	35.18	35.18	100 %
Mancelona	71.34	34.30	48.08 %
Chestonia	35.55	11.17	31.42 %
Star	34.34	21.69	63.16 %
Warner	35.58	9.52	26.76 %
Milton	41.14	32.77	79.65 %
Elk Rapids	10.96	6.22	56.75 %
Helena	23.05	23.05	100 %
Grand Traverse			
Acme	25.23	0.15	0.59 %
White Water	53.49	30.61	57.23 %
Otsego			
Elmira	36.24	3.24	8.94 %

TABLE 14 CONTINUED: TOWNSHIPS WITHIN ELK RIVER CHAIN OF LAKES WATERSHED

Township	Total Area (mi^2)	Total Area in Watershed (mi^2)	% of Township in Watershed
Kalkaska			
Kalkaska	71.21	23.15	32.51 %
Clearwater	33.77	33.77	100.00 %
Rapid River	35.23	34.58	98.15 %
Cold Springs	36.24	11.86	32.73 %
Charlevoix			
Marion	26.41	7.42	28.13 %
South Arm	32.73	10.73	32.78 %
Norwood	18.33	0.06	0.33 %

TABLE 15: MUNICIPALITIES WITHIN THE WATERSHED

Municipality	Total Area (mi^2)	Total Area in Watershed (mi^2)	% of Municipality in Watershed
Bellaire	1.96	1.96	100.0 %
Elk Rapids	1.98	1.26	63.6 %
Kalkaska	2.51	0.73	29.1 %
Central Lake	1.26	1.26	100.0 %
Ellsworth	0.83	0.83	100.0 %
Mancelona	1.00	1.00	100.0 %

STAKEHOLDERS

Interest and concern for the ERCOL is great across a range of stakeholders in Northwestern Michigan. Broadly defined, these stakeholders are users, residents, and visitors of the watershed. The health of the watershed as a whole and all the natural resources within it impact all those who interact with it. There are several organizations, agencies, and institutions heavily involved in the protection of the ERCOL Watershed.

Tip of the Mitt Watershed Council (TOMWC) is dedicated to protecting all water resources through advocacy, public outreach and education, water research and water quality monitoring, ecological restoration, and watershed management planning. TOMWC is one of the primary organizations involved in crafting this watershed management plan.

The Watershed Center Grand Traverse Bay is another organization closely involved in the development the ERCOL watershed management plan. The Watershed Center advocates for the protection and preservation of the Grand Traverse Bay Watershed which includes the ERCOL Watershed. Through education and outreach, advocacy, and on-the-ground restoration, The Watershed Center helps maintain the health and quality of the ecologically, economically, and socio-culturally valuable water resources of Northwestern Michigan.

The Elk River Chain of Lakes Watershed Implementation Team (ERCOL-WPIT) is a collaborative collection of stakeholders within the ERCOL Watershed who are spearheading development of this watershed management plan. The ERCOL-WPIT is a partnership between The Watershed Center of Grand Traverse Bay, Tip of the Mitt Watershed Council, the Grand Traverse Regional Land Conservancy, Antrim County, local Township governments, Antrim Conservation District, Elk-Skegemog Lakes Association, the Three Lakes Association, Friends of Clam Lake, Friends of Rapid River, Intermediate Lake Association, Torch Lake Protection alliance, Grand Traverse Conservation district and several other friends groups, lake associations, and non-profit organizations.

1.8 ZONING ASSESSMENT

How communities manage their land use has a direct impact on the community's water resources. Zoning, master plans, and special regulations are a few of the more commonly used land management tools. Zoning ordinances establish the pattern of development, protect the environment and public health, and determine the character of communities. A community can sometimes draw authority from a regulatory act or a charter, or a general police power statute. Michigan has a planning enabling act (PA 33 of 2008) and a zoning enabling act (PA 110 of 2006) that provide broad authority for the use of local planning and zoning techniques (Michigan Association of Planning, n.d.). The Michigan Planning Enabling Act is defined as:

> "An Act to codify the laws regarding and to provide for county, township, city, and village planning; to provide for the creation, organization, powers, and duties of local planning commissions; to provide for the powers and duties of certain state and local governmental officers and agencies; to provide for the regulation and subdivision of land; and to repeal acts and parts of act" (Legislative Council, State of Michigan (B), 2016, p. 1)

The Michigan Zoning Enabling Act is defined as:

> "An Act to codify the laws regarding local units of government regulating the development and use of land; to provide for the adoption of zoning ordinances; to provide for the establishment in counties, townships, cities, and villages of zoning districts; to prescribe the powers and duties of certain officials; to provide for the assessment and collection of feed; to authorize the issuance of bonds and notes; to prescribe penalties and provide remedies; and to repeal acts and parts of acts" (Legislative Council, State of Michigan, 2016, p. 1).

Since protecting water quality requires looking at what happens on land, zoning is an important watershed management tool. Watershed planning is best conducted at the sub-watershed scale. Planners must recognize that stream quality is directly related to land use and that the amount of impervious surfaces is particularly important. Land use planning techniques that should be applied are those that preserve sensitive areas, redirect development to the areas that can support it, maintain or reduce impervious surface cover, and reduce or eliminate nonpoint sources of pollution.

Zoning effectiveness depends on many factors, particularly restrictions in the language, enforcement, and public support. Many people believe the law protects sensitive areas, only to find otherwise when development is proposed. Zoning can be used very effectively for managing land uses in a way that is compatible with watershed management goals. A wide variety of zoning and planning techniques can be used to manage land use and impervious cover in sub-watersheds. Some of these techniques include: watershed based zoning, overlay zoning, impervious overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, transfer of development rights (TDRs), and limiting infrastructure extensions.

Local officials face hard choices when deciding which land use planning techniques are the most appropriate to modify current zoning. Table 16, from the Center for Watershed Protection's Rapid Watershed Planning Handbook, provide further details on land use planning techniques and their utility for watershed protection (CWP, 1998).

Grenetta Thomassey of Tip of the Mitt Watershed Council conducted the Antrim County Local Ordinance Gaps Analysis in 2011 for the purpose of guiding watershed protection efforts. The purpose of this analysis is to provide local government officials a comprehensive resource for understanding the current water resource protections that are in place at the township and county levels, recommendations for protecting waters at the local level, and suggestions for improvement for better protecting water resources. The analysis focuses on specific critical elements that are necessary to address in order to protect local water resources. These critical elements include, master plan components; basic zoning components; shorelines;

impervious surfaces and stormwater management; soil erosion and sediment control; sewer/septic; wetlands; groundwater and wellhead protection; other: floodplains, steep slopes, and critical dunes (Thomassey, 2011). This gaps analysis is a vital tool that should be utilized by local government officials to ensure that planning and zoning activities optimize the best possible outcomes for watershed protection. A copy of the Antrim County Local Ordinance Gaps Analysis (2011) can be found on Tip of the Mitt Watershed Council's website at: http://www.watershedcouncil.org/uploads/7/2/5/1/7251350/gaps_analysis_final_web.pdf.

In addition, the DEQ has published a book titled: *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (Ardizone, Wyckoff, and MCMP, 2003). A copy of this guidebook is available via the DEQ website: www.michigan.gov/deq (GTB Watershed Management Plan, 2005).

TABLE 16: LAND USE PLANNING TECHNIQUES

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Watershed-Based Zoning	Watershed and subwatershed boundaries are in the foundation for land use planning.	Can be used to protect receiving water quality on the subwatershed scale by relocating development out of particular subwatersheds.
Overlay Zoning	Superimposes additional regulations for specific development criteria within specific mapped districts.	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to protect receiving water quality at both the subwatershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the zone.	May be used to obtain proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental protection.	Can be used to encourage development within a particular subwatershed or to obtain open space in exchange for a density bonus at the site level
Performance Zoning	Specifies a performance requirement that accompanies a zoning district	Can be used to require additional levels of performance within a subwatershed or at the site level.
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where agricultural or rural land is to be preserved.	Can be used in conjunction with natural watershed or subwatershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness.

TABLE 16 CONTINUED: LAND USE PLANNING TECHNIQUES

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Infill/Community Redevelopment	Encourage new development and redevelopment within existing developed areas.	May be used in conjunction with watershed based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area."	May be used in conjunction with watershed based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increase densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer, water, or roads) to designated areas to avoid increased development in these areas.	May be used as a temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

Table from Center for Watershed Protection's Rapid Watershed Planning Handbook – page 2.4-5 and excerpted from the Grand Traverse Bay Watershed Management Plan 2005.

1.9 LAKE USES, TOURISM, AND RECREATION

The Michigan Department of Environmental Quality has identified the designated and desired uses of water in the state of Michigan. Designated uses include agriculture, industrial water supply, navigation, warmwater or coldwater fishery, habitat for other indigenous aquatic life and wildlife, partial body contact recreation, and total body contact recreation between May 1 and October 31 (GTB Watershed Management Plan 2005). The water resources of the ERCOL support a wide variety of economic activities within the watershed, ranging from agriculture to tourism. Visitors and local residents alike use this area for a variety of recreational purposes. The ERCOL Watershed features a number of parks and recreation areas, several interspersed with the lakes, rivers, and streams. Antrim Creek Natural Area, Cedar River Natural Area, Elk Rapids Day Park, Glacial Hills, and Grass River Natural Area are just a few places that provide opportunities for engaging with the watershed's natural resources. Water recreation is highly popular amongst residents and visitors and uses of water bodies include (but are not limited to) swimming, power boating, beach walking, fishing, sailing, kayaking/canoeing, personal water craft uses, and scuba diving. There are 36 public boat launches and many trails within the watershed that provide access to the water bodies.

The natural beauty of the Elk River Chain of Lakes area and the broader Grand Traverse Bay region attracts tourists from around the world. One popular event that attracts people from near and far is the Paddle Antrim Festival which is held every year on the second weekend after Labor Day. This event is coordinated by the non-profit organization, Paddle Antrim, which works hard to both preserve the watershed and connect people to it using paddle sports. This festival engages participants in a two-day kayak paddle of over 40 miles in the ERCOL. Not only does this event boost tourism in the area, but it also provides ample opportunity to show visitors and residents the pleasures of Northwestern Michigan's water resources and the importance of protecting them (Paddle Antrim, n.d.).

The National Cherry Festival in Traverse City attracts more than 500,000 participants each year who celebrate the harvest and revel with festivities over an eight-day period. Northwestern Michigan, including the Elk River Chain of Lakes area, is known as the Cherry Capital of the World. It produces half of the state's tart cherry crop and more than 80% of its sweet cherries (GTB Watershed Management Plan 2005). Many of the Cherry Festival visitors wander to surrounding areas, recreating at locations such as Shorts Brewing Company in Bellaire or using the many access points to Torch Lake.

1.10 PLANNING AREAS

For the purpose of organization and description of the various watershed parameters that will be discussed within this watershed management plan, the Elk River Chain of Lakes watershed has been broken up into three planning areas. These areas are the Upper Chain, Middle Chain, and Lower Chain. The Upper Chain planning area includes Beals, Scotts, Six Mile, Saint Clair, Ellsworth, Wilson, Ben-way, and Hanley Lakes and the associated streams and drainage basin. The Middle Chain consists of Intermediate, Bellaire, and Clam Lakes and the associated streams and drainage basin. Finally, the Lower Chain consists of Torch, Skegemog, and Elk Lakes and the associated streams and drainage basin.

CHAPTER 2
WATER QUALITY SUMMARY

CHAPTER 2: WATER QUALITY SUMMARY

2.1 INTRODUCTION

The accurate assessment of current water quality conditions within the Elk River Chain of Lakes (ERCOL) watershed is critical to understanding the nature of these waters, recognizing the issues affecting them, and developing the goals discussed in the later chapters of this document. This chapter outlines the chosen target water quality parameters, summarizes existing monitoring efforts, provides relevant reference conditions, and presents the available data for each lake within the main channel of the ERCOL as well as significant rivers and streams within the watershed. The watershed has been divided into three different geographical sections with similar water and land-use characteristics. The Upper Chain is considered all waters and drainage connecting Beals Lake to Hanley Lake, the Middle Chain spans from Intermediate Lake to Clam Lake, and the Lower Chain includes Torch Lake, Skegemog Lake, and Elk Lake.

In order to provide the most effective picture of current water quality within the ERCOL watershed, data was compiled and summarized from the year 2000 to 2015, as can be seen in the section headings that accompany each map figure. Earlier observations are noted within the primary monitoring efforts summary but are excluded from analysis in the data summary tables. Stream water chemistry was not summarized within this section due to the lack of consistent observation and high daily and seasonal variability of chemical parameters within stream ecosystems.

The organization of results follows the same format throughout the chapter for enhanced clarity. The discussion of water quality for each subsection is preceded by a map showing all water bodies that are referred to within that subsection. A graphical depiction of available data is provided for each lake with regard to the lake water quality target parameters. All axes were scaled the same between different lakes and bars reaching the top of the graph exceeded 30 observation in some cases. Observation numbers greater than 30 were not depicted in order to effectively highlight time periods with minimal observations. Maximum depth and surface area are given for each lake to provide a brief background of the lake's physical attributes.

The data summary tables are organized to record mean values, standard deviations, minimum and maximum values, as well as the number of observations. These details are provided in order to provide an accurate picture of the variation of water quality conditions and provide information about the confidence of statements regarding existing water quality within these lakes. The interpretation section compares observed values to the water quality requirements set by the Michigan Department of Environmental Quality (MDEQ) and reference condition within the state and ecoregion as surveyed by the U.S. Environmental Protection Agency (EPA) and U.S. Geological Survey (USGS). The outliers section provides a brief summary of observations that fell significantly (greater than two standard deviations) away from the calculated mean value and were deemed to be of potential importance.

Data for rivers and streams within the watershed are presented in a slightly different way with benthic macroinvertebrates summarized according to their community health throughout a particular waterbody. These observations were made by a number of different organizations. The interpretation section provides a more qualitative statement about which streams appear to be most impacted by negative factors. Enteric microorganisms are summarized in a similar fashion to water quality with mean values, standard deviations, minimum and maximum values, and number of observations for each water body. The interpretation section compares observed concentrations relative to requirements set by the MDEQ.

2.2 WATER QUALITY PARAMETERS

Nine target water quality parameters were identified to be of greatest significance to this management plan based on data availability and principles of aquatic system health. Seven of these parameters are centered on lake water quality: secchi depth, dissolved oxygen, chlorophyll a, nitrogen, phosphorus, specific conductance, and chloride. The other two parameters are related to stream water quality: benthic macroinvertebrate community health metrics and enteric microorganism (*E. coli*) concentrations. Although other parameters may prove significant in the future, this set of variables represents the most concise and effective picture of water quality within the ERCOL watershed with regard to past, current, and near-future monitoring efforts.

SECCHI DEPTH

Secchi depth is a measure of the amount of clarity of a particular body of water and is recorded as a distance beneath the water surface to which visibility extends. This is not a true measure of turbidity as it can be affected by a number of environmental factors, and it is important to take note of recent runoff events when collecting data. Given that sediment levels are typically very low in the center of lakes where measurements are typically taken and the high variability of such levels, this measure is most useful as an indicator of phytoplankton density and eutrophication.

The EPA recommends that secchi depth remain about 3.33 m (10.9 ft) for lakes within Ecoregion VII, based on historical aggregate data (EPA, 2000). The MDEQ does not specify any particular requirements for secchi depth, but it is stated that turbidity and suspended solids must not occur in levels harmful to designated uses of the water (MDEQ, 2006).

DISSOLVED OXYGEN

Dissolved oxygen concentration is a measure of the amount of oxygen dissolved in a body of water and is one of the primary limiting factors for aquatic life. Measurements of this parameter were restricted to daytime observations from late spring to early fall to reduce the confounding influence of natural seasonal and daily variations in oxygen concentrations. Data summaries were divided into the upper, middle, and lower thirds of the water column for this parameter to account for summer stratification of temperature and oxygen by depth in most lakes.

The EPA criteria for dissolved oxygen state that the 30-day mean must exceed 6.5 mg/l for coldwater lakes and streams, with a 7-day mean minimum of 5.0 mg/l and 1 day minimum of 4.0 mg/l. For warmwater lakes and streams the EPA states a 30-day mean minimum of 5.5 mg/l, with a 7-day mean minimum of 4.0 mg/l and 1 day minimum of 3.0 mg/l (EPA, 1986). More strict recommendations are made for early life stages of fish. The MDEQ mandates that dissolved oxygen levels for inland lakes and streams designated for coldwater fish exceed 7 mg/l at all times and that dissolved oxygen levels for all other bodies of water exceed 5 mg/l (MDEQ, 2006).

CHLOROPHYLL A

Chlorophyll a is the most dominant form of chlorophyll found in green plants and algae and concentrations of this parameter are used to quantify the amount of algae growing within a particular body of water. Some naturally occurring amount of algae is to be expected in all but the most oligotrophic and nutrient-poor lakes, but particularly high values of chlorophyll a can indicate an overabundance of algae that leads to reductions in dissolved oxygen and water clarity. Elevated concentrations of chlorophyll often occur with increases in nutrient runoff and distinct peaks may indicate the presence of harmful algal blooms within a body of water.

The EPA recommends that chlorophyll a concentrations do not exceed 2.63 µg/lfor lakes and 1.50 µg/lfor rivers and streams within this ecoregion (EPA, 2000). The MDEQ does not establish any specific criteria for chlorophyll a concentrations, but water clarity and color must not be sufficiently affected by this parameter to impair any designated uses (MDEQ, 2006).

TOTAL NITROGEN

Nitrogen is a key nutrient in the growth of aquatic plants and algae. Total nitrogen consists of the sum of all its common forms; ammonia, nitrate, nitrite, and organic nitrogen. Although other forms are often considered, the use of total nitrogen in the management plan allowed for the greatest degree of comparison and consistency between various monitoring efforts. Nitrogen is typically present in much greater abundance than phosphorus in water bodies and is usually not considered a limiting nutrient for harmful algal growth. However, in high quantities there is a risk of promoting algal activity and eutrophication that can lead to dangerous reductions in dissolved oxygen. Nitrogen enters bodies of water primarily through nutrient runoff from agriculture, lawn fertilizer, and wastewater, including human and animal waste carried through septic systems.

The EPA recommends that total nitrogen levels do not exceed 0.66 mg/l for lakes and 2.18 mg/l for rivers and streams for Ecoregion VII (EPA, 2000). The MDEQ does not specify defined requirements for this parameter, but it is required that nutrients are limited to the extent necessary to prevent stimulating the growth of aquatic plants, fungi, and bacteria that adversely affect designated uses (MDEQ, 2006).

TOTAL PHOSPHORUS

Phosphorus is the other key nutrient regarding the growth of aquatic plants and algae and it exists in far lower concentrations than nitrogen in most bodies of water, operating as the primary limiting nutrient. Total phosphorus consists of all organic and inorganic forms of phosphorus, including phosphates. Elevated concentrations of this parameter can lead to increased algal activity and significant reductions in dissolved oxygen. Phosphorus enters a body of water primarily through nonpoint sources that include agricultural runoff, chemical lawn inputs, and wastewater. Septic system failure can be a significant contributor to excessive phosphorus inputs.

The EPA recommends in general that phosphate phosphorus should not exceed 25 μg/lin any lake or reservoir or 50 μg/lwhere any stream enters an inland lake (EPA, 1986). For Ecoregion VII the EPA recommends that total phosphorus levels do not exceed 14.75 μg/lfor lakes and 33.0 μg/lfor rivers and streams (EPA, 2000). The MDEQ does not specify defined requirements for this parameter in most areas, but it is required that nutrients are limited to the extent necessary to prevent stimulating the growth of aquatic plants, fungi, and bacteria that adversely affect designated uses (MDEQ, 2006).

SPECIFIC CONDUCTANCE

Specific conductance is an analog to total dissolved solids and measures the electrical conductivity of a body of water. Although there is not an exact conversion between the two, specific conductivity measured in $\mu S/cm^2$ can be considered to be about twice the amount of dissolved solids measured in ppm or mg/l. Specific conductance can vary greatly based on storm events and periods of increased runoff, and it is important to take note of previous runoff events when recording data.

The MDEQ states that total dissolved solids must remain below a monthly average of 500 mg/l (about 1,000 $\mu S/cm^2$) and remain below 750 mg/l (about 1,500 $\mu S/cm^2$) at all times (MDEQ, 2006).

CHLORIDE

Chloride concentrations contribute to specific conductivity, but are significant in their own right as chloride exists prominently in many de-icers, water softeners, and other home products and is often tied directly to human development. At very high concentrations chloride can become toxic to aquatic organisms and an irritant to humans. This parameter can also serve as a rough analog to the level of human impact on a particular lake through stormwater runoff and other factors.

The MDEQ does not specify any required limits for chloride concentrations within this watershed, but prohibits high levels that are injurious to any designated uses (MDEQ, 2006).

BENTHIC MACROINVERTEBRATE COMMUNITY

Sampling the benthic macroinvertebrate community within a particular stream or river can provide valuable information about long-term water quality characteristics within that body of water. Chemistry observations are useful for environmental conditions in streams, but can fluctuate widely over short time periods due to precipitation events and often do not reflect the status of the aquatic biota. Benthic macroinvertebrates are measured due to their more constant community composition, yet relatively short life cycles (typically 1-3 years) that allow them to respond relatively quickly to changes in water quality. There are many measures of benthic macroinvertebrate community structure and function that relate to the quality of the ecosystem. For example, measures of total taxa, pollution sensitive taxa, and species evenness, with some metrics—such as MDEQ Procedure 51—integrating multiple measures of community composition and species abundance.

There are no established requirements for benthic macroinvertebrate communities within the State of Michigan (MDEQ, 2006), but most assessments classify community health into discrete categories. *Excellent* designations are typically reserved for the most diverse and robust macroinvertebrate communities and there are few observations of this nature in most areas. Communities that are recorded as *good* show limited negative pressure, while those assessed as *poor* or *fair* indicate stressed areas with an overall reduction in stream quality that are of most concern for remediation efforts.

ENTERIC MICROORGANISMS

Esherichia coli is a type of bacteria commonly found in the intestines of mammals. They provide a reliable indicator of the possible presence of enteric pathogens and hazardous conditions in recreational waters. Human-related enteric bacteria enter waterways primarily through wastewater discharge and septic system failure and can be a serious health concern if there are primary contact exposures via swimming and boating activities. Animal farming operations typically lead to increased *E. coli* concentrations in nearby waterways and can be problematic when highly concentrated or improperly managed. High values indicate potential contamination from human or animal waste.

The EPA makes two sets of recommendations, with the first as a mean value of 126 colonies per 100 milliliters (cfu/100ml) and the second, a more stringent mean value of 100 cfu/100ml (EPA, 2012). The MDEQ mandates that areas with total body contact recreation do not exceed 130 cfu/100ml for a 30-day mean or exceed 300 cfu/100ml at any time. Surface waters for partial body contact recreation are not to exceed 1,000 cfu/100ml (MDEQ, 2006).

2.3 REQUIREMENTS AND REFERENCE CONDITIONS

The following tables are intended to provide context for values of target parameters observed in each of the major lakes within the Elk River Chain of Lakes (ERCOL) watershed. The State of Michigan Requirements for Target Parameters table is derived from the water quality standards outlined in Part 4 of Act 451 (MDEQ, 2006) as mandated by the Clean Water Act of 1972. This table is not exhaustive and only includes requirements for parameters that have been monitored consistently within this watershed in order to provide reference to observed values. Additionally, requirements that are not pertinent to the bodies of water described here are left out of this simplified table. For a full summary of the water quality requirements laid out in Part 4 of Act 451 see Table 56 in Chapter 4: Designated Uses and Impairments.

TABLE 17: STATE OF MICHIGAN REQUIREMENTS FOR TARGET PARAMETERS

Parameter	Requirement
Secchi Depth	No harmful impacts on designated uses
Dissolved Oxygen	Minimum 7/mg/l for coldwater streams and lakes; mimimum 5 mg/l for all other waters
Chlorophyll a	No harmful impacts on designated uses
Total Nitrogen	No harmful impacts on designated uses
Total Phosphorus	No harmful impacts on designated uses
Total Dissolved Solids (Specific Conductance)	30-day mean of TDS below 500 mg/l (about 1,000 $\mu S/cm^2$); TDS below 750 mg/l (about 1,500 $\mu S/cm^2$) at all times
Chloride	No harmful impacts on designated uses
Microorganisms	Maximum 30-day mean of 130 cfu/100ml; maximum 300 cfu/100ml at all times for full body contact use; maximum 1,000 cfu/100ml for partial body contact use

The Reference Conditions for Michigan Inland Lakes table is derived from three federal reports detailing regional water quality within the state of Michigan. Two of these sources focus on historical water quality data within Ecoregion VII.51, Northern Central Hardwood Forests, as designated by the EPA. This ecoregion covers a small area in the Northwestern portion of Michigan's Lower Peninsula and moderate portions of both Minnesota and Wisconsin. The third source of reference conditions summarizes data from lakes throughout the entire state of Michigan. All three of these sources were included to capture some variety with spatial and temporal extent, comparing first to the ecoregion and then to the entire state.

The first column describing reference conditions within Ecoregion VII.51 from 1990-1998 is from an EPA assessment conducted throughout all of the level III ecoregions within Ecoregion VII (EPA, 2000). The second column describes reference conditions in the same spatial extent from 2001-2005 and was conducted by the U.S. Geological Survey (USGS) with cooperation from the Michigan Department of Natural Resources (Fuller & Minnerick, 2008). The third column describes reference conditions throughout the state of Michigan's inland lakes from 2001-2010 and is derived from another USGS study studying regional water quality (Fuller & Taricska, 2012.)

The interpretation section of the water quality for each lake draws upon these reference conditions to provide context to the observed data. Although lake characteristics vary naturally throughout the ecoregion and certainly throughout the state, if observed lake conditions are relatively high or low compared to regional benchmarks it provides a clearer picture of the water quality within the ERCOL watershed. Until more robust water quality monitoring efforts are established, these qualitative comparisons provide the best available assessment of the state of the lakes within this watershed.

TABLE 18: REFERENCE CONDITIONS FOR MICHIGAN INLAND LAKES

Parameter	Ecoregion VII.51 1990-1998	Ecoregion VII.51 2001-2005	Statewide 2001-2010
Secchi Depth (ft)	10.50	11.20	10.30
Dissolved Oxygen (mg/l)	-	-	8.12 5.49 2.22
Chlorophyll a (µg/l)	2.02	2.90	6.10
Total Nitrogen (mg/l)	0.66	0.52	0.68
Total Phosphorus (µg/l)	20.00	11.00	21.00
Specific Conductance (µS/cm^2)	-	-	289.00
Chloride (mg/l)	-	7.30	16.70

2.4 MONITORING EFFORTS

Water quality data has been collected throughout the ERCOL watershed since as early as 1967 but spatial and temporal coverage has been somewhat inconsistent even into the present time. The types of monitoring efforts range from one-time governmental efforts measuring many parameters across large areas to citizen science campaigns carried out by local volunteers. Existing efforts have been summarized in order to better understand the magnitude and character of water quality data available within the ERCOL watershed.

Tip of the Mitt Watershed Council (TOMWC) has been one of the most active organizations compiling water quality data within the area and has implemented three monitoring programs exploring the state of inland lakes and rivers. The Comprehensive Water Quality Monitoring program has been carried out directly by TOMWC beginning in 1992 and assesses dissolved oxygen, nitrogen, total phosphorus, specific conductance, chloride, pH, and surface temperature every three years. This is the only monitoring effort to characterize all 14 lakes within the primary chain, although observations of Beals Lake and Scotts Lake ceased after 1998. TOMWC's Volunteer Lake Monitoring program began in 1990 and has been collecting data until the present time. This effort enlists citizen scientists to catalog secchi depth, chlorophyll a levels, and surface temperature throughout the chain and has accumulated data for 10 of the lakes, excluding Beals Lake, Scotts Lake, Saint Claire Lake, and Wilson Lake. The similarly natured Volunteer Stream Monitoring

Program that was launched in 2004 has monitored two sites on Eastport Creek since 2005, and surveyed two sites on Spencer Creek from 2005-2008 with respect to the benthic macroinvertebrate community.

The Watershed Center (TWC), serving the Grand Traverse Bay area, has been summarizing a number of monitoring efforts within a maintained database, but their main data contribution to this summary is through their Adopt-A-Stream program. This effort tasks teams with collecting and identifying benthic macroinvertebrates and documenting stream conditions in the spring and fall. Samples have been conducted at over 30 stream sites within the Middle Chain and Lower Chain since 2009, with 11 of these sites directly on the Rapid River. A limited amount of *E. coli* data has also been compiled by the Watershed Center in a study published in 2004 evaluating levels in the Rapid River, Torch River and Elk River between over the past 4 years.

Michigan Clean Water Corps (MiCorps) has been collecting water chemistry throughout the ERCOL watershed for quite some time. The Cooperative Lakes Monitoring Program implemented by MiCorps has been reporting data on water quality since 1975 for nine of the lakes within the ERCOL watershed. Water chemistry data is relatively consistent for Elk Lake, Intermediate Lake, Six Mile Lake, Lake Skegemog, and Wilson Lake during the 1980's and early 1990's and Lake Bellaire, Clam Lake, and Torch Lake during the late 1970's and 2000's, but Hanley Lake only has observations during 1990 and 1991 and there is no data for the other small lakes within the ERCOL. For lakes monitored within this program, data on secchi depth, dissolved oxygen, chlorophyll a, total phosphorus, and surface water temperature were collected. MiCorps has also collected benthic macroinvertebrate data through its volunteer monitoring program in a number of rivers and streams within the Middle Chain and Lower Chain since 2009.

The Michigan Department of Environmental Quality (MDEQ) and United States Geological Survey (USGS) collaborated from 2001 and 2010 to implement the Lake Water Quality Assessment program (LWQA) across the state of Michigan. Lakes within the ERCOL watershed were sampled once either during 2003 or 2008. This effort measured a multitude of water quality parameters and included all of the chemical target parameters highlighted by this management plan among many others. The MDEQ also conducts biological sampling and physical habitat assessment within wadable streams and summarized the benthic macroinvertebrate community at several sites within the Cedar and Rapid Rivers in 2013. A limited amount of chemical data was collected by the MDEQ in Cold Creek and Rapid River in 2003, but given the extreme variability of river chemistry and limited observations it was not included in this summarization.

The Three Lakes Association (TLA) conducts bacteriological monitoring at various sites throughout the watershed with *E. coli* sampled at over 20 sites, primarily around Torch Lake, since 2008. This effort consists of typically 1-2 measurements taken at each tributary site during the summer of each year, formalized in an annual report by the organization.

The United States Environmental Protection Agency houses the oldest water quality data, dating back to 1967, for the ERCOL watershed in its Legacy STORET system. This effort includes monitoring for 12 lakes within the chain, excluding only Beals Lake and Scotts Lake in the upper reaches, and considers a wide variety of water quality parameters including secchi depth, dissolved oxygen, chlorophyll a, nitrogen, phosphorus, specific conductance, and chloride. This program ceased compiling new data for the region in 1988.

Other water quality monitoring efforts have occurred throughout this region and this list is not assumed to be exhaustive, merely a summarization of the primary programs that were used to compile the data needed for the analysis presented in the rest of this chapter. Some of these organizations have not yet made their data from 2015 available and smaller monitoring efforts may not be represented here, though they still play a role in watershed monitoring. The Grand Traverse Band of Ottawa and Chippewa Indians took water quality samples for two sites on the Clam River and Torch River from 2012 to 2015, but these were also excluded for the sake of analysis given the variability of these systems and limited scope of data.

TABLE 19: SUMMARY OF MONITORING EFFORTS

Primary Organization	Program	Target Parameters	Location	Time Frame
Tip of the Mitt Watershed Council	Comprehensive Water Quality Monitoring	Dissolved oxygen, nitrogen, phosphorus, specific conductance, chloride	Upper Chain, Middle Chain, Lower Chain	1992 – 2013* *taken at 3-year intervals
	Volunteer Lake Monitoring	Secchi depth, chlorophyll a	Six Mile, Ellsworth, Ben-way, Hanley, Middle Chain, Lower Chain	1990 – 2014
	Volunteer Stream Monitoring	Benthic macroinvertebrate community	Lower Chain rivers and streams	2004 – 2015
The Watershed Center	Adopt-a-Stream	Benthic macroinvertebrate community	Middle Chain & Lower Chain rivers and streams	2009 – 2015
	Local Tributary E. coli Monitoring	Enteric microorganisms	Rapid River, Torch River, Elk River	2000 – 2004
Michigan Clean Water Corps	Cooperative Lake Monitoring Program	Secchi depth, dissolved oxygen, chlorophyll a, phosphorus	Six Mile, Wilson, Hanley, Middle Chain, Lower Chain	1975 – 1994, 2004 – 2015* *Bellaire, Clam, Torch
	Volunteer Stream Monitoring Program	Benthic macroinvertebrate community	Middle Chain & Lower Chain rivers and streams	2009 – 2015
Michigan Department of Environmental Quality	Lake Water Quality Assessment* *Collaboration with USGS	Secchi depth, dissolved oxygen, chlorophyll a, nitrogen, phosphorus, specific conductance, chloride	Six Mile, Ellsworth, Ben-way, Torch, Skegemog Saint Claire, Wilson, Intermediate, Bellaire, Clam, Elk	2003 2008
	Biological Sampling and Habitat Assessment	Benthic macroinvertebrate community	Cedar River, Rapid River	2013
Three Lakes Association	E. coli Stream Sampling	Enteric microorganisms	Middle Chain & Lower Chain rivers and streams	2008 – 2014
U.S. Environmental Protection Agency	STORET Legacy Data	Secchi depth, dissolved oxygen, chlorophyll a, nitrogen, phosphorus, specific conductance, chloride	Six Mile, Saint Claire, Ellsworth, Wilson, Benway, Hanley, Middle Chain, Lower Chain	1967 – 1988

2.5 WATER QUALITY SUMMARIES

The following is a summary of water quality split into the 3 distinct regions as described in chapter 1.8.

UPPER CHAIN: WATER QUALITY SUMMARY (2000 - 2015)

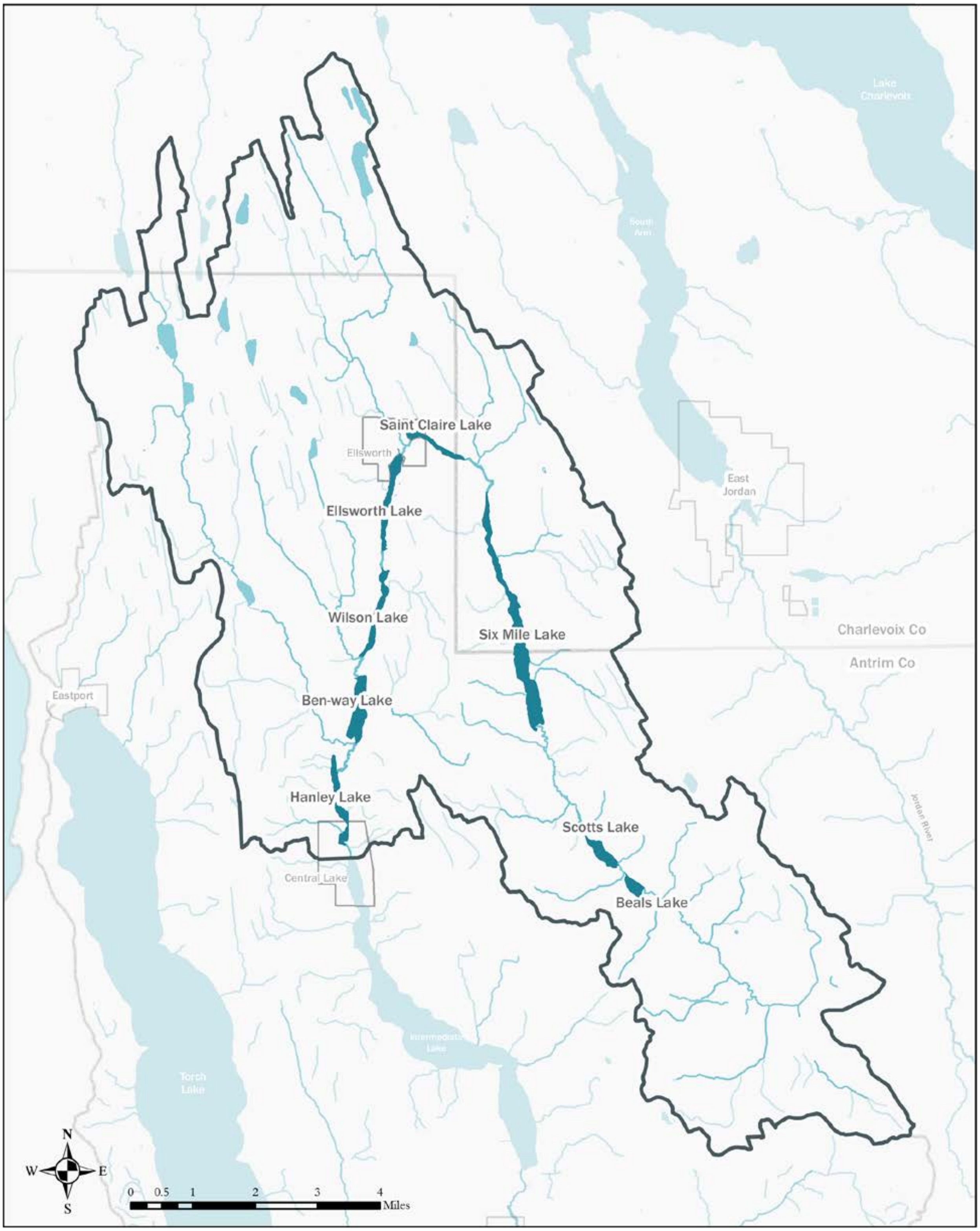


Figure 15: A map of the surface waters within the upper chain region of the ERCOL watershed.

BEALS LAKE & SCOTTS LAKE

DATA AVAILABILITY

No water quality monitoring data has been recorded for Beals Lake or Scotts Lake since 1998.

SUMMARY

Beals Lake

Maximum depth: 16 feet

Surface area: 39.0 acres

Scotts Lake

Maximum depth: 35 feet

Surface area: 63.3 acres

When last recorded in the spring of 1995 and 1998 by Tip of the Mitt Watershed Council, secchi depth at Beals Lake was between 7 and 8 feet, dissolved oxygen concentrations were around 10 mg/l throughout the water column, total nitrogen values were between 0.35 and .50 mg/l, and phosphorus concentrations were at about 15 µg/l. Specific conductivity values were about 300 $\mu S/cm^2$ and chloride concentrations at about 5 mg/l. Data for Scotts Lake was also recorded in 1995 and 1998, showing a secchi depth between 7.5 and 11.5 feet, dissolved oxygen concentration of around 10 – 11 mg/l in 1995 and slightly reduced values in 1998 with a very low concentration in the bottom third of the water column. Total nitrogen levels varied significantly, but were primarily around 0.40 to 0.50 mg/l with total phosphorus concentrations observed around 15 to 20 µg/l. Specific conductivity values were about 300 $\mu S/cm^2$ and chloride concentrations about 5 mg/l.

INTERPRETATION

Without more frequent and recent data points it is impossible to make any conclusions about trends from these observations. The available data is at least 18 years old and only provide a point of historical reference and the variance with time is unknown due to limited sampling. Although these two lakes at the top of the Chain of Lakes are very small and likely experience reduced human impact compared to areas further downstream, it is still pertinent to understand the characteristics and trends within their waters. It is recommended that they be observed for the prescribed water quality parameters to update these datasets and maintain more consistent monitoring.

SIX MILE LAKE

TABLE 20: SIX MILE LAKE DATA AVAILABILITY

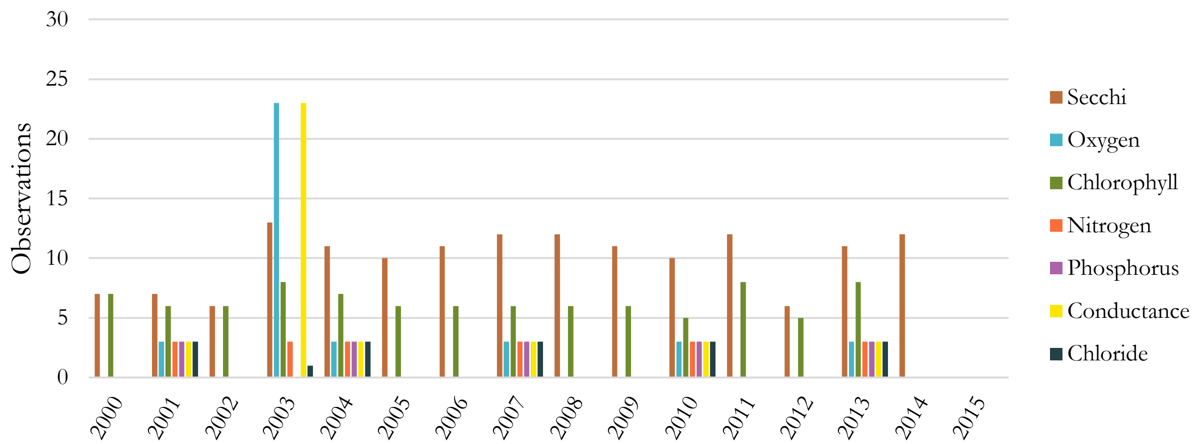


TABLE 21: SIX MILE LAKE SUMMARY

Maximum depth: 31 feet

Surface area: 370 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	9.34	2.06	5.00	16.00	151
Dissolved Oxygen* (mg/l)	9.70 8.44 7.36	1.34 2.53 4.30	7.60 2.50 0.60	11.40 11.40 11.10	11 15 12
Chlorophyll a (µg/l)	4.01	2.27	0.00	15.50	90
Total Nitrogen (mg/l)	0.479	0.074	0.323	0.610	18
Total Phosphorus (µg/l)	6.59	3.53	0.80	13.10	15
Specific Conductance (µS/cm^2)	316	35	259	384	38
Chloride (mg/l)	6.33	0.99	4.60	8.00	16

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Secchi depth is slightly lower than the reference conditions or EPA recommendation for this ecoregion, but does not appear problematic. Dissolved oxygen appears to be at healthy levels and are in clear exceedance of the 5 mg/l required for warmwater lakes at all levels of the water column. Chlorophyll a levels are slightly higher than the reference conditions and recommendations provided by the EPA for this ecoregion with a concentration of 4.01 μg/l. Total nitrogen and phosphorus concentrations are both below the reference conditions given for the region. Specific conductance is slightly above the statewide average, but remains well below the equivalent recommendation for total dissolved solids given by the MDEQ. Chloride levels are below the regional reference conditions.

OUTLIERS

Secchi depth was observed as high as 16 feet briefly during the summers of 2004, 2012, 2013, and 2014. Dissolved oxygen was recorded at a surprisingly low concentration of 2.5 mg/l in the middle of the water column in August of 2003. Chlorophyll a levels peaked during the late summers of 2000 and 2004 at about 9 μg/land 15 μg/lrespectively.

SAINT CLAIRE LAKE

TABLE 22: SAINT CLAIRE LAKE DATA AVAILABILITY

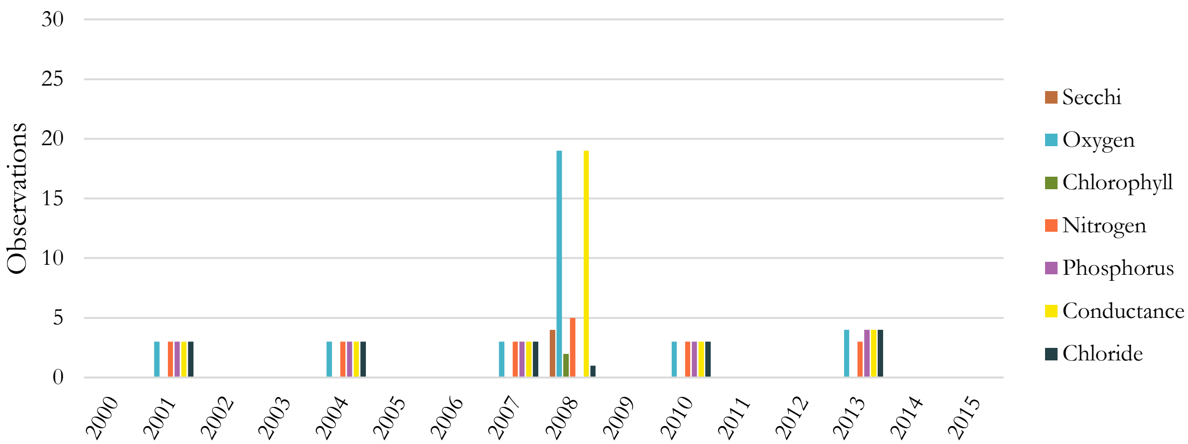


TABLE 23: SAINT CLAIRE LAKE SUMMARY

Maximum depth: 32 feet

Surface area: 60 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	10.0	0.58	9.50	10.50	4
Dissolved Oxygen* (mg/l)	9.72 7.03 2.89	1.29 3.85 3.72	7.90 1.40 0.00	12.00 12.20 12.10	11 14 10
Chlorophyll a (µg/l)	3.60	3.11	1.40	5.80	2
Total Nitrogen (mg/l)	0.504	0.138	0.328	0.813	20
Total Phosphorus (µg/l)	6.89	4.12	1.10	14.70	15
Specific Conductance (µS/cm^2)	394	95	259	682	35
Chloride (mg/l)	13.30	9.25	5.60	38.40	16

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Secchi depth at Saint Claire Lake is quite close to the regional reference conditions. While dissolved oxygen levels in the upper two-thirds of the water column are well above the 5 mg/l requirement for warmwater lakes, the lower third is significantly below this value, indicating somewhat hypoxic conditions. Chlorophyll a concentrations are slightly higher than reference conditions for Ecoregion VII.51, but remain lower than the statewide condition. Total nitrogen and phosphorus concentrations are both lower than the given reference conditions, although nitrogen levels are close to the average value given by the USGS report for Ecoregion VII.51 for 2001-2005. Specific conductance is higher than the statewide reference condition but below harmful levels. Chloride concentrations are higher than expected based on the ecoregion reference conditions, but remain slightly below the statewide average and are likely not problematic.

OUTLIERS

Dissolved oxygen concentration at the bottom of the lake was recorded as particularly high in April of 2007 with a value just over 12 mg/l. Total nitrogen was observed at unusually high concentrations during the spring of 2008 and 2010 with recordings at around 0.800 mg/l. Specific conductance and chloride values were exceptionally high at a sample in the spring of 2010 at approximately 680 $\mu S/cm^2$ and 38 mg/l respectively.

ELLSWORTH LAKE

TABLE 24: ELLSWORTH LAKE DATA AVAILABILITY

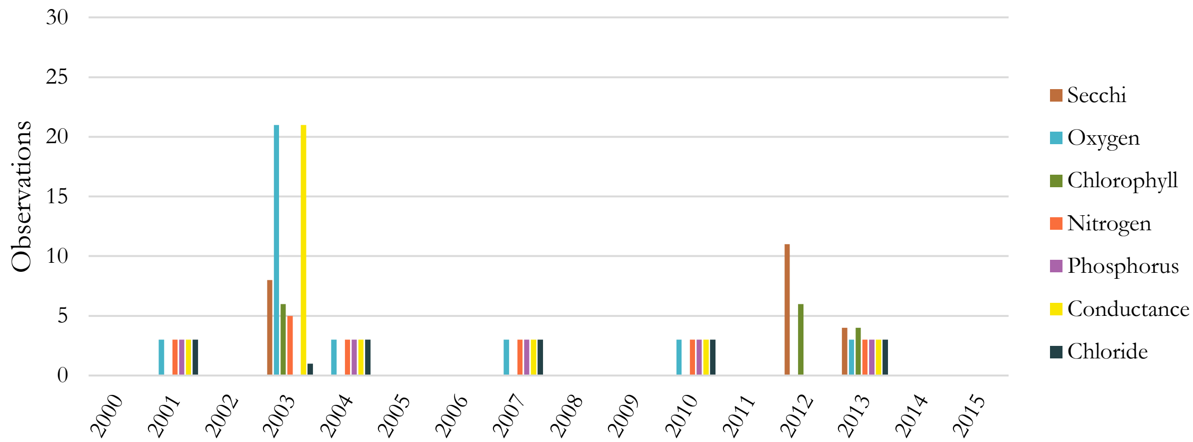


TABLE 25: ELLSWORTH LAKE SUMMARY

Maximum depth: 42 feet

Surface area: 106 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	9.87	2.51	4.50	13.10	23
Dissolved Oxygen* (mg/l)	9.50 7.48 4.54	1.75 4.38 4.73	5.90 0.40 0.30	11.90 11.80 11.40	12 13 11
Chlorophyll a (µg/l)	2.99	2.36	0.20	9.10	16
Total Nitrogen (mg/l)	0.614	0.196	0.356	1.060	20
Total Phosphorus (µg/l)	8.65	7.18	2.60	29.70	15
Specific Conductance (µS/cm^2)	371	63	281	520	36
Chloride (mg/l)	9.33	1.72	7.30	13.50	16

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Ellsworth Lake exhibits a secchi depth similar to the other lakes within the region. Dissolved oxygen levels for this warmwater lake are well above the 5 mg/l requirement set by the MDEQ in the upper two-thirds of the water column, but average slightly below this value in the lower third. Chlorophyll a levels are similar to the reference conditions for the ecoregion. Total nitrogen is above the ecoregion reference condition cited by the USGS for 2001-2005, but remains slightly below the statewide condition. Total phosphorus is below given reference conditions for the area. Specific conductivity is higher than the statewide reference condition, but not high enough to be problematic. Chloride levels are slightly higher than the ecoregion reference conditions, but not excessive.

OUTLIERS

Secchi depth was recorded as unusually low in June of 2012 at 4.5 feet. At the surface of the water column, dissolved oxygen concentration was observed as particularly low in August of 2003 with a value of less than 6 mg/l. Chlorophyll a concentrations peaked in August of 2013 at over 9 μg/l. Total nitrogen and phosphorus levels were both significantly higher than normal when observed in May of 2001 at 1.06 mg/l about 30 μg/l respectively. Readings of specific conductance were particularly high in August of 2003 and March of 2010 with values in exceedance of 500 $\mu S/cm^2$. Chloride concentration was also observed at an elevated value of over 13 mg/l in March of 2010.

WILSON LAKE

TABLE 26: WILSON LAKE DATA AVAILABILITY

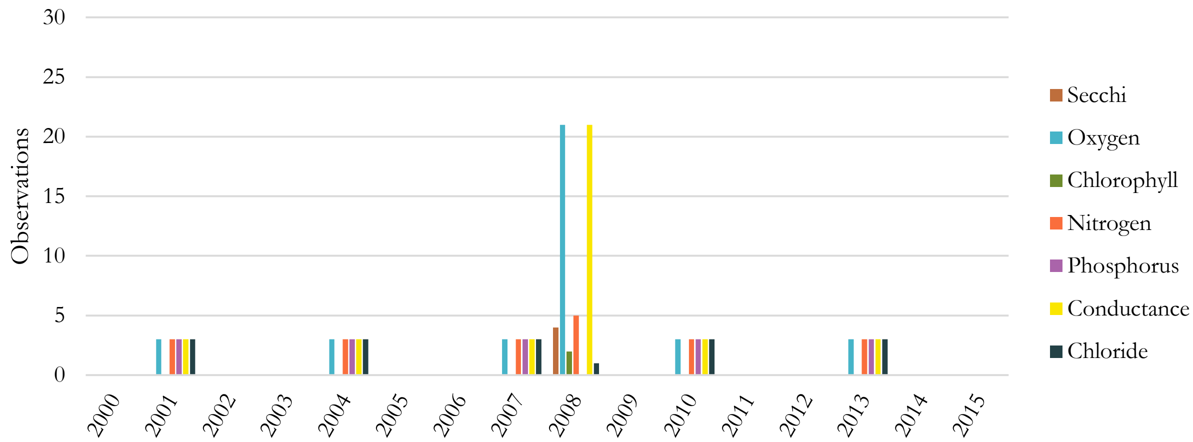


TABLE 27: WILSON LAKE SUMMARY

Maximum depth: 48 feet

Surface area: 89 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	9.85	1.56	8.50	11.20	4
Dissolved Oxygen* (mg/l)	9.31 6.52 0.99	1.62 4.54 1.35	5.40 0.10 0.00	11.80 11.40 3.90	13 13 10
Chlorophyll a (µg/l)	2.80	2.55	1.00	4.60	2
Total Nitrogen (mg/l)	0.620	0.209	0.215	1.000	20
Total Phosphorus (µg/l)	10.10	10.30	1.90	31.70	15
Specific Conductance (µS/cm^2)	366	40	291	440	36
Chloride (mg/l)	9.87	2.34	7.20	16.40	16

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Secchi depth at Wilson Lake is similar to regional reference conditions. Dissolved oxygen values at the base of the lake are far below the MDEQ requirement of 5 mg/l for warmwater lakes and are bordering on anoxic. Oxygen levels throughout the rest of the water column appear sufficient, although there is a troubling minimum through the mid-level. Nitrogen levels are higher than the reference condition for the ecoregion in 2001-2005, but remain below statewide averages. Total phosphorus is slightly below the same reference conditions. Specific conductance is higher than the statewide average for lakes, but below levels that are likely to be problematic. Chloride levels are higher than the ecoregion reference condition, but lower than statewide averages.

OUTLIERS

Dissolved oxygen concentrations were atypically low at the surface in the summer of 2008 at around 5 mg/l. Total phosphorus concentrations were recorded at unusually high values in the springs of 2001 and 2010 with values over 30 μg/l. Chloride levels peaked in the spring of 2004 with a recording over 16 mg/l.

BEN-WAY LAKE

TABLE 28: BEN-WAY LAKE DATA AVAILABILITY

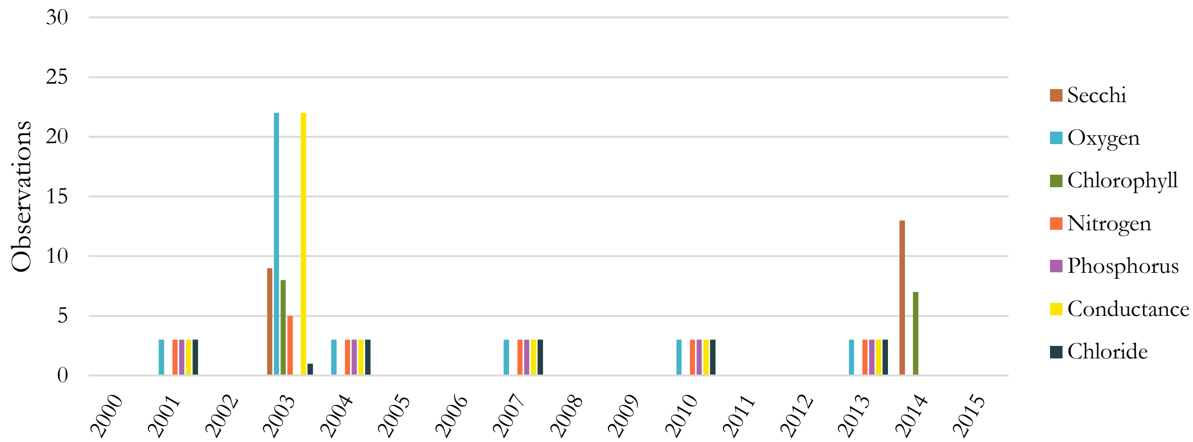


TABLE 29: BEN-WAY LAKE SUMMARY

Maximum depth: 42 feet

Surface area: 127 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	11.50	1.90	8.40	15.10	22
Dissolved Oxygen* (mg/l)	9.94 7.68 3.68	1.15 3.40 4.05	8.10 1.90 0.00	11.40 11.50 11.20	11 14 12
Chlorophyll a (µg/l)	2.84	1.89	0.30	7.00	15
Total Nitrogen (mg/l)	0.686	0.283	0.456	1.700	20
Total Phosphorus (µg/l)	10.80	15.80	1.60	64.60	15
Specific Conductance (µS/cm^2)	359	32.1	305	420	37
Chloride (mg/l)	9.09	0.97	7.40	10.80	16

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Ben-way Lake has a secchi depth slightly higher than the ecoregion or statewide average. Dissolved oxygen concentrations at the bottom of the lake are below the 5 mg/l requirement set by the MDEQ for warmwater lakes, but the rest of the water column is well above this criteria. Chlorophyll a levels are very similar to those typical to the ecoregion. Total nitrogen concentrations appear slightly elevated, although they remain around the statewide average. Average phosphorus concentrations are below reference conditions, although there is a high maximum in excess of EPA suggestions.

OUTLIERS

Chlorophyll a levels were particularly high in July of 2003 with a recorded value of 7 μg/l. Total nitrogen experienced a dramatic peak in August of the same year with an observed concentration of 1.70 mg/l. Total phosphorus exhibited an exceptionally high concentration in May of 2013 with a value of almost 65 μg/l.

HANLEY LAKE

TABLE 30: HANLEY DATA AVAILABILITY

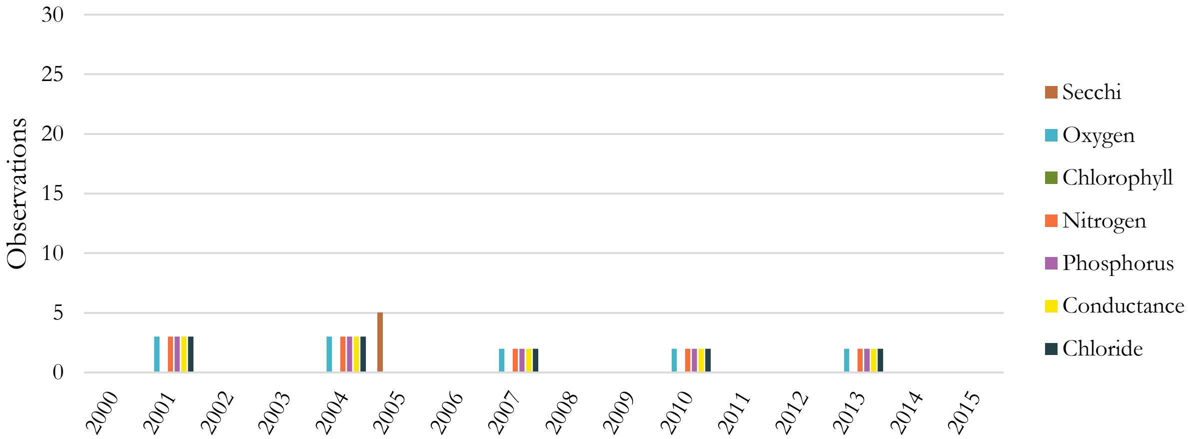


TABLE 31: HANLEY LAKE SUMMARY

Maximum depth: 27 feet

Surface area: 91 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	12.60	1.52	11.00	15.00	5
Dissolved Oxygen* (mg/l)	10.80 10.20 7.50	0.78 1.08 4.39	9.64 9.41 0.97	11.79 10.94 11.47	5 2 5
Chlorophyll a (µg/l)	-	-	-	-	0
Total Nitrogen (mg/l)	0.617	0.096	0.486	0.750	12
Total Phosphorus (µg/l)	7.88	5.13	3.00	16.80	12
Specific Conductance (µS/cm^2)	334	30	299	407	12
Chloride (mg/l)	9.05	1.24	7.50	10.90	12

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Hanley Lake has a relatively high secchi depth compared to reference conditions. Dissolved oxygen levels appear very healthy and are in clear excess of statewide averages and MDEQ requirements, although observations are very limited. No chlorophyll a data is available from 2000-2015 for this lake. Total nitrogen levels are similar to statewide averages and ecoregion conditions from 1990-1998, but are a fair amount higher than the ecoregion conditions reported from 2001-2005. Phosphorus levels are below any of the reference conditions. Specific conductance is higher than statewide averages, but likely not problematic. Chloride levels are higher than ecoregion reference conditions, but lower than the statewide average.

OUTLIERS

A particularly high level of specific conductance was recorded in early April of 2010 in excess of 400 $\mu S/cm^2$.

MIDDLE CHAIN: WATER QUALITY SUMMARY (2000 - 2015)

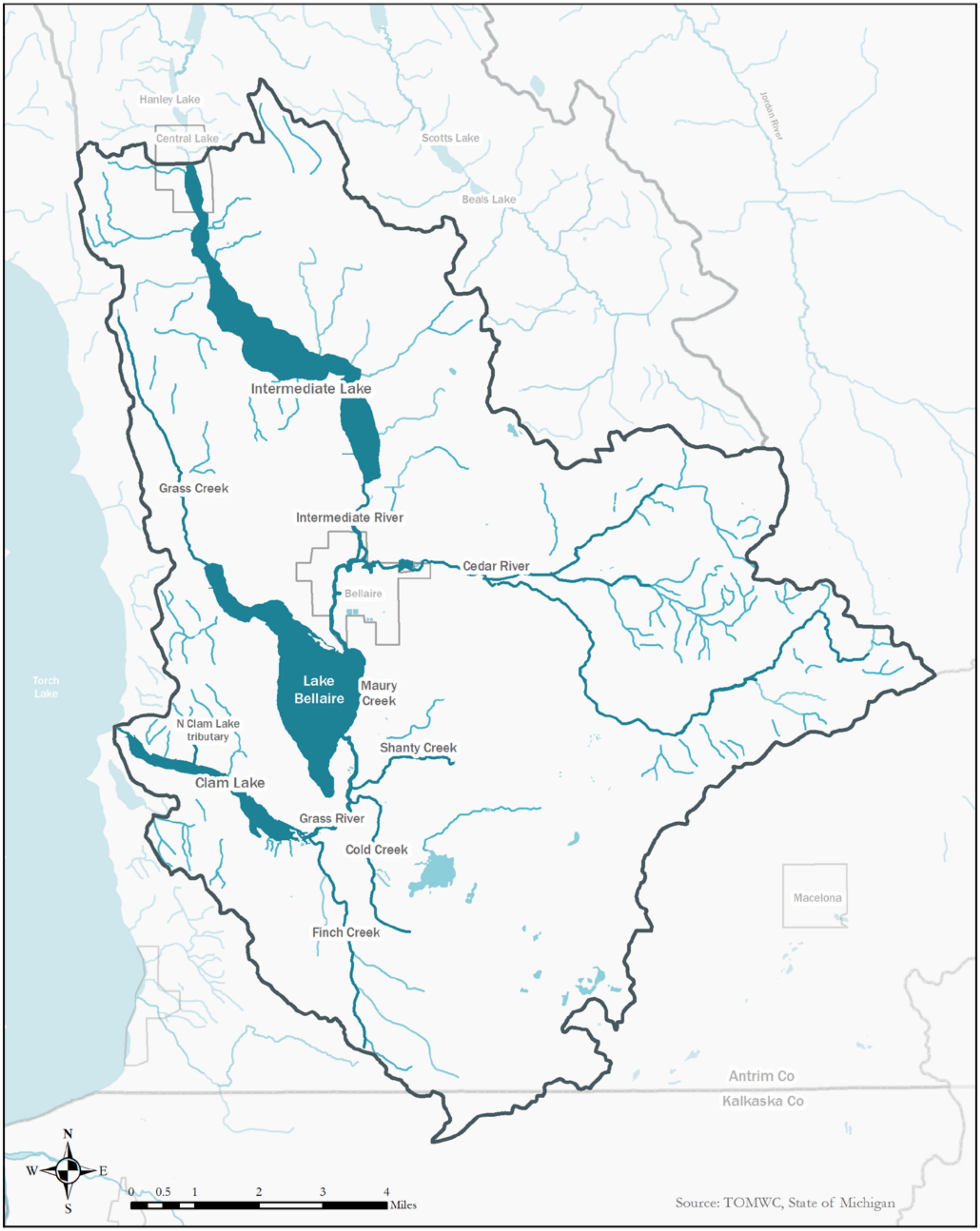


Figure 16: A map of the surface waters within the middle chain region of the ERCOL watershed.

INTERMEDIATE LAKE

TABLE 32: INTERMEDIATE LAKE DATA AVAILABILITY

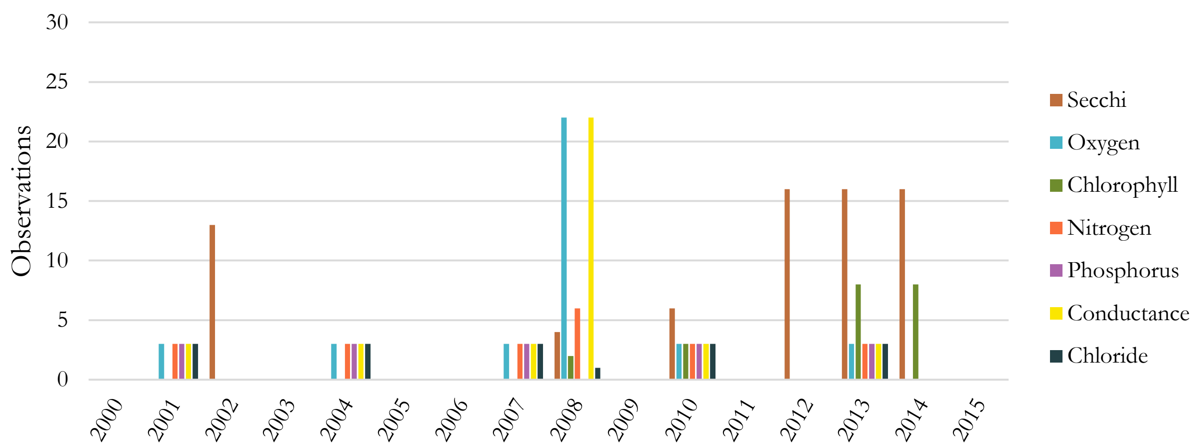


TABLE 33: INTERMEDIATE LAKE SUMMARY

Maximum depth: 70 feet

Surface area: 1,569 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	15.60	6.22	7.50	32.0	71
Dissolved Oxygen* (mg/l)	9.54 8.16 6.89	1.30 2.89 4.42	7.30 3.10 0.10	11.80 11.60 11.40	12 12 10
Chlorophyll a (µg/l)	1.30	0.89	0.10	2.90	21
Total Nitrogen (mg/l)	0.597	0.092	0.440	0.820	21
Total Phosphorus (µg/l)	5.45	2.47	2.50	10.10	15
Specific Conductance (µS/cm^2)	358	12	334	373	34
Chloride (mg/l)	10.30	1.54	8.00	12.30	16

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTEPRETATION

Intermediate Lake has a secchi depth much higher than the reference conditions for the ecoregion or statewide. Although there are some hypoxic minimum values, dissolved oxygen concentrations average higher than the MDEQ requirement of 5 mg/l at all depths. Chlorophyll a concentrations are below the reference conditions for the region. Total nitrogen is similar to reference values statewide and for the ecoregion. Average phosphorus concentrations are well below regional reference conditions. Specific conductance is higher than the statewide reference condition, but is likely not problematic. Chloride levels are slightly higher than average for the ecoregion, but well below the statewide average.

OUTLIERS

Secchi depth exhibited unusually high values in the late spring of 2012 and late spring and early summer in 2013 at approximately 30 feet of visibility below the water surface. A troubling minimum of 0.10 mg/l of dissolved oxygen was observed in the bottom of the water column in August of 2008. A significant peak value of total nitrogen was measured at 0.820 mg/l in May of 2001.

LAKE BELLAIRE

TABLE 34: LAKE BELLAIRE DATA AVAILABILITY

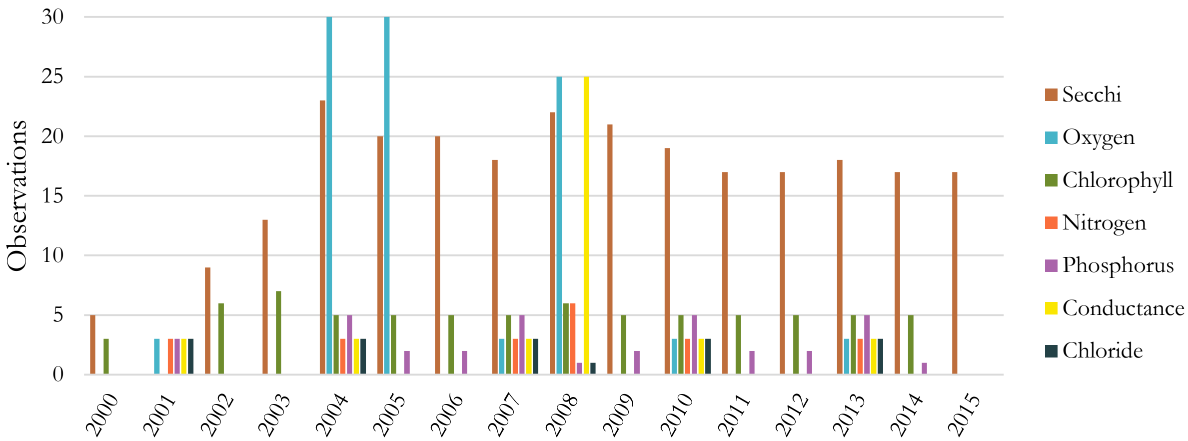


TABLE 35: LAKE BELLAIRE SUMMARY

Maximum depth: 95 feet

Surface area: 1,789 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	14.10	4.13	5.00	27.00	256
Dissolved Oxygen* (mg/l)	9.34 9.54 8.28	1.04 1.12 2.32	7.70 7.08 0.72	13.50 13.30 14.80	154 142 88
Chlorophyll a (µg/l)	1.39	0.69	0.00	3.10	72
Total Nitrogen (mg/l)	0.548	0.061	0.452	0.650	21
Total Phosphorus (µg/l)	4.02	3.27	0.00	13.00	29
Specific Conductance (µS/cm^2)	327	13	295	338	40
Chloride (mg/l)	8.93	1.13	7.20	10.70	16

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Lake Bellaire has a secchi depth that is a fair amount higher than the regional reference conditions and average dissolved oxygen values are well above the MDEQ requirement of 5 mg/l for all depths. There was a nearly anoxic minimum recorded at the bottom of the lake that merits further monitoring. Chlorophyll a levels are well below reference conditions. Total nitrogen concentrations are similar to regional reference conditions and phosphorus levels are well below regional averages and recommendations. Specific conductance is slightly higher than statewide averages, but is likely not problematic. Chloride levels are similar to ecoregion reference conditions and do not appear to be an issue.

OUTLIERS

Secchi depth levels were high during the summers of 2013 and 2012, peaking at around 27 feet of visibility and during the late summer of 2009, there was a brief period where secchi depth dropped to 5 feet. Dissolved oxygen levels were particularly high at the surface and middle of the water column during mid-late April of 2007, 2008, and 2013—residing in excess of 12.0 mg/l—and reached particularly low concentrations at the bottom of the water column in September of 2004 and 2005 with a minimum of less than 1.0 mg/l. A high concentration was a few months earlier at over 14.0 mg/l. Chlorophyll a levels were at their highest during the late summer and early fall of 2009, reaching a crest of around 3.0 μg/l. Phosphorus concentration peaked at an exceptionally high level of 13 μg/lduring the spring of 2004. Specific conductance levels were relatively low in April of 2007, with recorded values around 295 $\mu S/cm^2$.

CLAM LAKE

TABLE 36: CLAM LAKE DATA AVAILABILITY

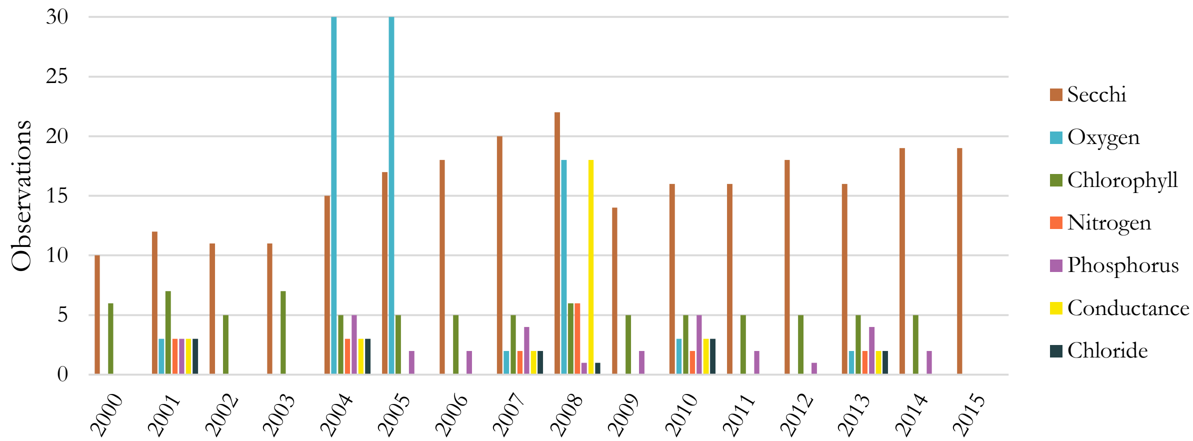


TABLE 37: CLAM LAKE SUMMARY

Maximum depth: 27 feet

Surface area: 437 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	16.40	4.00	7.50	26.00	254
Dissolved Oxygen* (mg/l)	9.41 9.07 8.82	1.03 1.01 1.86	8.00 7.20 4.40	12.10 11.50 12.20	42 56 41
Chlorophyll a (µg/l)	1.16	0.84	0.00	3.50	76
Total Nitrogen (mg/l)	0.493	0.063	0.390	0.580	18
Total Phosphorus (µg/l)	5.08	3.42	0.00	12.00	29
Specific Conductance ($\mu S/cm^2$)	332	14	301	347	31
Chloride (mg/l)	8.25	1.72	4.00	10.30	13

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Clam Lake exhibits a higher secchi depth than average conditions through the state and region. Dissolved oxygen levels are sufficiently high throughout the water column based on the MDEQ requirements. Chlrophyll a levels are well below reference conditions and nitrogen and phosphorus concentrations are lower than regional averages. Specific conductance is slightly higher than the statewide reference condition, but does not appear to be an issue. Chloride levels are similar to reference conditions for the ecoregion.

OUTLIERS

Particularly low readings were observed in June of 2000 and August of 2008 at less than 8 ft. Dissolved oxygen levels were relatively high at around 11-12 mg/l in April of 2007, 2008, 2010, and 2013 in the middle and upper portions of the water column and reached a particularly low concentration in August of 2005 of under 5.0 mg/l at the bottom of the lake. Chlorophyll a levels were slightly elevated in July of 2003 and 2006 in excess of 3.0 μg/l. Phosphorus concentrations peaked in 2005 at 12 μg/l.

RIVERS AND STREAMS

TABLE 38: MIDDLE CHAIN BENTHIC MACROINVERTEBRATE COMMUNITY

Location	Quality	Poor Observations	Fair Observations	Good Observations	Excellent Observations
Cedar River	Fair/Good	2	6	9	1
Cold Creek	Fair	3	27	1	0
Finch Creek	Fair	0	22	3	0
Grass River	Poor/Fair	2	2	0	0
Maury Creek	Fair	2	11	3	0
Shanty Creek	Fair	6	15	2	0

INTERPRETATION

All of the rivers and streams that feed into the Middle Chain appear to be of fair quality with respect to their benthic macroinvertebrate communities. There is some indication that the Cedar River has a healthier community than some of the other bodies of water in this area, but with limited observations it cannot be stated clearly. Similarly, further samples of Grass River would be needed to see if it indeed has a lower quality community than the other listed streams. There are many factors that contribute to the assessed quality of the benthic macroinvertebrate community and although there do not appear to be significant areas of poor quality in the Middle Chain, further monitoring of these sites is important to inform a quick response in the case of worsening stream quality.

Finch Creek and Shanty Creek were observed to have elevated total nitrogen levels of around 1.0 mg/l in a study put out by Grass River Natural Area in 2016, potentially contributing to reduced stream quality. However, Cold Creek appears to have a similar stream quality despite being observed at around 0.3 mg/l of total nitrogen in the same survey (Clement, 2016).

TABLE 39: MIDDLE CHAIN ENTERIC MICROORGANISMS

Location	Mean Value (cfu/100ml)	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Cedar River	26.1	36.1	7	142	13
Clam Lake outlet	48.4	111	2	345	9
Cold Creek	31.3	32.5	10	130	13
Finch Creek	11.7	8.71	2	29	13
Grass Creek	118	147	11	488	11
Grass River	58.3	68.0	6	202	12
Intermediate River near Bellaire	67.3	32.7	29	113	9
Maury Creek	146	40.5	65	172	6
N Clam Lake tributary	30.6	71.1	2	219	9
Shanty Creek	50.0	102	6	387	13

INTERPRETATION

Maury Creek is the only tributary to the Middle Chain that exhibits an average concentration in excess of the 130 cfu/100ml limit for *E. coli* set by the MDEQ for total body contact recreation, although Grass Creek also appears to have elevated concentrations. Due to the limited observations for all of these streams, more comprehensive monitoring efforts are required to verify these suggested levels. While there are several observations in excess of the 300 cfu/100ml limit set by the State of Michigan, none of the streams were recorded above 500 cfu/100ml at any time and do not appear to be characterized by problematic concentrations of *E. coli*.

LOWER CHAIN: WATER QUALITY SUMMARY (2000 - 2015)

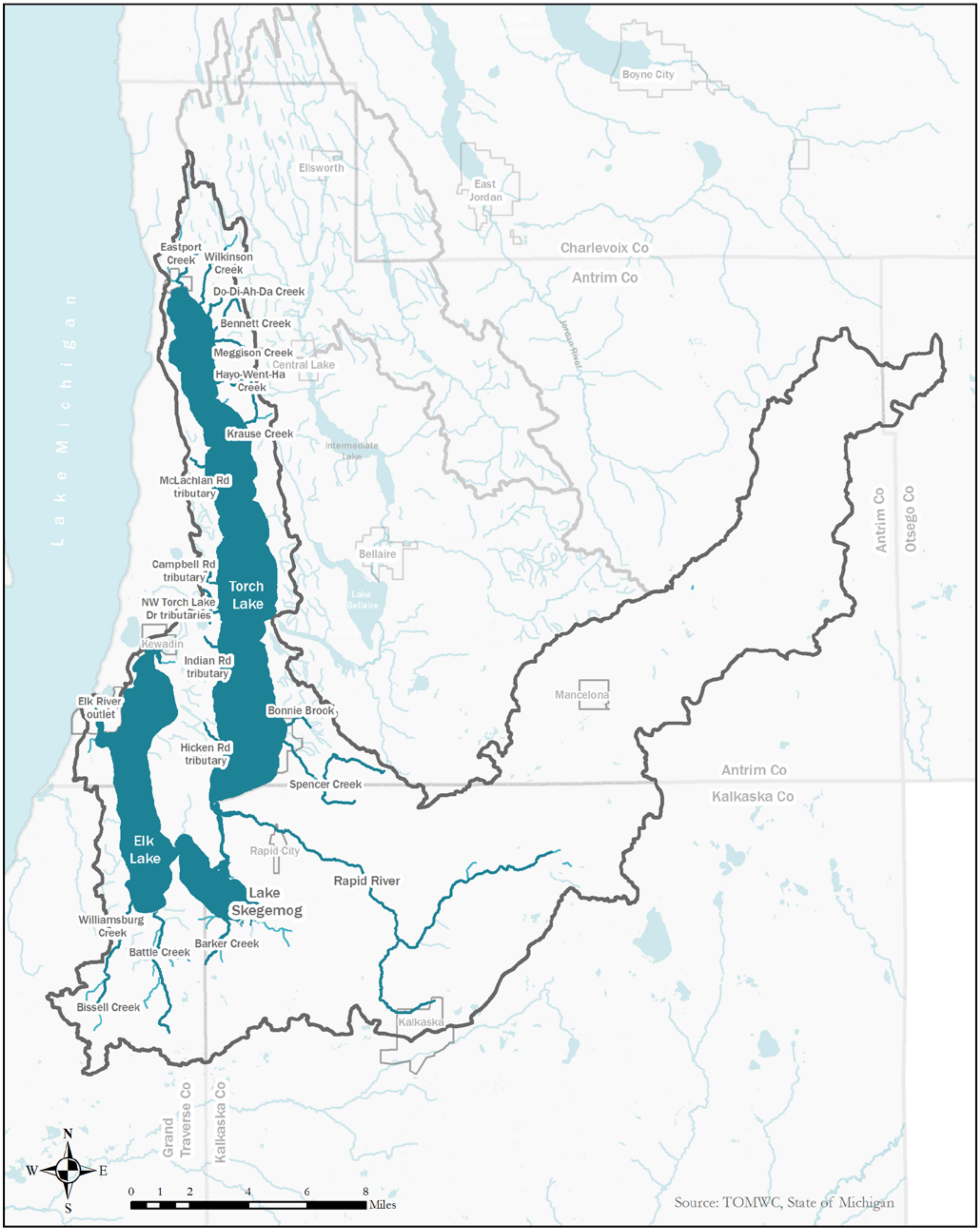


Figure 17: A map of the surface waters within the lower chain region of the ERCOL watershed.

TORCH LAKE

TABLE 40: TORCH LAKE DATA AVAILABILITY

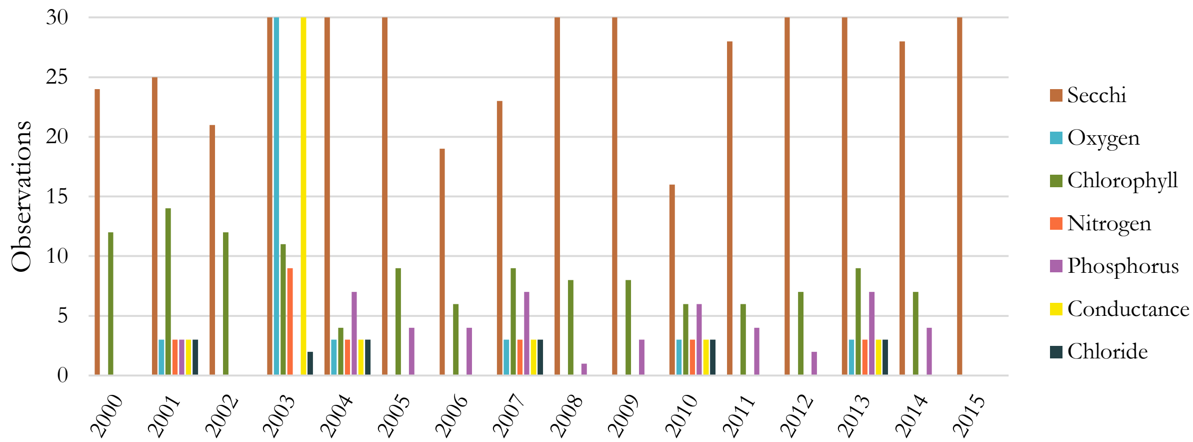


TABLE 41: TORCH LAKE SUMMARY

Maximum depth: 302 feet

Surface area: 18,473 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	26.00	7.59	12.00	46.00	444
Dissolved Oxygen* (mg/l)	11.60 12.50 11.90	1.83 0.86 1.11	7.90 9.30 8.30	14.80 14.40 13.50	49 34 24
Chlorophyll a (µg/l)	0.15	0.21	0.00	0.70	128
Total Nitrogen (mg/l)	0.458	0.094	0.369	0.740	24
Total Phosphorus (µg/l)	2.95	3.86	0.00	14.00	47
Specific Conductance (µS/cm^2)	288	13	246	302	107
Chloride (mg/l)	7.02	1.45	5.10	9.40	17

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Torch Lake has a significantly higher secchi depth than reference conditions or lakes further up the chain. Dissolved oxygen levels in this lake are very high and appear to exceed the 7 mg/l requirement set by the MDEQ for coldwater lakes throughout the water column. Chlorophyll a levels are very low, far below established reference conditions. Total nitrogen is slightly lower than the reference for the ecoregion in 2001-2005 and phosphorus is well below all given reference conditions. Specific conductance is very similar to the statewide average. Chloride levels are slightly below the reference condition for the ecoregion.

OUTLIERS

Secchi depth was observed at particularly high levels—exceeding 40 feet of visibility—in the late spring or early summer of 2007, 2008, 2009, 2010, 2011, and 2014. Dissolved oxygen concentrations throughout the water column were slightly lower than expected in August of 2003 with values of less than 10 mg/l, but observed levels were higher than anticipated in the middle of the water column at above 14 mg/l just a few months prior. Total nitrogen reached a peak value of over 0.700 mg/l in April of 2003 and total phosphorus was observed at unusually high concentrations of almost 15 μg/lfor a sample in the spring and fall of 2004.

LAKE SKEGEMOG

TABLE 42: LAKE SKEGEMOG DATA AVAILABILITY

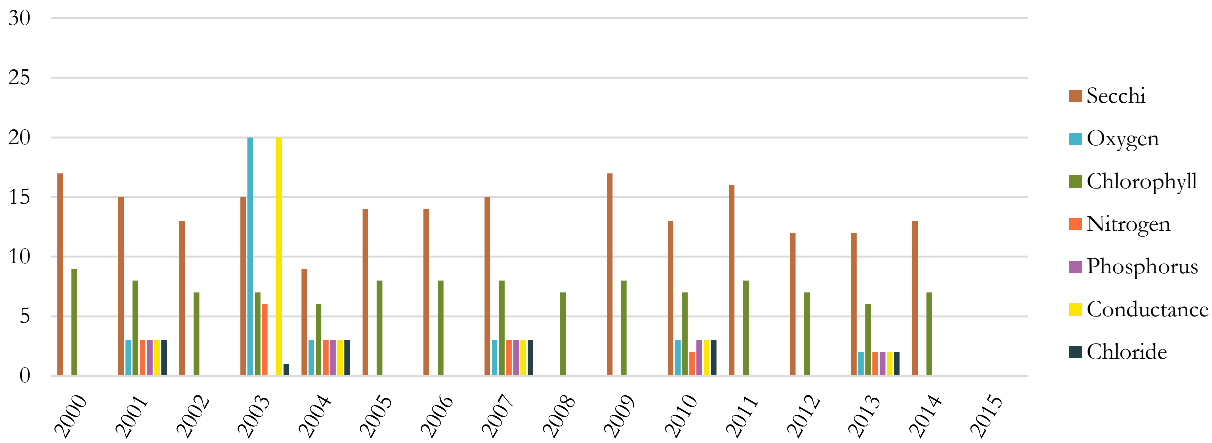


TABLE 43: LAKE SKEGEMOG SUMMARY

Maximum depth: 29 feet

Surface area: 2,766 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	12.60	3.84	6.50	22.00	195
Dissolved Oxygen* (mg/l)	9.95 9.42 9.67	2.08 1.98 2.97	7.60 7.30 4.80	12.80 11.40 12.90	13 10 9
Chlorophyll a (µg/l)	1.47	0.89	0.00	4.20	111
Total Nitrogen (mg/l)	0.534	0.341	0.292	1.400	18
Total Phosphorus (µg/l)	2.63	1.13	1.00	4.10	11
Specific Conductance (µS/cm^2)	284	26	255	313	32
Chloride (mg/l)	7.58	1.38	5.80	9.60	13

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Secchi depth is lower in Lake Skegemog than some of the surrounding lakes, but remains above reference values. Average dissolved oxygen values are well above the 5 mg/l requirement given by the MDEQ for this warmwater lake, although there is a minimum near this value at the bottom of the lake. Chlorophyll a levels are below reference conditions for the ecoregion. Total nitrogen is very similar to the reference condition for the ecoregion for 2001-2005 and total phosphorus is well below reference values. Specific conductance is very similar to the statewide average and chloride concentrations are similar to the ecoregion reference level.

OUTLIERS

Secchi depth was recorded at particularly high values in excess of 20 feet during the summer of 2003, 2013, and 2014. Chlorophyll a was above typical levels, approaching 4.0 µg/l, during the summers of 2007, 2010, and 2011. Total nitrogen concentration was observed above 1.20 mg/l in the summer of 2003. Total phosphorus reached a peak of just over 5.0 µg/lin May of 2001.

ELK LAKE

TABLE 44: ELK LAKE DATA AVAILABILITY

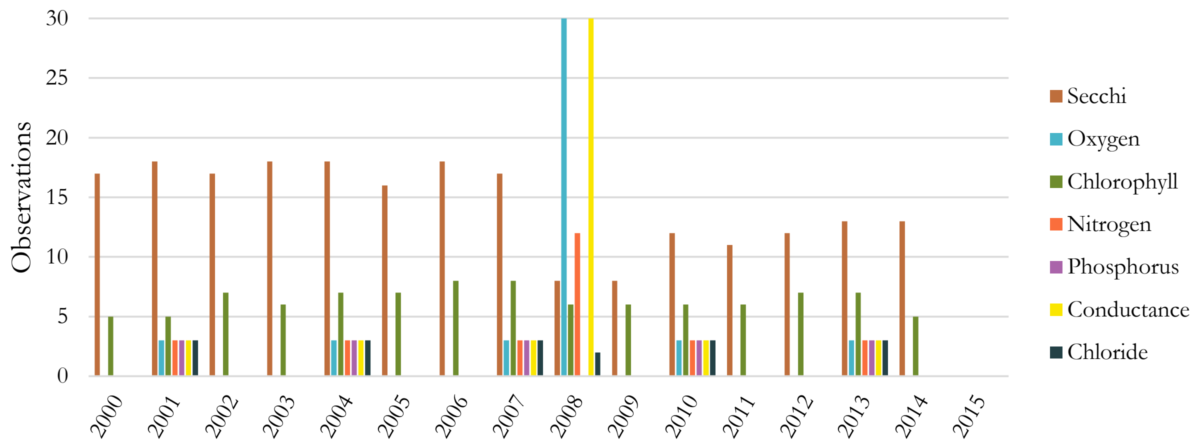


TABLE 45: ELK LAKE SUMMARY

Maximum depth: 195 feet

Surface area: 8,194 acres

Parameter	Mean Value	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Secchi Depth (ft)	16.60	4.47	9.80	32.00	217
Dissolved Oxygen* (mg/l)	10.40 11.20 12.00	1.72 1.32 0.96	8.10 9.80 10.30	13.20 13.60 13.10	33 21 10
Chlorophyll a (µg/l)	0.44	0.42	0.00	3.10	96
Total Nitrogen (mg/l)	0.351	0.039	0.300	0.458	27
Total Phosphorus (µg/l)	2.42	2.40	0.00	9.60	14
Specific Conductance (µS/cm^2)	279	11	247	293	65
Chloride (mg/l)	8.66	1.64	5.90	10.60	17

*Dissolved oxygen values are stratified into thirds of the water column. The first values listed are for measurements within the top third, the next values for the middle third, and the final values for the bottom third of lake depth.

INTERPRETATION

Elk Lake has an average secchi depth well above statewide and regional references and dissolved oxygen levels are very high throughout the water column. All of these are in exceedance of the 7 mg/l requirement for coldwater lakes set by the MDEQ. Chlorophyll a concentrations are very low and remain well below reference conditions. Total nitrogen and phosphorus are well below the reference conditions for the ecoregion or statewide averages. Specific conductance is slightly below statewide averages and chloride levels are slightly above the ecoregion reference, but lower than statewide averages.

OUTLIERS

Secchi depth exhibited some particularly high values in excess of 25 feet during the spring and early summer of 2003-2007. Chlorophyll concentrations peaked in August of 2011 at just over 3.0 µg/l. Total nitrogen and phosphorus concentrations were observed on the same day in April of 2010 at about 0.450 mg/l and 10 µg/l respectively.

RIVERS AND STREAMS

TABLE 46: LOWER CHAIN BENTHIC MACROINVERTEBRATE COMMUNITY

Location	Quality	Poor Observations	Fair Observations	Good Observations	Excellent Observations
Barker Creek	Fair	0	4	0	0
Battle Creek	Fair	0	8	0	0
Bissell Creek	Fair/Good	0	14	5	0
Bonnie Brook	Poor	8	0	0	0
Eastport Creek	Good	0	0	4	0
Rapid River	Fair	20	62	12	3
Spencer Creek	Poor/Fair	4	4	0	0
Wilkinson Creek	Fair	4	12	0	0
Williamsburg Creek	Good	0	1	17	0

INTERPRETATION

There is some variation of the quality of the benthic macroinvertebrate communities within the rivers and streams of the Lower Chain. While the average condition appears to be of fair quality, Bonnie Brook and Spencer Creek both exhibit benthic macroinvertebrate communities poorer than this benchmark. Bissell Creek and Williamsburg Creek (Bissell Creek feeds directly into Williamsburg Creek) at the South end of Elk Lake are of higher quality than the other listed bodies of water other than Eastport Creek at the North end of Torch Lake. There appears to be a faint pattern wherein the streams along the East side of Torch Lake have poorer benthic macroinvertebrate communities, but further samples are needed.

TABLE 47: LOWER CHAIN ENTERIC MICROORGANISMS

Location	Mean Value (cfu/100ml)	Standard Deviation	Minimum Value	Maximum Value	Number of Observations
Bennett Creek	190	199	13.0	687	15
Do-Di-Ah-Da Creek	372	638	0.00	2419	13
Eastport Creek	305	374	0.00	1414	20
Elk River outlet	37.3	85.6	0.00	440	49
Hayo-Went-Ha Creek	64.3	71.9	16.0	147	3
Krause Creek	119	128	9	411	13
Meggison Creek	183	195	19	727	14
Indian Rd tributary	550	506	30.0	1414	9
Rapid River	65.7	175	1	1120	41
Spencer Creek	131	123	3	483	14
Torch River	7.5	18.6	0	81	52
Campbell Rd tributary	101	85.9	11.0	285	13
Hicken Rd tributary	225	234	23.0	548	6
McLachlan Rd tributary	153	219	29	788	13
NW Torch Lake Dr tributary 1	306	382	35	1300	10
NW Torch Lake Dr tributary 2	325	297	88	958	10
Wilkinson Creek	405	446	64	1553	15

INTERPRETATION

Bennett Creek, Do-Di-Ah-Da Creek, Eastport Creek, Meggison Creek, Spencer Creek, Wilkinson Creek and an unnamed tributary near Indian Rd along the Northeast shoreline of Torch Lake and other Torch Lake tributaries near Hicken Rd, McLachlan Rd, and NW Torch Lake Dr along the Western side of the lake all exhibited average *E. coli* concentrations in excess of the 130 cfu/100ml 30-day mean concentration set by the MDEQ for waters used for total body contact recreation. In addition, Do-Di-Ah-Da Creek, Eastport Creek, the Indian Rd tributary, the NW Torch Lake Dr tributaries, and Wilkinson Creek have each showed at least one observed concentration above the 1,000 cfu/100ml limit for partial body contact since 2009. All streams except for Hayo-Went-Ha Creek, Torch River, and the W Torch Lake tributary near Campbell Road have exceeded the 300 cfu/100ml limit for full body contact use at some point from 2009-2015.

Waters in the main chain of lakes do not appear to be experiencing elevated levels of *E. coli*, with average concentrations well below 130 cfu/100ml in Elk River and Torch River. In 2003, a portion of the Elk River outlet into Lake Michigan was measured in excess of 300 cfu/100ml and further monitoring in this area is recommended. From these results it appears that there are problematic *E. coli* levels along the Western and Northern ends of Torch Lake, potentially due to increased agricultural activity or failing sceptic systems. More comprehensive monitoring efforts and regulatory measures are needed to better explain these trends.

2.6 SUMMARY

Overall the current state of surface water quality within the ERCOL watershed appears to be quite healthy, but there are several apparent issues that call for improvements in water quality monitoring and watershed protection efforts. It is important to note that the available set of data is rather limited for many of these observations and that further study is recommended to verify these conditions. Water clarity, chlorophyll a, and nutrient concentrations do not appear to problematic within the main channel of the ERCOL with few exceptions. There are generally slightly elevated specific conductivity and chloride readings relative to the chosen reference conditions, but likely not at problematic levels.

When examining lakes on an individual basis we can see some more significant localized issues within the watershed. The summarized data indicates a potential hypoxic zone at the bottom of Lake Saint Claire and a likely hypoxic zone at the bottom of Wilson Lake, with significant implications for the health of these aquatic ecosystems. Ellsworth Lake and Ben-way Lake also show reduced dissolved oxygen in the lower third of the water column and may experience similar issues. The following table describes lake water quality conditions that were deemed significant in relation to the reference conditions and MDEQ requirements laid out in this chapter.

TABLE 48: WATER QUALITY OF MAJOR LAKES

Lake	Condition of Target Parameters
Beals/Scotts	Unknown; insufficient data
Six Mile	Slightly elevated chlorophyll a levels
Saint Claire	Potential hypoxia; elevated specific conductivity and chloride levels
Ellsworth	Slightly reduced oxygen at bottom; slightly elevated specific conductivity and chloride levels
Wilson	Likely hypoxia; slightly elevated specific conductivity and chloride levels
Ben-way	Reduced oxygen at bottom; slightly elevated nitrogen, specific conductivity, and chloride levels
Hanley	Slightly elevated chloride levels
Intermediate	Slightly elevated specific conductivity and chloride levels
Bellaire	Slightly elevated chloride levels
Clam	Slightly elevated chloride levels
Torch	No known issues
Skegemog	No known issues
Elk	Slightly elevated chloride levels

A summary table of benthic macroinvertebrate community health is provided below, combining results from the Middle Chain and Lower Chain. It can be seen that stream community health is generally fair throughout the surveyed streams with a few examples of streams of both higher and lower quality. Bissell Creek, Eastport Creek, Williamsburg Creek, and the Cedar River appear to be healthier than the majority of streams within the watershed and may be less urgently considered for ecological restoration efforts. Bonnie Brook, Grass River, and Spencer Creek seem to be of generally poorer quality than the surrounding streams and may require more immediate remediation efforts.

There is no recorded stream monitoring within the Upper Chain and it is recommended that these efforts are expanded to include these streams within the picture of stream community health throughout the ERCOL watershed. Benthic macroinvertebrate community is only one measure of stream health and further monitoring efforts are suggested, particularly for streams that are observed to be of poorer quality. More diverse community metrics that account for both aquatic insect and fish community composition and targeted flow and chemical monitoring could further elucidate the effects and causes of reduced water quality in these stream regions. Finer spatial detail can be seen within databases managed by MiCorps and the Watershed Center from which this data was summarized.

TABLE 49: BENTHIC MACROINVERTEBRATE COMMUNITY HEALTH

Stream	Benthic Macroinvertebrate Community
Barker Creek	Fair
Battle Creek	Fair
Bissell Creek	Fair/Good
Bonnie Brook	Poor
Cedar River	Fair/Good
Cold Creek	Fair
Eastport Creek	Good
Finch Creek	Fair
Grass River	Poor/Fair
Maury Creek	Fair
Rapid River	Fair
Shanty Creek	Fair
Spencer Creek	Poor/Fair
Wilkinson Creek	Fair
Williamsburg Creek	Good

Assessments of enteric microorganisms throughout the watershed revealed a significant number of streams in violation of levels recommended for safe recreational use by the MDEQ. In all, 12 different streams were observed to have mean concentrations above the 130 cfu/100ml requirement for total body recreation and 17 streams exhibited maximum concentrations above the 300 cfu/100ml requirement, 6 of which were also in exceedance of the maximum concentration of 1,000 cfu/100ml allowed for partial body recreation (MDEQ, 2006). These streams are listed below according to the criteria in which they are of violation.

There may be additional sites with problematic concentrations of harmful bacteria and future monitoring is recommended in streams near those already observed with high concentrations to elucidate some of the regional trends that are suggested by this data. Although the Upper Chain is less developed and potentially less prone to elevated concentrations of *E. coli* that lower portions of the ERCOL, it is recommended that some stream monitoring be expanded to this region to assess current conditions.

TABLE 50: ENTERIC MICROORGANISM CONDITIONS

Streams with mean concentration above requirement for total body recreation	Streams with maximum concentration above requirement for total body recreation*	Streams with maximum concentration above requirement for partial body recreation
Bennett Creek	Bennett Creek	Do-Di-Ah-Da Creek
Do-Di-Ah-Da Creek	Clam Lake outlet	Eastport Creek
Eastport Creek	Elk River outlet	Indian Rd tributary
Hicken Rd tributary	Grass Creek	NW Torch Lake Dr tributary 1
Indian Rd tributary	Hicken Rd tributary	Rapid River
Maury Creek	Krause Creek	Wilkinson Creek
McLachlan Rd tributary	McLachlan Rd tributary	
Meggison Creek	Meggison Creek	
NW Torch Lake Dr tributary 1	NW Torch Lake Dr tributary 2	
NW Torch Lake Dr tributary 2	Shanty Creek	
Spencer Creek	Spencer Creek	
Wilkinson Creek		

*Streams that are listed with maximum concentrations above the requirement for partial body contact are necessarily included within this column because of the lower threshold but are not listed here

CHAPTER 3
NONPOINT SOURCE POLLUTION AND OTHER ECOLOGICAL STRESSORS

CHAPTER 3: NONPOINT SOURCE POLLUTION AND OTHER ECOLOGICAL STRESSORS

3.1 INTRODUCTION

The Elk River Chain of Lakes (ERCOL) is a highly important natural resource in northern Michigan with great recreational and economic value for local communities, including full-time residents, vacationers, and tourists. The value this region provides to a wide variety of stakeholders warrants strong protection efforts, particularly in the context of current and emerging issues that threaten to impair ERCOL waters through the release of nonpoint source pollutants and ecosystem degradations. A number of these threats to the lakes have been analyzed over the last ten years and this chapter summarizes the inventories, surveys, and analyses conducted to quantify these threats.

3.2 STORMWATER SURVEY

Stormwater runoff is generated when precipitation (rain or snowmelt) flows over land or impervious surfaces and does not infiltrate into the ground. As runoff moves over paved streets, parking lots, and building rooftops, it accumulates debris, chemicals, sediment or other pollutants that can adversely affect water quality when discharged through stormwater outfalls into local waterbodies. The amount of runoff that occurs is dependent upon a variety of conditions including: storm intensity and duration, topography, time of year, soil moisture and permeability, extent and type of vegetative cover, and amount of impervious surfaces. In most urbanized areas, stormwater is the primary source of nonpoint source pollution.

In the ERCOL, towns and villages are impacted by concentrated development and typically produce greater runoff relative to more naturalized areas due to increased impervious surface area. In 2013 and 2014, staff from The Watershed Center and the Antrim Conservation District conducted initial stormwater runoff assessments for six communities in the watershed - Alden, Bellaire, Central Lake, Elk Rapids, Ellsworth, and Shanty Creek Resort. The purpose was to help local governments begin to address pollution from stormwater runoff in their communities in order to protect water quality. The assessment was twofold: 1) an impervious surface assessment was conducted using remote sensing imagery to determine the percent impervious cover within each village boundary and 2) suggested best management practices were identified that could be implemented to strategically manage stormwater runoff.

In addition to this assessment, land use (e.g. commercial) within city boundaries, storm sewer maps provided by each city, drainage areas, stormwater outlet locations, and modeled pollutant loads were compiled for each village or community. The following table and maps highlight these key components.

TABLE 51: ESTIMATED STORMWATER IMPACTS

	Alden	Bellaire	Central Lake	Elk Rapids	Ellsworth
Total land area (acres)	135.50	1,407.80	755.40	1,273.20	781.00
Total area draining into (acres)	TBD	TBD	TBD	TBD	TBD
Land uses (% of total)					
Natural / open space	29.59 %	54.94 %	16.59 %	6.72 %	33.87 %
Commercial	15.30 %	5.48 %	2.61 %	9.83 %	3.90 %
Industrial	0.00 %	1.54 %	0.00 %	7.88 %	1.11 %
Institutional	0.00 %	3.28 %	7.72 %	2.40 %	2.43 %
Residential	55.11 %	26.00 %	56.94 %	54.90 %	48.98 %
Water	0.00 %	8.76 %	16.14 %	18.27 %	9.71 %
Impervious cover (% of total)	18.75 %	11.05 %	14.75 %	19.87 %	8.58 %
Area draining to lake or river via storm sewers (acres)	TBD	TBD	TBD	TBD	TBD
Estimated pollution contributions from storm sewers					
Phosphorus	TBD	TBD	TBD	TBD	TBD
Sediment	TBD	TBD	TBD	TBD	TBD
Comparative pollutant export annually					
Aquatic plant growth (lbs.)	TBD	TBD	TBD	TBD	TBD
Dump truck loads of soil	TBD	TBD	TBD	TBD	TBD

Stormwater impacts estimated from urban land use figures.

ALDEN STORM SYSTEM AND LAND USE

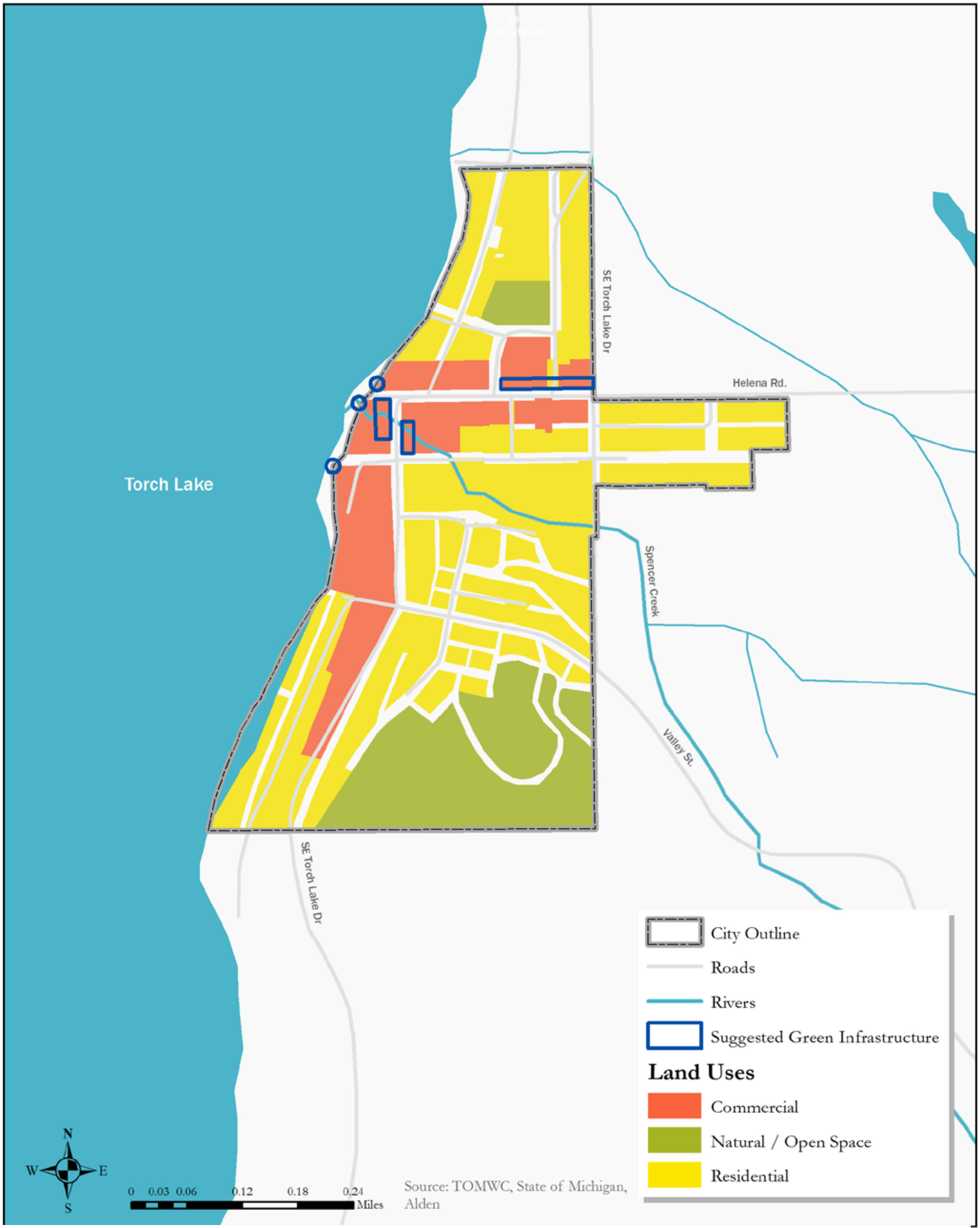


Figure 18: Urban land use types within Alden and suggested green infrastructure sites.

BELLAIRE STORM SYSTEM AND LAND USE

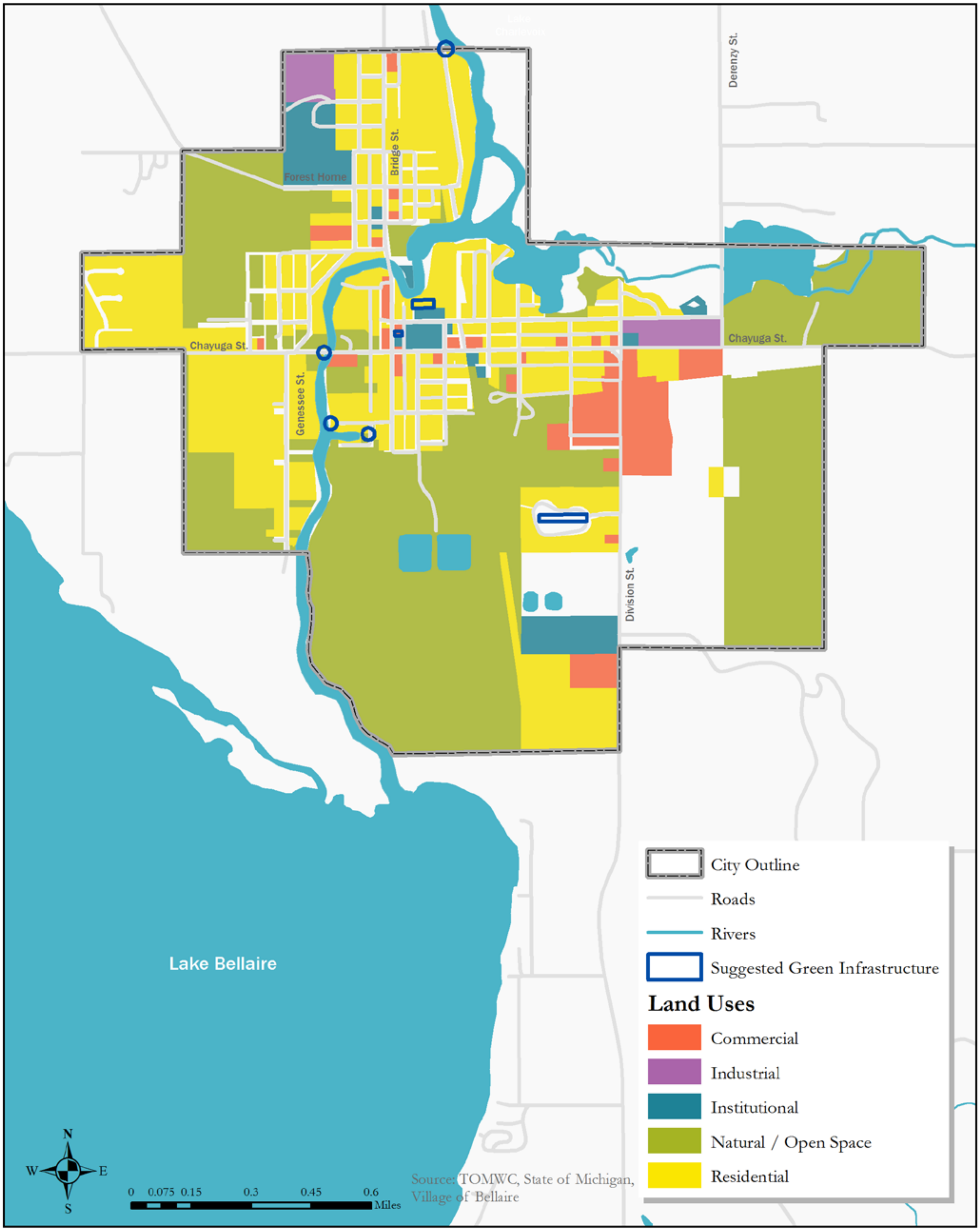


Figure 19: Urban land use types within Bellaire and suggested green infrastructure sites.

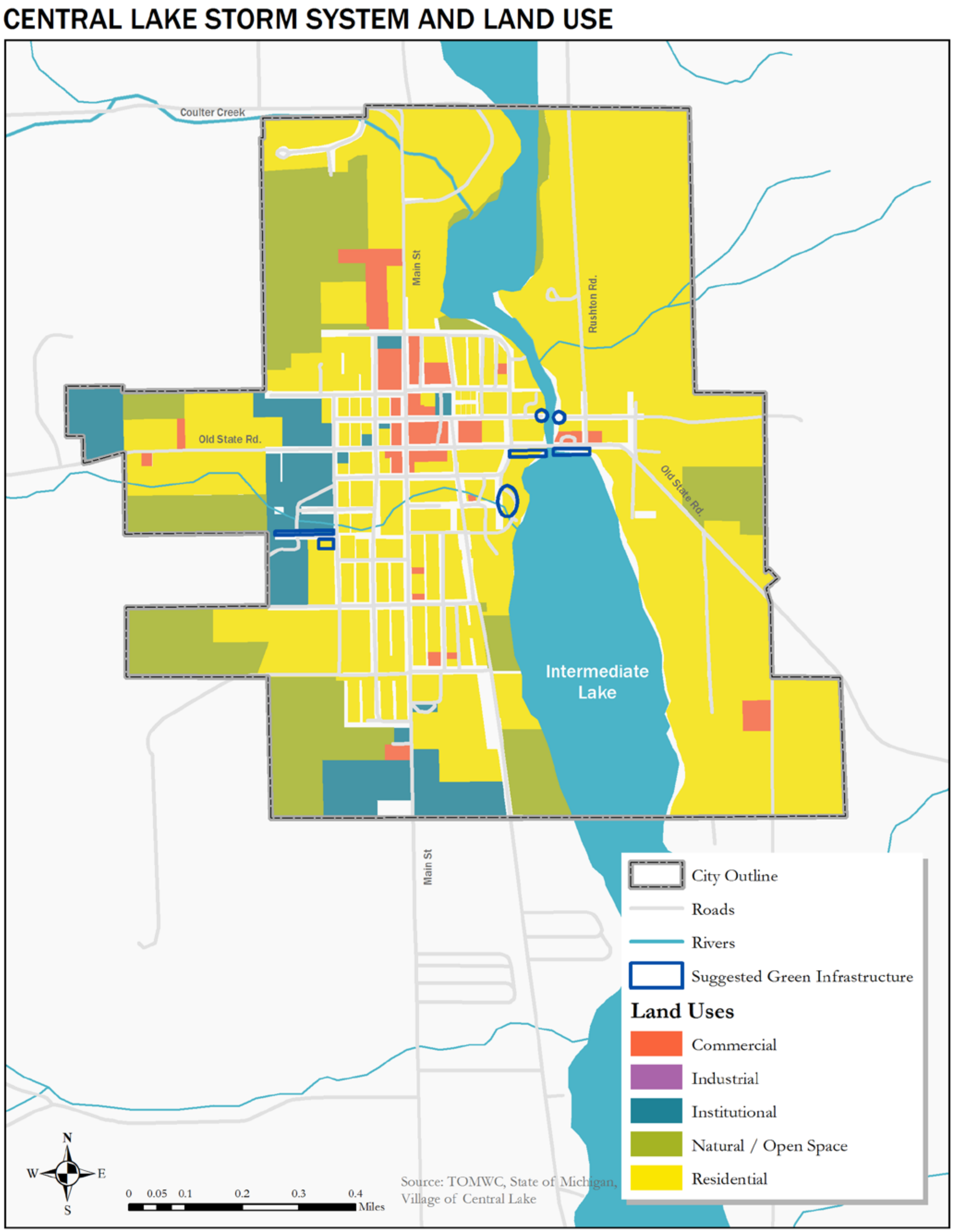


Figure 20: Urban land use types within Central Lake and suggested green infrastructure sites.

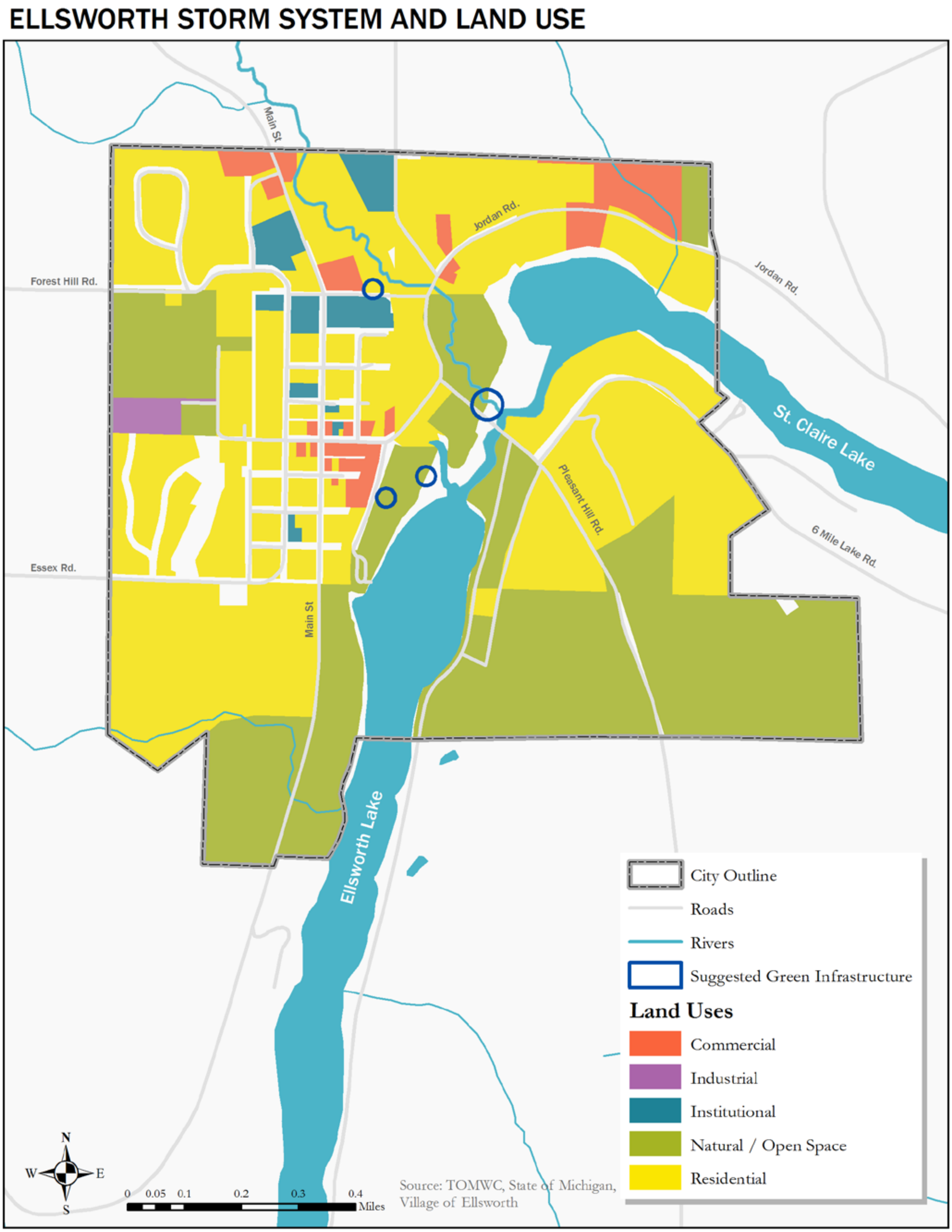


Figure 21: Urban land use types within Ellsworth and suggested green infrastructure sites.

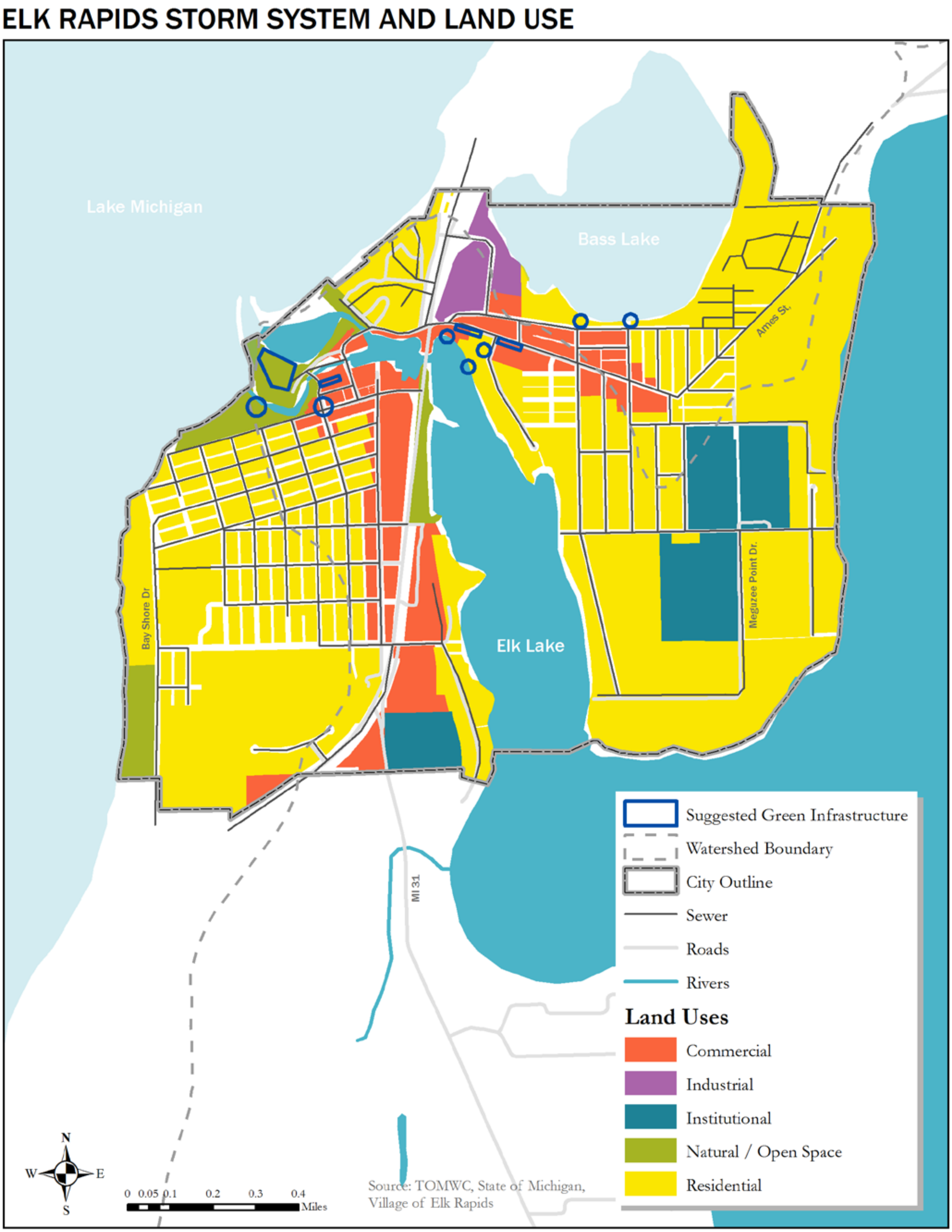


Figure 22: Urban land use types within Elk Rapids and suggested green infrastructure sites.

3.3 LAKE AND CONNECTING CHANNEL SHORELINE DEVELOPEMENT AND EROSION INVENTORY

A set of connecting channel and lake shoreline surveys will be completed between 2016 and 2018 by TOMWC. These surveys will assess development and erosion along the shorelines. Results will be added to this section as they are made available.

3.4 STREAMBANK DEVELOPMENT AND EROSION INVENTORY

The rivers and streams in the ERCOL are of generally high water quality with diverse biological communities, but development pressures and alterations to flow regimes threaten the bank integrity of a number of these water bodies. Unfortunately very few have been comprehensively surveyed for human alterations and erosion issues. This is partially due to the fact that only the lower portions of the Rapid River are navigable by small watercraft during high flows, out of over 100 rivers and streams within the watershed. Many of the streams are covered by such thick terrestrial vegetation that they cannot even be traversed by foot. The only river areas that are navigable by larger motorized watercraft are actually relatively short stretches of connecting channels between the various lakes. Section 3.3 discusses the status of these channels in greater detail.

Despite the challenges of surveying these areas and the lack of comprehensive data, some studies have been undertaken to assess erosion and development along ERCOL rivers and streams. A comprehensive sedimentation analysis of the Rapid, Grass, and Torch river systems was performed in 2012 by the Three Lakes Association to analyze the transport and deposition of sediments along those rivers. These reports indicated that severe erosion, channel widening and sedimentation loading has occurred along these river systems when compared to historical records.

Over the course of May to October 2015 an additional set of stream bank erosion surveys was carried out to document sediment erosion features in the ERCOL streams and rivers. These surveys were performed by a team of graduate students from the University of Michigan trained and guided by the ERCOL-WPIT. Erosion features were measured for length, width, depth, and degree of erosion. Most surveys consisted of looking for erosion sites within the line of sight from a road stream crossing. Typically these surveys only evaluated 10-100 feet of stream bank down and upstream of a road stream crossing. Eleven more extensive surveys were performed by walking the riverbed 500 feet upstream and downstream of a road stream crossing. These surveys included the use of a GPS to track distance walked along the riverbed as well as to geotag any erosion features found. One small watercraft navigation survey took place on the lower portion of Rapid River between Kellogg Road and Aarwood Road NW and covered 4.5 miles of the river. . This set of streambank surveys is summarized in Table 51 below.

TABLE 52: STREAMBANK SURVEYS COMPLETED IN 2015

Number of Surveys Completed	**Survey Type**
138	Sediment erosion features noted within line of sight while standing at road stream crossing
11	Walking river bed 500ft upstream and 500ft downstream of a road stream crossing noting sediment erosion features
1	Small watercraft (kayak) survey. Paddling along river and noting sediment erosion features.

Summary of streambank erosion surveys conducted.

From the measurements taken at each of these surveys, sediment erosion loads were calculated. Sediment erosion loads are visualized in Figure 23. In addition Appendix A has a table with erosion loads, causes and locations. It should be noted that Figure 23 gives only a partial view of the problem of erosion in the rivers and streams of the ERCOL. It does not indicate possible sediment erosion features between survey locations (which were primarily road stream crossings), and does not indicate problems with sediment deposition and channel alterations.

The majority of the rivers and streams in the ERCOL watershed are composed primarily of natural habitat within their riparian buffer zones. However, development pressures have been increasing and vegetation structures have been altered in some of these riparian zones. In addition, streambank alterations such as armoring and sea walls have occurred at a number of sites. Unfortunately there has been no formal survey of river and streambank alterations, although development pressures along the many river systems can be indicated through the development analysis in Chapter 3.9.

STREAMBANK EROSION SITES

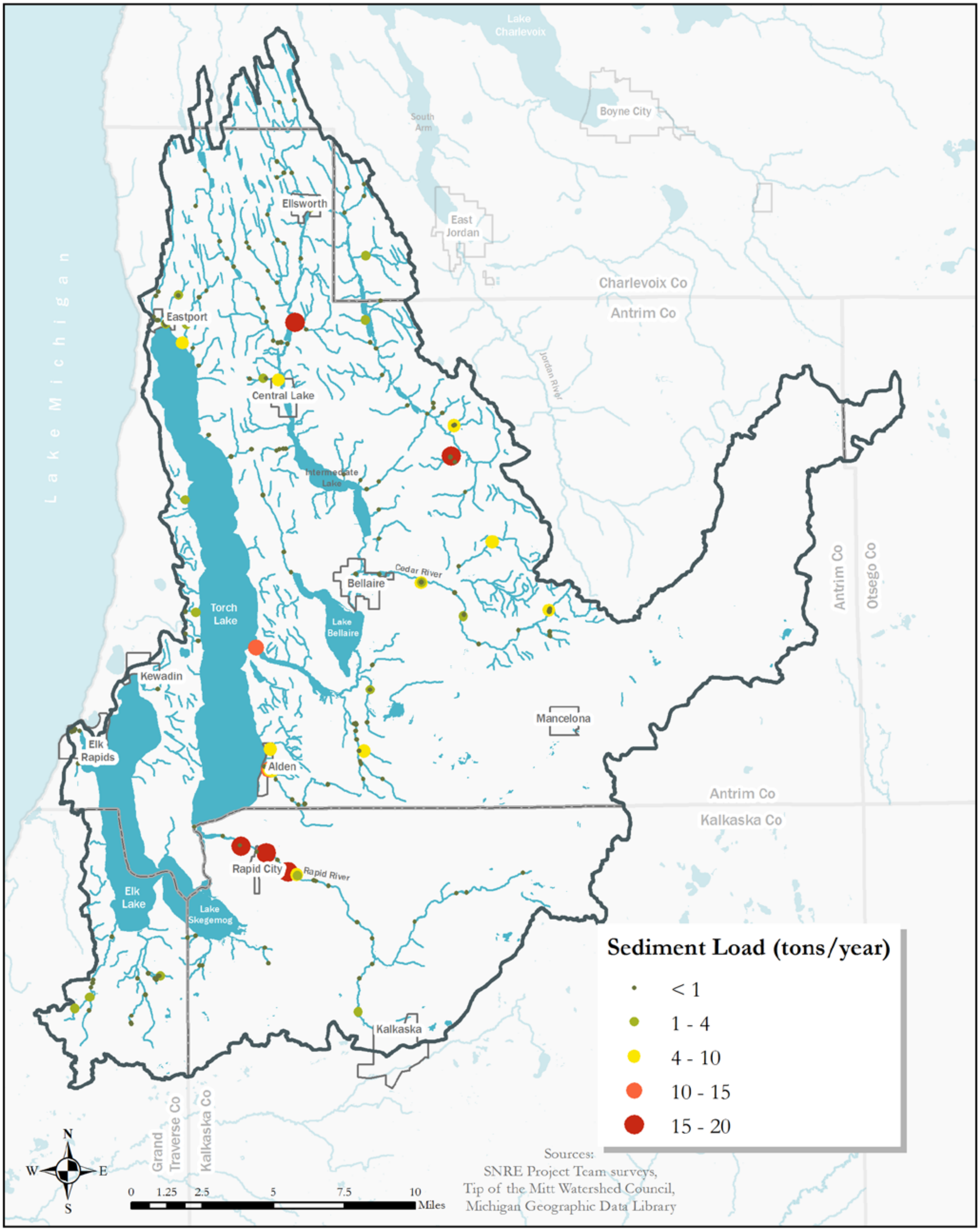


Figure 23: Estimated sediment loads of streambank erosion sites surveyed during 2015.

3.5 ROAD STREAM CROSSING INVENTORY

Road stream crossings are numerous within the ERCOL watershed and improperly sized culverts and bridges can lead to a number of problems including increasing sediment erosion and habitat fragmentation. Undersized culverts can increase water velocities within the structure beyond the feasible swimming speed of juvenile and adult fish, effectively blocking their passage through portions of the stream. The increase in flow velocity can also cause scouring and other erosion issues downstream of the culvert and impoundments as well as flooding upstream. Finally the road itself can be considered an erosion feature. Gravel and dirt roads are open sediments that can be directly transported into a water channel, while paved roads act as above ground transport channels. If the stream crossing is at the low point of the road, which most are, all sediment movement along the road eventually ends up in the river or stream channel.

A number of previous efforts have taken place to assess the large number of road stream crossings within the ERCOL watershed. The Conservation Resource Alliance surveyed a number of crossings in the Six Mile Lake area while the Three Lakes Association evaluated crossings along Finch, Shanty and Cold Creek in 2011. These organizations used different methods to evaluate the streams with a primary focus on qualitatively assessing erosion features and structural damages. Both organizations found a number of severely impacted sites with significant erosion features.

In an attempt to perform a more comprehensive quantitative analysis of road stream crossings in the ERCOL watershed, a team of graduate students under the guidance and training of TOMWC surveyed 149 crossings between the months of May to October in 2015. This team used a standardized procedure known as the Great Lakes Road Stream Crossing Inventory developed by the Great Lakes Connectivity Workgroup. This methodology has been adopted across the great lakes basin by groups such as Michigan Association of County Road Commissions, Michigan Department of Environmental Quality, Michigan Department of Natural Resources, U.S. Forest Service, U.S. Fish and Wildlife Service, Wisconsin Department of Natural Resources, Huron Pines, Conservation Resource Alliance, Superior Watershed Partnership, Michigan Trout Unlimited, and others. This standardized procedure analyzes road conditions, crossing structure conditions, erosion features, and flows within the structure and at a nearby reference site. In addition, pictures and a sketch are taken for each site. A sample data sheet for the analysis can be found in Appendix B.

From the survey, an analysis is performed to estimate sediment erosion totals resulting from the road and nearby streambank erosion features. An additional analysis compares the discharge at a nearby reference riffle to discharge within the culvert or bridge at the crossing to calculate fish passability.

This 2015 survey selected a set of crossings from the estimated 250 road stream crossings within the ERCOL to allow for a look across the entire watershed. Sites were selected with visible crossing features (viewed from Google Earth) that occurred in streams with running water year round. 116 full surveys were conducted as well as an additional 33 spot checks. Spot checks did not include flow or erosion measurements, but consisted of a visual analysis for significant issues such as erosion features, culverts with high flows or perched openings, nearby impoundments, and poor road or structure conditions. If major issues were found a complete survey was performed, therefore any spot checks can be assumed to have minor crossing issues. Because spot checks had no quantitative information taken they could not be included in the results provided in Table 52 which are calculated using a quantitative formula.

TABLE 53: ROAD STREAM CROSSING SURVEY RESULTS

Composite of Impairments at Crossing	Number of Road Stream Crossings	Fish Passability Impairment	Number of Road Stream Crossings	Sediment Erosion from Road (tons/year)	Number of Road Stream Crossings
Severe	66	Severe	59	0-.99	95
Moderate	36	Moderate	28	1-3.99	18
Minor	14	Minor	24	4-9.99	1
		None	5	10 or greater	2

Summary of road stream crossing survey results.

Appendix C includes a table that details all results from this survey and Figures 24, 25, and 26 visualize the results of the survey. As can be indicated by the results, road stream crossings have a high impact on fish habitat within the ERCOL watershed. The impact to fish passability through a road stream crossing structure is calculated by comparing flow rates within the structure to a nearby reference riffle. These results indicate that flows are increased moderately to severely by the majority of the surveyed crossings in the watershed, also leading to changes in sediment transport and deposition that could contribute to increased erosion issues. A number of roads, particularly with gravel or native surfaces, are increasing erosion loading into nearby rivers and streams. Problems with road stream crossings in general are widespread and found on nearly every river and stream within the watershed.

From the total set of surveys, the ten sites with the largest problems in fish passability, erosion and structural issues were highlighted and listed in Table 53 below. In addition Appendix C give a list of the top 3 worst crossings for each sub-watershed as well as sediment erosion loads for sub-watersheds.

TABLE 54: TOP TEN WORST ROAD STREAM CROSSINGS

Road Stream Crossing Label*	Stream/River	Road	Issues
CL11	Crow Creek	Elder Rd	Native Surface (sand) road, severe erosion on road, undersized culvert, perched.
HL10	King Creek	Essex Rd	Undersized perched culvert, filled with sediment, impoundment
HL18	Benway Creek	Rushton Rd	Undersized perched culvert, structural integrity jeopardized, additional impairing structures, severe streambank erosion
IR08	Cedar River (N Branch)	County Rd 620	Native surfaced road eroding into stream, crossing washed out, culverts undersized and filled with sediment, culverts crushed and broken
IR18	Cedar River	Cedar River Rd	Undersized perched culverts, high flows through culvert increasing downstream erosion
RR09	Little Rapid River	Old M72 NW	Gravel road eroding into river, culverts fully submerged
SC06	Unnamed	Six Mile Lake Rd	Culvert extremely undersized, 3 foot perch downstream side, increased downstream erosion
TL14	Unnamed	N Buhland Road	Culvert undersized, extreme perch, increased downstream erosion
TL16	Unnamed	NE Torch Lake Drive	Culvert undersized, extreme perch, increased downstream erosion
TL20	Unnamed	NW Torch Lake Drive	Culvert undersized, extreme perch, increased downstream erosion

Top ten most impacted road stream crossings by composite severity rating.
*See Appendix C for GPS locations associated with labels.

Due to the fact that there are a large number of severely impacted crossings throughout the watershed and due to the fact that not all crossings were sampled, it is not possible to prioritize an entire sub-watershed over another. Table 53 and Appendix C instead give the most severely impacted sites for both the entire ERCOL and each sub-watershed. This can be used then to prioritize individual improvement projects. While a detailed analysis quantitatively prioritizing each sub-watershed cannot be completed, it should be noted that in terms of average sediment erosion load as well as in composite severity score, the Torch Lake sub-watershed has consistently the highest in these categories. The steep topography, sandy soils, and surrounding residential and agricultural land use makes the Torch Lake sub-watershed one of the most jeopardized by road stream crossings.

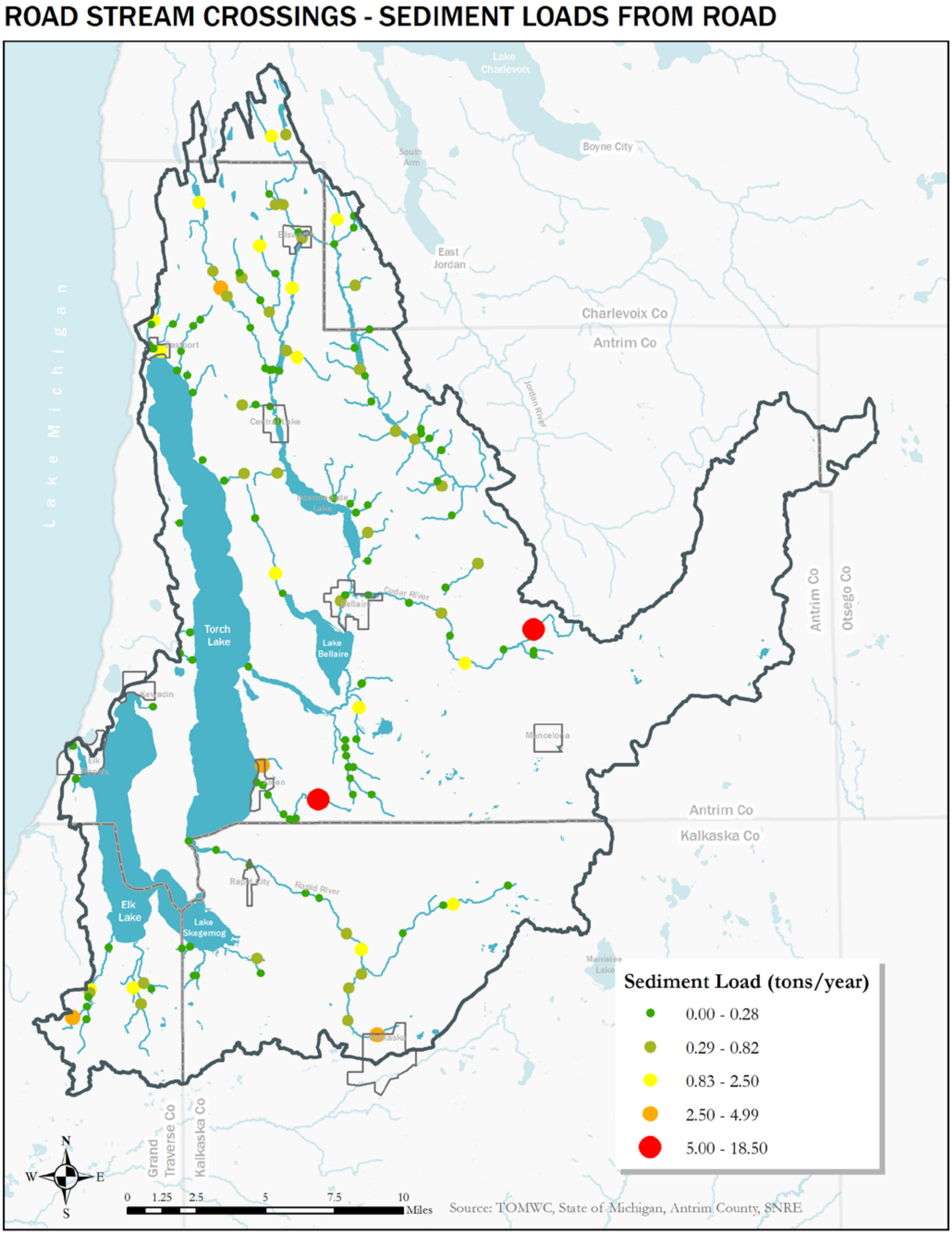


Figure 24: Estimated road sediment loads at surveyed road stream crossing sites in the ERCOL watershed.

ROAD STREAM CROSSINGS - FISH PASSAGE IMPACT

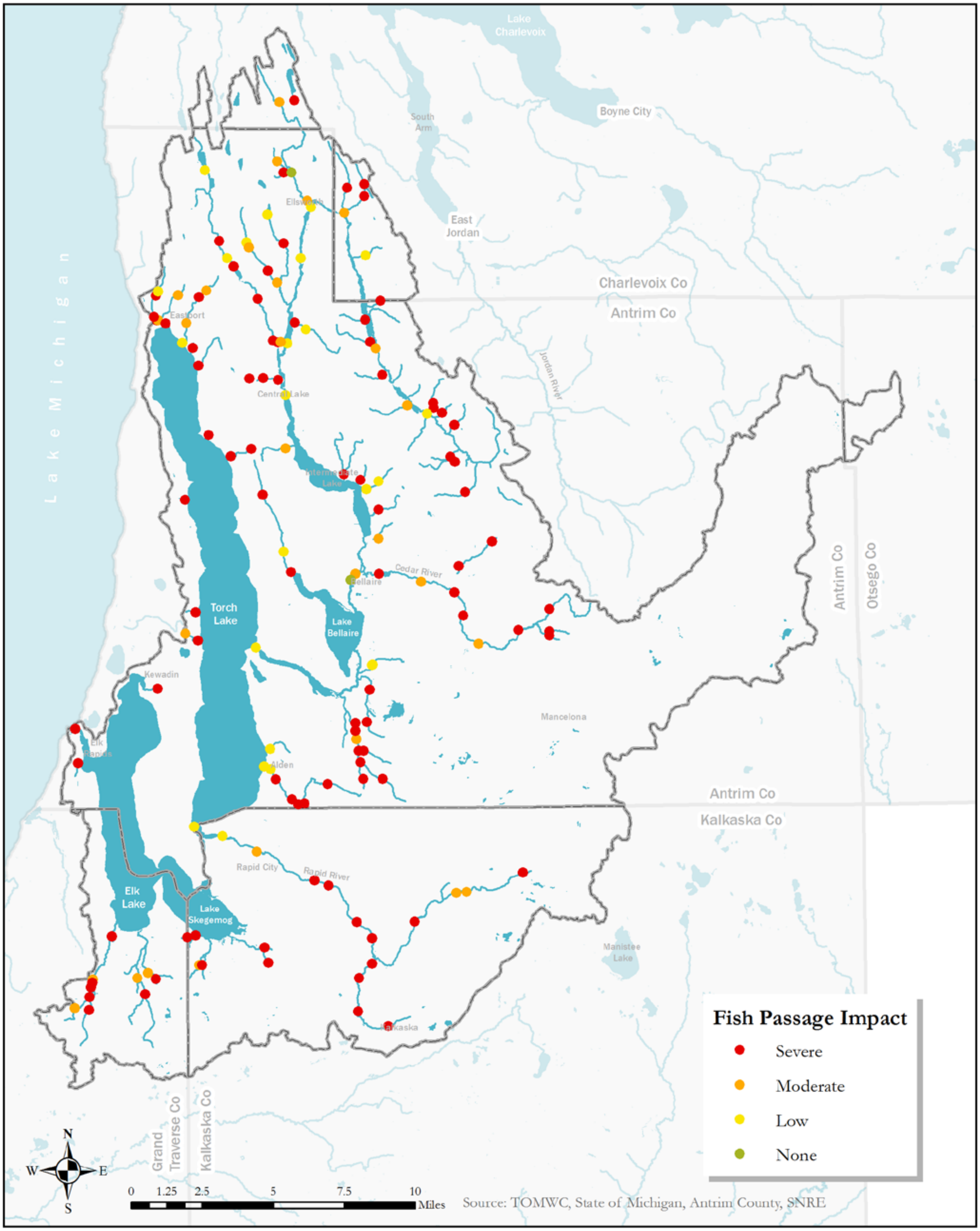


Figure 25: Estimated fish passage impact of surveyed road stream crossing sites in the ERCOL watershed.

ROAD STREAM CROSSINGS - COMPOSITE IMPACT

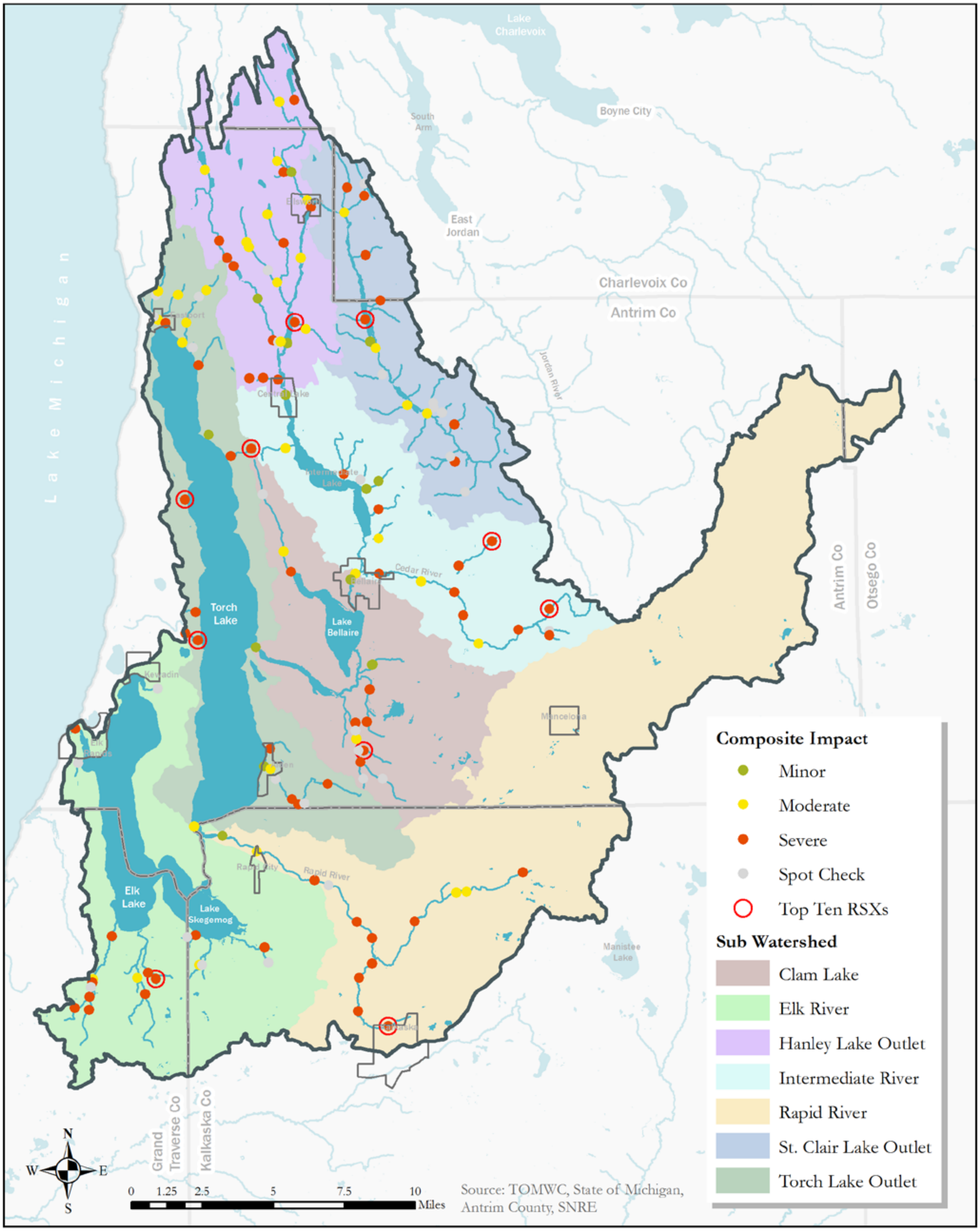


Figure 26: Assessed composite score for surveyed road stream crossing sites in the ERCOL watershed.

3.6 RECREATION IMPACT ASSESSMENT

A summary of recreational facilities on major lakes is presented in Table 54. Private boat dock estimates and marinas were counted using satellite imagery and public beach and boat launches data were collected via information available on various web pages.

Further analysis will be added to this section, including a recreation impact assessment providing a narrative discussion of marinas, boat use, and other recreational factors.

TABLE 55: BOATING AND RECREATION FACILITIES ON MAJOR LAKES

	Public Boat Launches	Public Beaches	Private Boat Docks (est.)	Marinas
Six Mile Lake	1	0	323	0
Intermediate Lake	4	0	543	0
Lake Bellaire	3	0	444	0
Torch Lake	6	4	1,545	3
Lake Skegemog	3	0	570	0
Elk Lake	6	0	1,032	4

Summary of structures for boating access and recreational use on major lakes within the watershed.

3.7 FOREST COVER AND PRACTICES ANALYSIS

There is currently no comprehensive survey of forest resources and practices within the ERCOL watershed. With the large quantity of forest resources and their contribution to protecting watershed health, it is important that efforts are implemented to understand the status of specific stands of forest in addition to the coarse picture of land cover provided in Figure 6 within Chapter 1 of this document. Further information will be added to this section as more information is acquired regarding forest cover and practices throughout the watershed.

3.8 AGRICULTURAL IMPACT ANALYSIS

There are approximately 68 square miles of cropland within the Elk River Chain of Lakes watershed and 11.5 additional square miles of agricultural land dedicated to pastureland and hay production. According to the 2012 Census of Agriculture, there are approximately 1,614 farms in the five counties that that can be found within the ERCOL watershed. With the exception of Kalkaska County, ERCOL watershed counties have seen a decline in the number of farms from the 2007 agricultural census to the 2012 agricultural census. The majority of farms in Antrim County are between 50 and 179 acres and the average farm size is

155 acres. There are many smaller farms as well ranging from between 10 and 49 acres. In Grand Traverse County, the majority of farms range from 10 to 49 acres, and very few farms are over 500 acres. Charlevoix County's farms are much like those of Antrim County, with the majority (over 120 farms) being between 50 and 179 acres. Otsego County has fewer farms than the other counties that share boundaries with the ERCOL watershed, with the majority between 10 and 49 acres or 50 and 179 acres. Kalkaska County has very few exceptionally large farms (greater than 500 acres), but many smaller farms that range from 10 to 179 acres. Throughout the area numerous different crops are grown, including many orchards and vineyards. The most common crops throughout the region include hay, tart cherries, corn, potatoes, soybeans, wheat, and other vegetables. Livestock raised in the area include cattle, hogs, and pigs, among others (USDA, 2012).

Agricultural land comprises 15.93 % of the watershed area as the second largest land use type behind forested land. Agricultural land within a river catchment can have serious impacts on the health of water bodies, with numerous studies documenting the impacts on water quality metrics. It has been shown that as the amount of agricultural land increases within a watershed, water quality, habitat, and biological diversity decline (Allan, 2004). The negative impacts on watershed health are primarily due to increasing nonpoint source pollution inputs (including sediments, nutrients, and pesticides) associated with agricultural land. The use of insecticides and herbicides on agricultural land near rivers and streams is typically associated with a loss of aquatic macroinvertebrate taxa, which are often used as biological indicators of overall water quality and stream health. Habitat quality, bank stability, and sedimentation of stream beds are also highly influenced by the amount of agricultural land within a catchment. Livestock trampling can lead to increased sediment loading from soil deposited in the stream, influencing available habitat as well as river hydrology (Allan, 2004).

AGRICULTURAL SURVEYS

Windshield surveys of agricultural areas in the watershed were conducted in August and October of 2015. Pepper Bromelmeier of the US Department of Agriculture Natural Resource Conservation Service (NRCS) in Antrim County assisted with identifying priority townships to be surveyed within the watershed. The five townships that were surveyed were Banks Township (East and West), Milton Township (North and South), Central Lake Township, Elk Rapids Township, and Torch Lake Township. Agricultural sites within these townships were prioritized based on their size, proximity to water bodies, and known issues identified by Pepper Bromelmeier.

A total of 95 agricultural sites were surveyed in these five townships, encompassing over 200 parcels of land. Observations were recorded for each site based on several metrics, based on those outlined in the Watershed Inventory Workbook for Indiana: A Guide for Watershed Partnerships (Frankenberger et al., 2002). Recorded observations included agricultural operation type, crop status, tillage, signs of erosion, estimated number and type of livestock, pasture management, access to streams, vegetative filter strips, and riparian buffers.

An impact rating was calculated for each of the surveyed sites. This process utilized aerial imagery, maps, and windshield survey observations, yielding the following metrics:

- Presence of water body on site
- Presence of water body within half mile of site
- Steepness of slopes
- Pesticide use
- Conventional tillage
- Livestock near stream
- Vegetated filter strips on nearby properties
- Mowing between orchard rows
- Vegetated buffer strip at roadside
- Riparian filter strips

Of the cropland and orchard sites, 35 sites received an impact score of "very low," 21 sites received a score of "low," 27 sites received a score of "moderate," and 3 sites received a score of "high" impact. Of the livestock operation sites, 6 sites received an impact score of "high" and 3 sites received a score of "low."

Sites with high or moderate impact scores had several issues. For cropland sites, there was often a very limited or entirely absent vegetative filter strip at the roadside. This buffer plays an important role by preventing sediment, nutrients, and other pollutants from traveling onto roads to be washed away during storm events. Many orchards had significant mowing between orchard rows, reducing vegetative filtering of pollutants. According to Pepper Bromelmeier, almost all orchards use pesticides on their trees, contributing to the many orchard sites with an elevated impact score. Most sites with a high impact score contained a water body running through the property or within a half mile. However, in most of these sites there was an intact riparian buffer between the agricultural operation and the water body. There was very few sites of significant erosion found within the majority of cropland agricultural sites, a positive finding in terms of watershed health, but many row crop sites (particularly corn) use conventional tillage methods with the potential to increase erosion and lead to increased sediment run off.

The majority of livestock sites that were surveyed had high impact scores. This was mainly due to the fact that many pasture areas were on very steep slopes, making run off more likely. In addition, there were several sites with serious erosion occurring and trampling of the vegetation, which can significantly contribute to surface run off of sediments. In contrast, most livestock operations did not allow the livestock to access water bodies on or around the property. As with cropland sites, the riparian buffers between livestock operations and water bodies were intact and relatively robust.

AGRICULTURAL SURVEY SITES

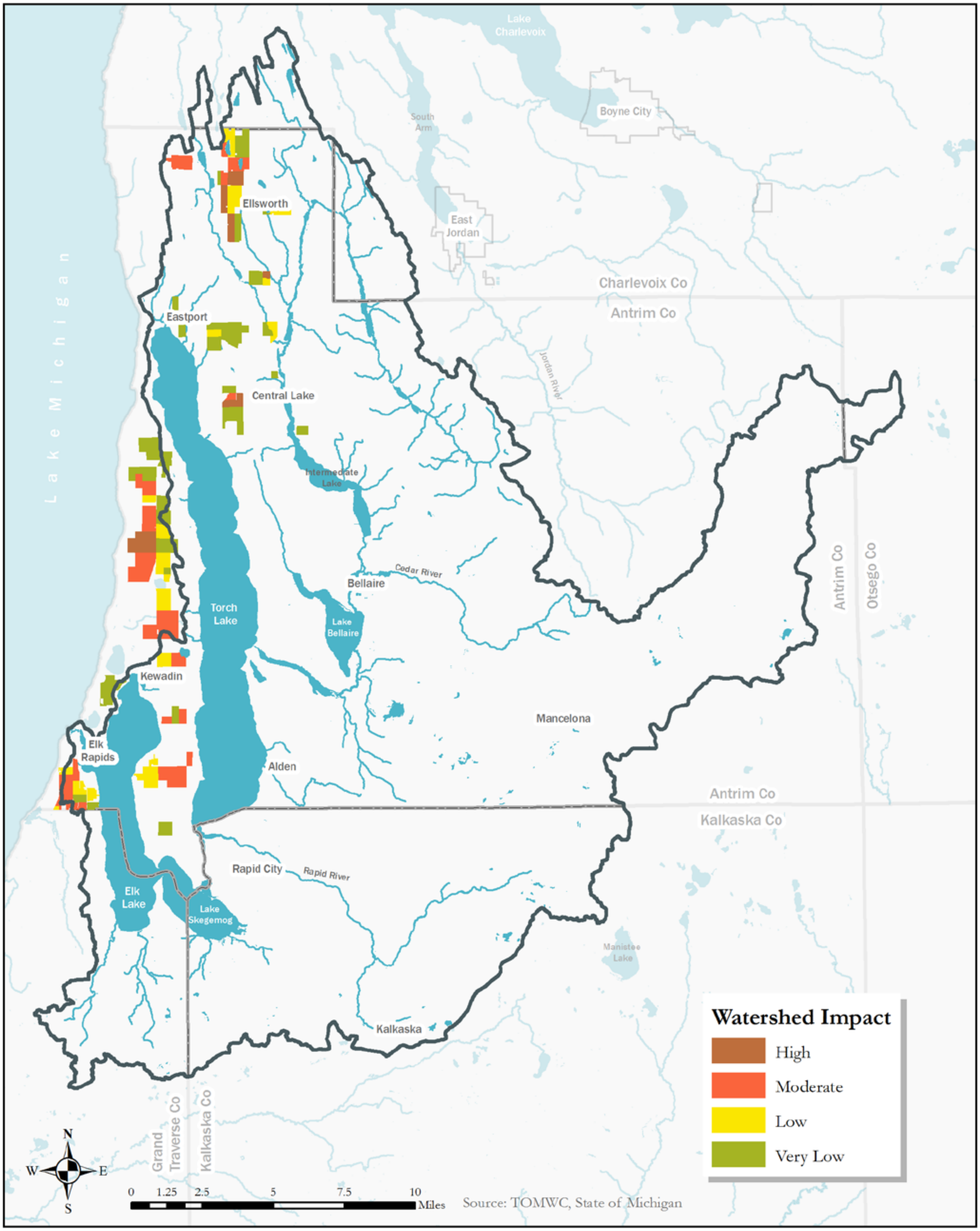


Figure 27: Agricultural sites surveyed in 2015 for estimated level of impact on the watershed.

3.9 SEPTIC SYSTEM ANALYSIS

To date no comprehensive analysis of septic systems has been conducted for townships within the ERCOL watershed. Relatively few residential properties are connected to an established sewer system and outdated septic systems are a significant concern as pathways for harmful bacteria into waterways. Additional information will be added to this section as it becomes available.

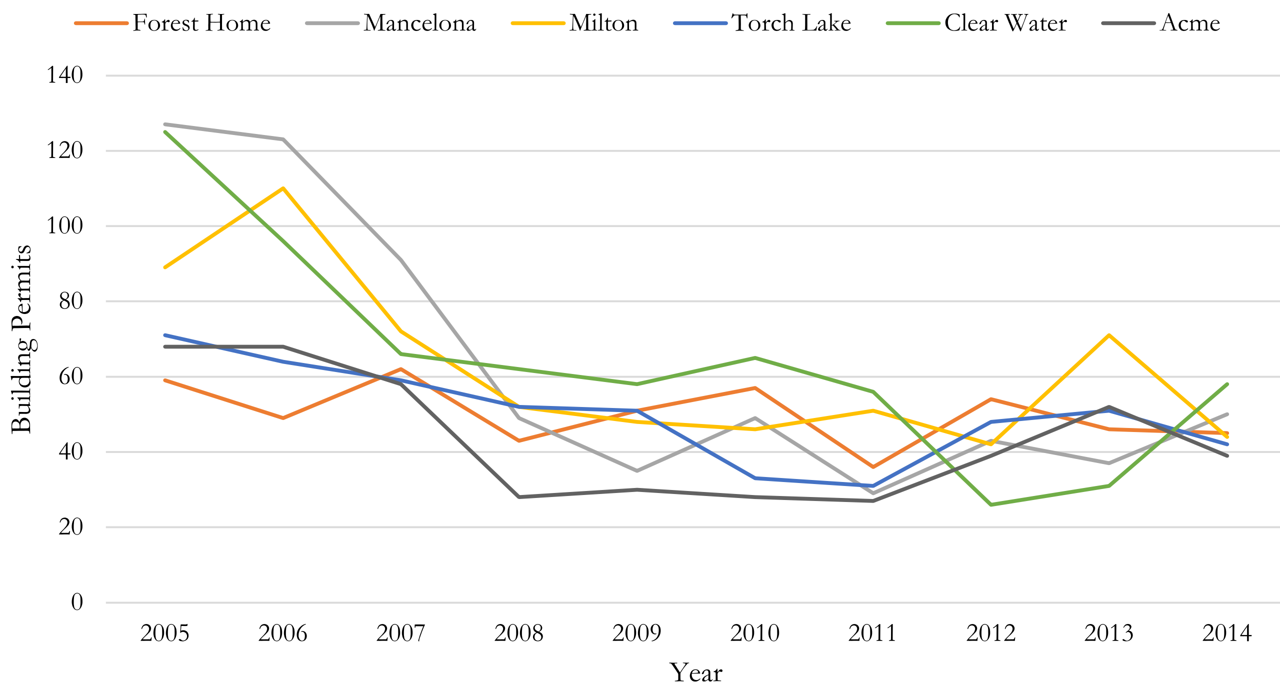
3.10 BUILDING PERMITS AND DEVELOPMENT ANALYSIS

Construction sites often remove vegetative cover and expose soil to the risk of excess erosion. This can lead to impacted water quality in receiving streams, rivers, and lakes. Most regulatory bodies have broadly recognized the challenges of high erosion from construction sites. Antrim and Grand Traverse counties both have strong soil erosion control ordinances that dictate permanent soil erosion control measures and temporary measures during construction. Site plan reviews are required and soil erosion control officers are on staff in Antrim, Grand Traverse, and Kalkaska counties. These three counties represent a large portion of building permits issued within the ERCOL watershed.

A suite of erosion control techniques can be installed to address erosion during temporary disturbance, but ordinances and control measures are not always as effective as intended. Contractors may not follow regulations closely enough and control measures are often poorly installed or fail to work properly. For example, in 2014 Grand Traverse Bay was exposed to plume of eroded soil from a poorly managed construction site. It is estimated that water quality was impacted for months following the failure of control technologies. Post development conditions are rarely as effective in control soil erosion. The desire for clear views to the water and neatly manicured lawns is a significant detriment to soil stability.

While precise data is not available on soil erosion and post construction impacts from individual sites, a general analysis of building permits within the watershed was conducted to help quantify areas where development is exerting the most pressure on nearby bodies of water. Figure 28 shows the cumulative number of building permits approved in each township for the last ten years of available data. Torch Lake, Milton, Forest Home, and Clearwater Townships have seen the highest amount of development in the last decade. Not all development is detrimental to the watershed, but these areas generally have a higher impact on resources within the watershed. An analysis shown in Table 56 indicates that building permits slowed around 2008 in correlation with an economic recession, with a moderate increase in most townships in the following years.

TABLE 56: BUILDING PERMIT TRENDS IN THE WATERSHED



Building permits issued in townships within the ERCOL by year.

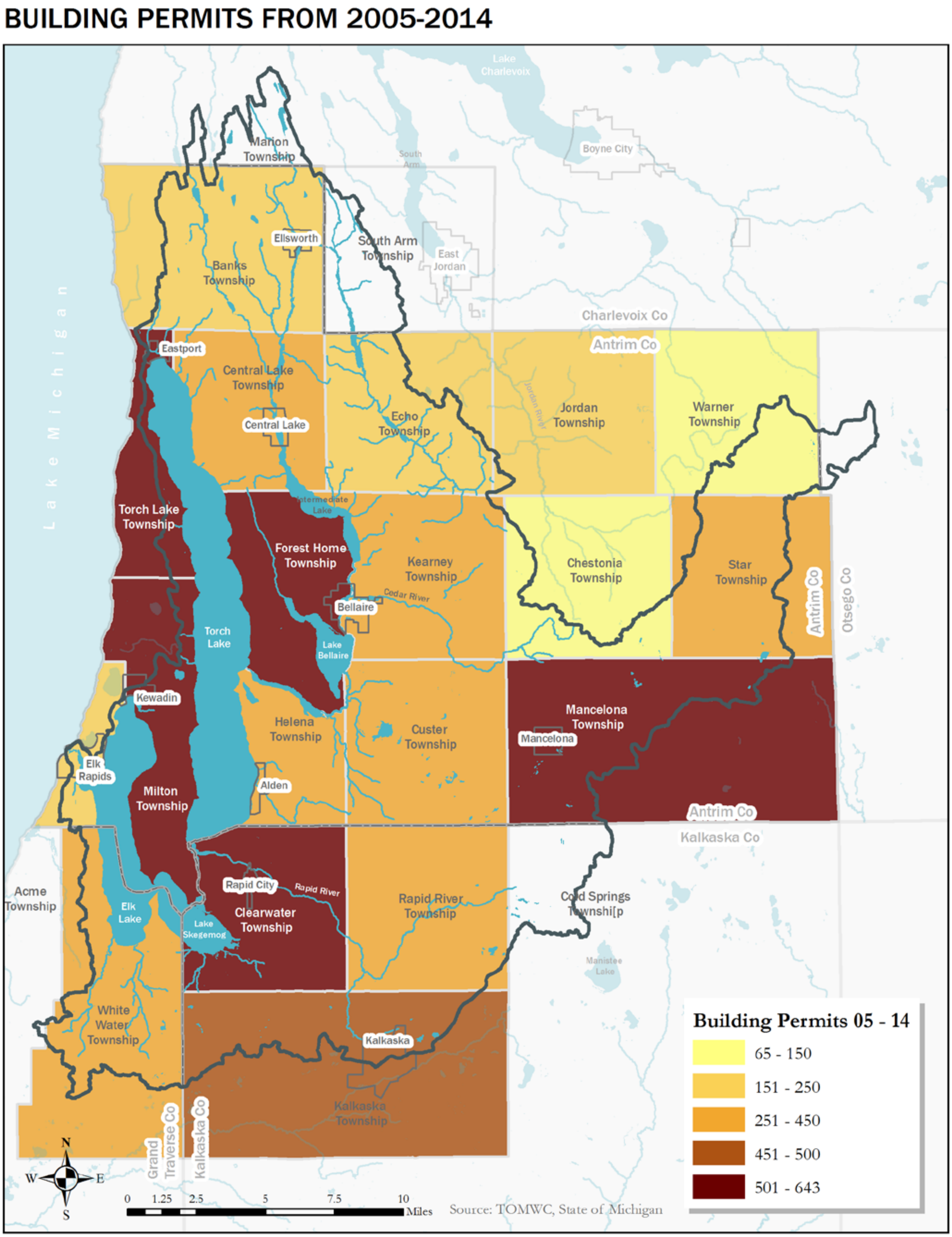


Figure 28: Building permits approved from 2005-2014 by township in the ERCOL watershed.

3.11 AQUATIC INVASIVE SPECIES SURVEYS

A series of aquatic invasive species surveys were completed by TOMWC during the summers of 2014 and 2015. Figures 29-32 highlight the findings of these surveys and visualize general distributions of prominent invasive aquatic macrophytes and mussels. Additional information on the status of invasive species within the ERCOL watershed will be added to this section as it becomes available.

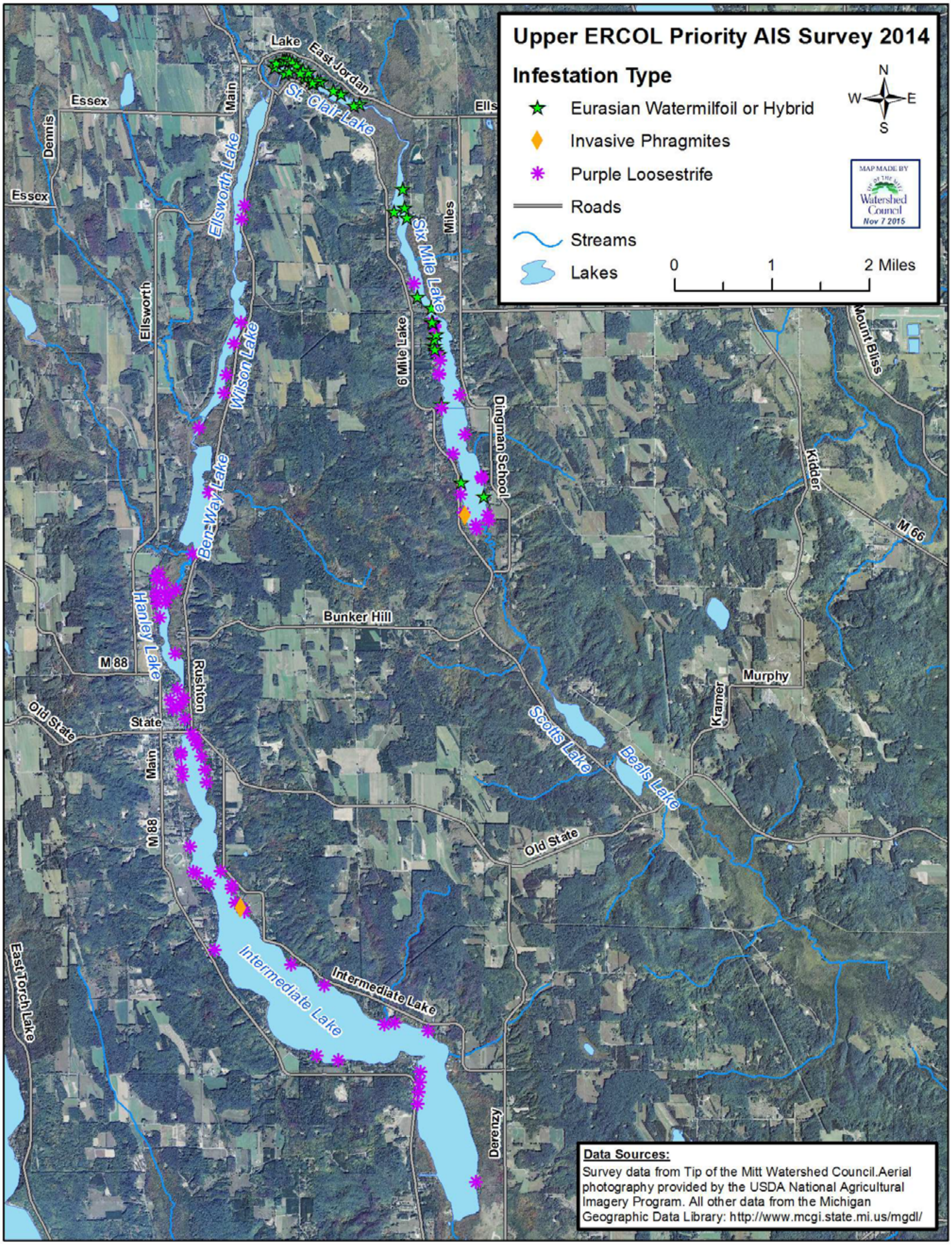


Figure 29: TOMWC aquatic invasive species survey results for the upper portion of the ERCOL.

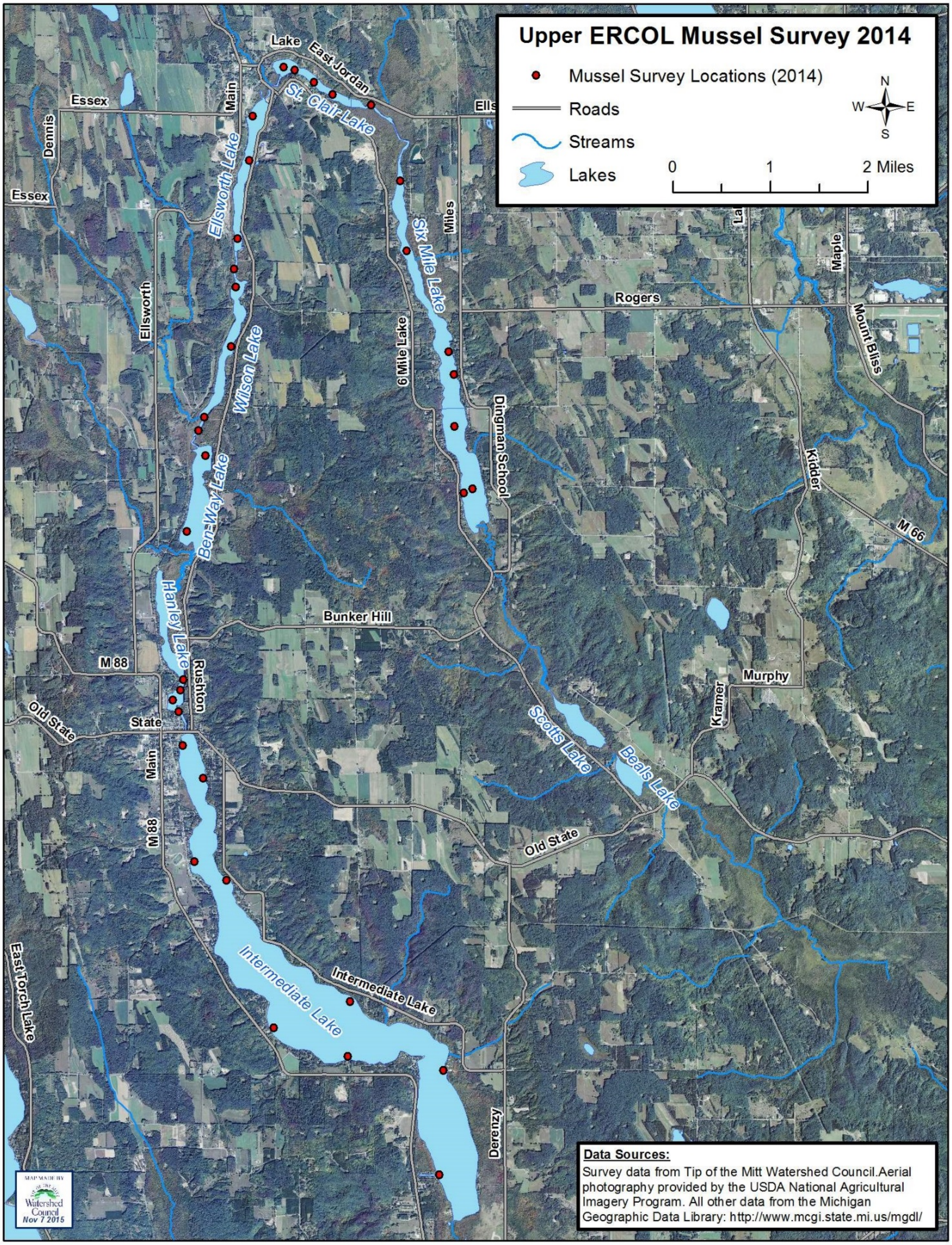


Figure 30: TOMWC mussel survey results for the upper portion of the ERCOL.

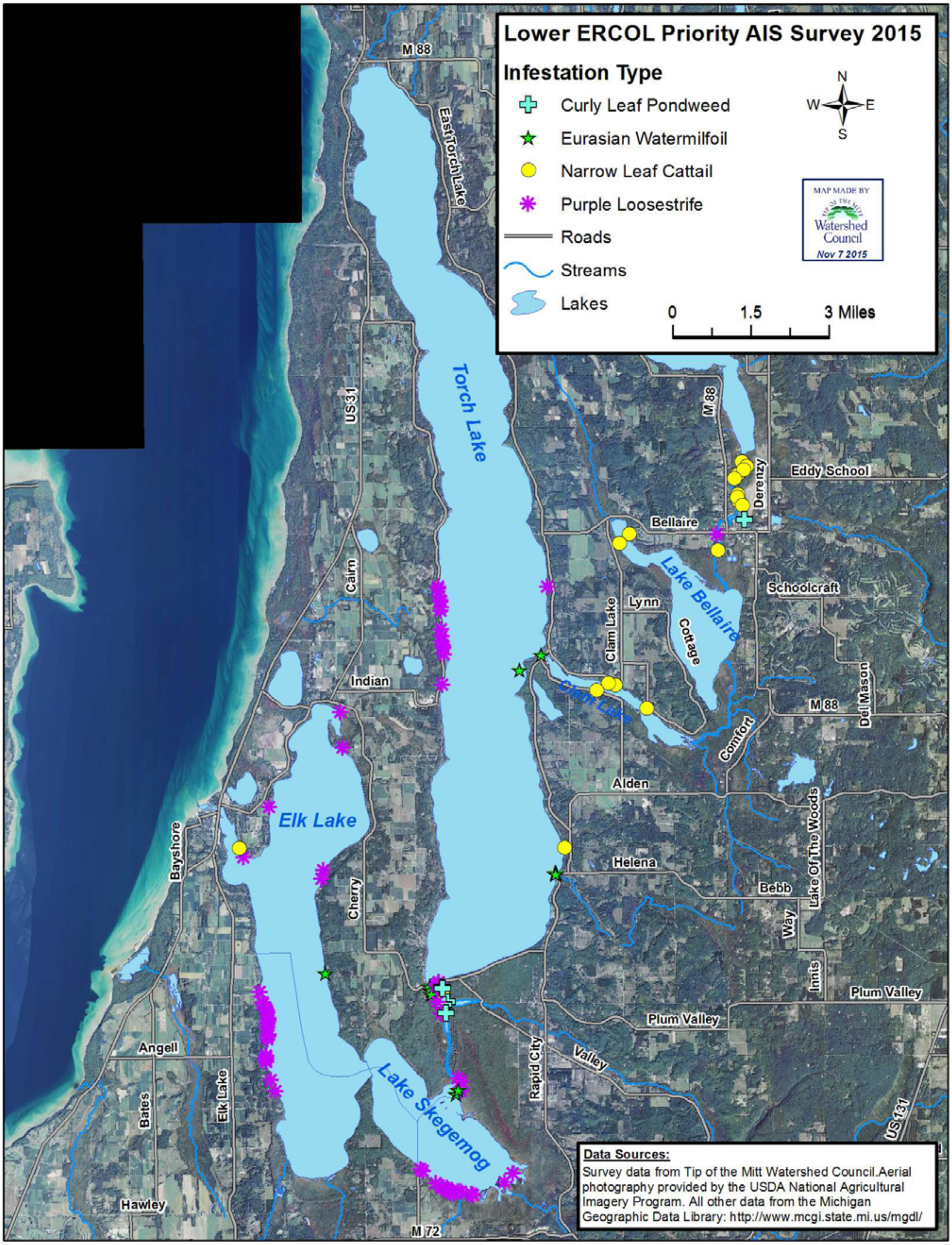


Figure 31: TOMWC aquatic invasive species survey results for the lower portion of the ERCOL.

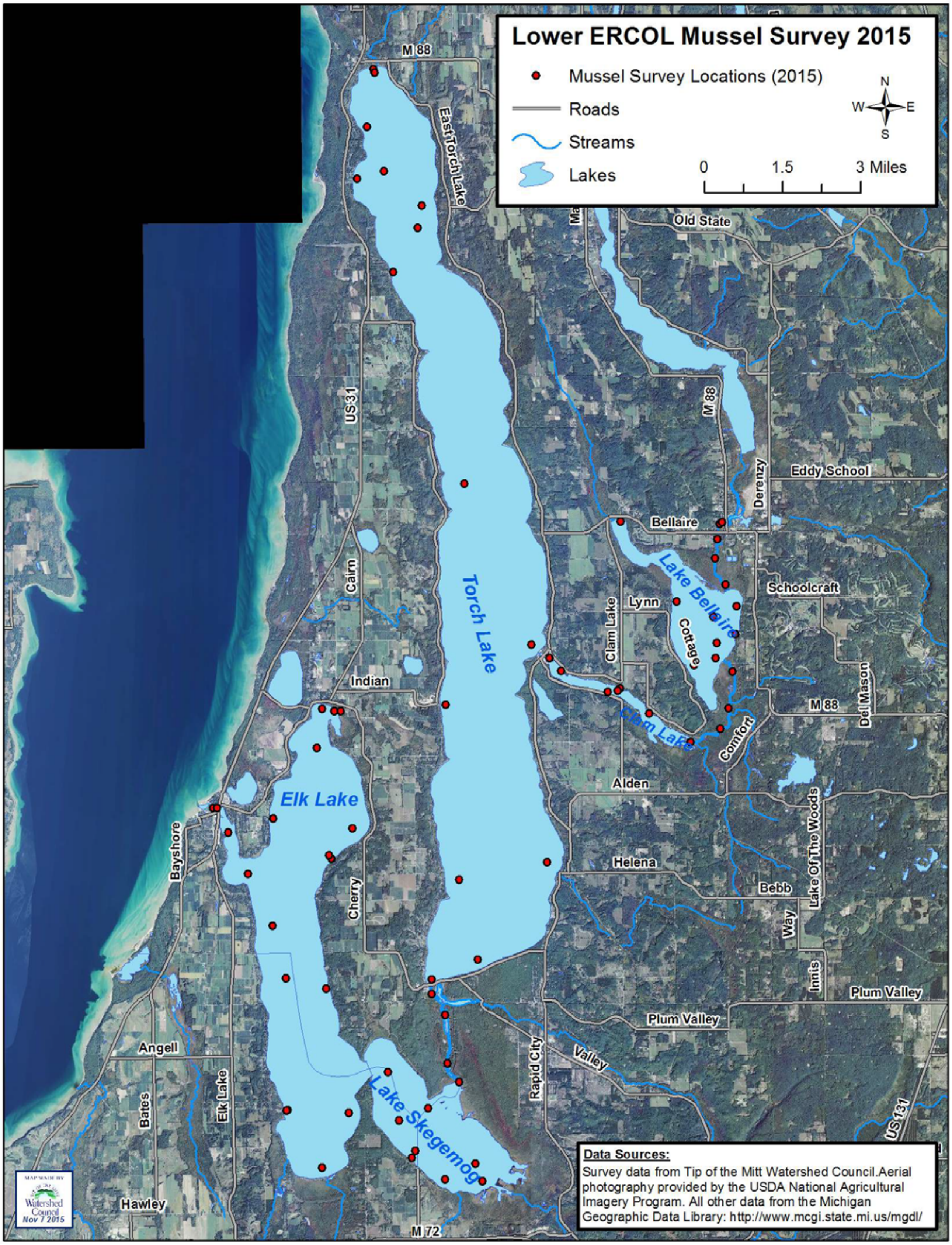


Figure 32: TOMWC mussel survey results for the lower portion of the ERCOL.

3.12 DAMS

There are a number of dams within the ERCOL that modify hydrology, habitat, and movement of aquatic species. A more complete survey of water infrastructure within the watershed and their associated status and impact is needed to inform management actions. Additional information will be added to this section as it becomes available.

RUGG POND

The dam at Rugg Pond within the Rapid River is one of the most significant issues related to water infrastructure throughout the ERCOL watershed. While the resulting reservoir provides valuable wildlife habitat and a popular recreational location, the existing dams are strained by years of accumulated sediment and management action needs to be considered. Additional information regarding Rug Pond will be added to this section as it become available.

3.13 NOXIOUS ALGAL BLOOMS

There are numerous reported instances of noxious algal blooms within the ERCOL area, but no comprehensive surveys have been conducted to describe causes and impacts in the necessary detail to inform effective management actions. Additional information will be added to this section as it becomes available.

3.14 TCE PLUME

The presence of a historical TCE plume moving through the eastern portions of the ERCOL watershed is well known, but no significant surveys have been conducted to explore the possible repercussions of this pollutant source. Additional information will be added to this section as it becomes available.

CHAPTER 4
DEGRADATIONS, IMPAIRMENTS AND TOOLS FOR PRIORITIZATION

CHAPTER 4: DEGRADATIONS, IMPAIRMENTS AND TOOLS FOR PRIORITIZATION

4.1 INTRODUCTION

This chapter lays out the primary threats to water quality within the ERCOL watershed and highlights a number of decision making tools. The legal guidelines within the state of Michigan for water quality standards are discussed in section 4.2 as well as the designated uses of surface waters in the State of Michigan. The designated uses that are legally defined as impaired within the ERCOL are also summarized within this section. Stakeholder input was collected from two well attended public town hall style meetings to generate a list of user defined desired uses. This list highlights some of the primary uses of surface waters by local users that are not captured in the list of designated uses.

A list of structural and action based threats synthesized from feedback from town hall meetings, local state agents, and members of the ERCOL-WPIT is presented in section 4.3. The primary pollutants corresponding to each of these threats is provided along with a list of potential causes in Table 63. A comprehensive rank was given to each threat according to its perceived impact by a group of local experts during a set of extensive workshops. In section 4.4 a set of maps and criteria to aid in decision making was developed from these threats and concerns, with discrete threatened locations laid out in a coarse grain critical areas map and an accompanying tiered system for prioritization.

Priority parcels for conservation are highlighted in section 4.5, with two maps generated to identify specific parcels of land within the ERCOL watershed with the most significant resources for protection. The first analysis emphasizes watershed protection with the second analysis emphasizing general land protection. Each analysis highlights the most effective targets for permanent protection to help ensure the integrity of resources within the ERCOL watershed.

4.2 STATE WATER QUALITY STANDARDS, DESIGNATED USES AND DESIRED USES

WATER QUALITY STANDARDS

The EPA'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. 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 ERCOL watershed was last monitored by MDEQ in 2013.

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 56. The State uses quantitative water quality standards to help determine if designated uses are impaired.

TABLE 57: STATE OF MICHIGAN WATER QUALITY STANDARDS

Pollutant	State-required level	Designated Uses Affected
Dissolved solids	500 mg/L monthly average or 750 mg/L at any time as a result of controllable point sources	All
Chlorides	125 mg/L monthly average	Public water supply
pH	6.5 to 9.0	
Taste or odor producing substances	Any concentration	Public water supply, industrial water supply, agricultural water supply, fish consumption
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: 0.00011 ug/L mercury, including methylmercury: 0.0013 ug/L PCBs (class): 0.00012 ug/L 2,3,7,8 - TCDD: 0.0000000031 ug/L	All but navigation
Radioactive substances	Pursuant to U.S nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1 mg/L monthly average for permitted point-source discharges	All
Microorganisms	130 Escherichia coli per 100 ml 30-day mean of 5 or more sampling events 300 E.coli per 100 ml 30-day 1,000 E.coli per 100 ml 30-day mean Human sewage discharges (treated or untreated) 200 fecal coliform per 100 ml 30-day mean or 400 fecal coliform per 100 ml in 7 days or less	Total body contact Total body contact Partial body contact Total body contact
Dissolved oxygen	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	Coldwater fishery Warmwater fishery
Temperature	Natural daily and seasonal temperature fluctuations shall be preserved: Monthly averages for inland lakes: J F M A M J J A S O N D 45 45 50 60 70 75 80 85 80 70 60 50 Monthly averages for warmwater inland streams in this watershed: J F M A M J J A S O N D 38 38 41 56 70 80 83 81 74 64 49 39 Monthly averages for coldwater inland streams in this watershed: J F M A M J J A S O N D 38 38 43 54 65 68 68 68 63 56 48 40	Coldwater fishery Other indigenous aquatic life and wildlife Warmwater fishery

Summary of Michigan water quality standards as required by section 3103 and 30106 of 1994 PA 451, MCL 324.3203 and 324.3106

STATE DEFINED 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 WQS states that all surface waters of the state are designated for, and shall be protected for seven particular uses. In addition there are two designated uses that limited water bodies are protected for. (Table 57)

TABLE 58: DESIGNATED USES FOR SURFACE WATERS IN THE STATE OF MICHIGAN

Designated Use	**General Definition**	**MI Surface waters protected for designated use**
Agriculture	Livestock watering, irrigation, and crop spraying	All
Navigation	Navigation of inland waters	All
Warmwater fishery	Supports warm water species	All
Coldwater fishery	Supports cold water species	Limited inland lakes and streams, and all Great Lakes and connecting waterways*
Other indigenous aquatic life and wildlife	Supports other indigenous animals, plants, and macroinvertebrates	All
Partial body contact recreation	Supports boating, wading, and fishing activities	All
Total body contact recreation	Supports swimming activities between May 1 to October 31	All, only between the dates May 1- October 31
Public water supply	Surface waters meet human cancer and non-cancer values set for drinking water	Only those designated in the publication "Public Water Supply Intakes in Michigan"
Industrial water supply	Water utilized in industrial or commercial applications	All
Fish consumption	There is a state-wide, mercury-based fish consumption advisory that applies to all of Michigan's inland lakes, including those within the Elk River Chain of Lakes	All

Summary of designated uses for surface waters within the State of Michigan.
*Designated surface waters protected for coldwater fisheries include all Great Lakes and connecting waterways with the exception of those in the Keweenaw water (including Portage Lake), Houghton County and Lake St. Clair. Inland surface waters protected for coldwater fisheries include those found in the publications "Coldwater Lakes of Michigan", "Designated Trout Lakes and Regulations" and "Designated Trout Streams for the State of Michigan."

The Elk River Chain of Lakes includes both coldwater and warmwater 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. Appendix D lists the publications which define coldwater fisheries in

Michigan as well as the specific coldwater lakes and streams that can be found in the ERCOL watershed. In total there are two major lakes and 29 rivers and streams which fall under this designation.
The designated 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 a watershed is currently unimpaired but could become impaired due to: 1) actual and/or projected land use changes and/or, 2) declining water quality trends, as shown by physical or analytical data. 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 Elk River Chain of Lakes Watershed (HUC #0406010503-4), included in the Boardman-Charlevoix Watershed (HUC #04060105), was monitored by the MDEQ in 2013 to assess designated uses and their levels of impairment. These assessments take place on a 5 year cycle of monitoring, the next of which will take place in 2018. The results from the 2013 study are available in the document "Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report, Appendix C" (Michigan DEQ 2016). Table 58 includes a list of areas which were found to have designated use impairments.

TABLE 59: DESIGNATED USE IMPAIRMENTS

Location	Designated Use Monitored	Status	Cause
Eastport Creek	Total body contact recreation	Not supporting	Escherichia coli
Wilkinson Creek	Total body contact recreation	Not supporting	Escherichia coli
Six Mile Lake (4 miles SW of East Jordan)	Fish consumption	Not supporting	Mercury in fish tissue
Ellsworth Lake (vicinity of Ellsworth, MI)	Fish consumption	Not supporting	Mercury in fish tissue
Lake Bellaire (vicinity of Bellaire)	Fish consumption	Not supporting	Mercury in fish tissue
Torch Lake (vicinity of Eastport)	Fish consumption	Not supporting	Mercury in fish tissue
	Fish consumption	Not supporting	Dioxin (including 2,3,7,8-TCDD)
	Fish consumption	Not supporting	PCB in fish tissue
Elk Lake (vicinity of Elk Rapids)	Fish consumption	Not supporting	Mercury in fish tissue
	Fish consumption	Not supporting	PCB in fish tissue

Impaired designated use sites within the ERCOL watershed.

It should be noted that Appendix B of the document Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report lists all areas within the Elk River Chain of Lakes watershed that were assessed for various designated uses. All sites had designated uses that were not assessed or that lacked sufficient data to make an accurate assessment, therefore the list is only partially comprehensive in terms of assessing the impact to the ERCOL's designated uses.

While the majority of assessed surface waters in the ERCOL are currently meeting all of the designated uses of the State, it should be noted that the ERCOL 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.

Recommendations provided in this management plan will seek to support all designated uses, but have the greatest impact on uses that are currently not being supported or have a high risk of degradation. This plan does not focus on mercury pollution due to its status as a legacy chemical and product of atmospheric deposition, as well as the widespread scale of impairment that requires a higher degree of management. For further information on mercury sources in the environment and mercury pollution prevention strategies, please refer to publications by Sills (1992) and Mehan (1996) provided within the document references. These two reports stem from two specific DEQ task force investigations into mercury in the environment, sources, and prevention. The DEQ has taken the lead to develop pollution prevention and abatement strategies throughout the State of Michigan for mercury contamination and other related toxins.

STAKEHOLDER DESIRED USES

In addition to researching legally defined designated uses, a number of locally determined desired uses for the bodies of water in the ERCOL were identified through personal conversations with stakeholders, ERCOL-WPIT planning meetings, and town hall style meetings. Over 60 individuals attended the town hall meetings at which attendees were asked to generate a list of what they see to be the most prominent uses of the lakes. Desired uses can be defined as activities in, on, or adjacent to bodies of water in the ERCOL in which residents and visitors participate, as well as inherent cultural and aesthetic values that the ERCOL provides. Tables 60 and 61 are a comprehensive summary of the desired uses as indicated through the ERCOL-WPIT and town hall meetings. These uses are split into non-consumptive and consumptive uses, with regard to removal of water from a water body. Some of these overlap directly with the state designated uses, while others fall outside the boundaries of those definitions.

TABLE 60: NON-CONSUMPTIVE STAKEHOLDER DESIRED USES

Non-consumptive Use	Explanation
Motor boating and boating culture	A number of individuals pointed out that recreational boating is highly popular in almost all of the lakes as well as the connecting channels between them. Many stated that with this large amount of boating comes a boating culture. That includes things like water sports, swimming, fishing and partying while in one's boat.
Kayaking and other non-motorized watercraft	This includes things like kayaking, canoeing, paddle boarding, windsurfing and sailing. While the area may be better known for motor sports, a number of individuals pointed out that these quiet water craft are becoming increasingly popular. Some noted the increase in festivals around these types of watercraft as well as water trails designed for them.
Swimming, snorkeling and scuba diving	Individuals noted public and private beaches as being popular, as well as swimming off of boats. While not nearly as common, some individuals also scuba dive and snorkel in the lakes.
Fishing	Both fishing from boats as well as fly fishing along the various rivers are popular in the ERCOL. In addition, some individuals mentioned the importance of ice fishing as a recreational sport in the area. This includes rod and reel fishing as well as fish spearing.
Hunting and trapping	Duck hunting was mentioned as an area of interest, particularly in the northern part of the chain of lakes as well as Clam Lake and a few of the other lakes with less boat traffic. In addition, a small number of individuals trap animals such as muskrat, beaver and mink along the various rivers, streams and lakes.
Aesthetic value	It came up in both meetings that one of the greatest values of the lakes and rivers was the pristine viewing opportunities they provided. Features such as crystal clear blue waters, wooded shorelines, and large open views were all noted as having a myriad of values. Some of the values of the aesthetics included a) allowing one to enter a relaxed and meditative state of mind b) increasing property values c) inducing or promoting spiritual reflection d) creating a heightened awareness of the beauty of the natural world.
Snowshoeing and other ice related activities	A couple of individuals noted snowshoeing as an activity that takes place on the frozen lakes. Cross country skiing, ice skating, and ice sailing may be other activities that happen on frozen lakes in the winter months.
Hiking and picnicking on public land	Hiking and picnicking were cited as important uses of the shoreline and streambank, particularly in public (state /municipal) owned sites as well as publicly accessible nonprofit owned conservation and natural areas.
Conservation and restoration	Some individuals stated that protection and restoration were important activities in which individual residents participated. The conveyance of conservation easements or the building and placement of fish shelters are examples of this.

List of non-consumptive desired uses of watershed resources designated by stakeholders.

TABLE 61: CONSUMPTIVE STAKEHOLDER DESIRED USES

Consumptive Use	Explanation
Irrigation and other agricultural related uses	It was noted that a number of the orchards use direct draws from rivers or lakes to water their trees in the summer months. In addition, some farms may draw water from the ERCOL watershed for crop irrigation and livestock water.
Drinking water	The lack of municipally provided treated water in almost all communities in the ERCOL watershed means the majority of residents are drawing water directly from ground water aquifers. A few individuals stated that some residents draw water directly from Torch and Elk Lakes.
Fire-suppression draws	A few of the counties in the watershed have set up systems of pipes at road stream crossings that allow them to directly draw water from a river or lake in the case of a fire emergency.

List of consumptive desired uses of watershed resources designated by stakeholders.

4.3 WATERSHED THREATS, POLLUTANTS, AND IMPAIRMENTS

To assess the threats to the designated and desired uses, a large number of government and non-government organizations have been collecting information on the ERCOL in the form of both qualitative and quantitative data. Chapters 2 and 3 highlight a large variety of the information that has been collected within the last ten years. To further assess how the designated uses and desired uses of the ERCOL may be threatened or impaired, the ERCOL-WPIT embarked on a process of categorizing and ranking a set of action-based and structural threats. A list of pollutants and stressors is presented in Table 62 and a list of threats, presented in Table 63, was created as a way to categorize physical structures or human driven actions that occur within the watershed that have jeopardized or may jeopardize uses of the ERCOL. On November 11th, 2015 the ERCOL-WPIT assembled an expert panel of over 30 local residents, watershed management organizations, and government officials to finalize this threats list. The threats were ranked based on the perceived severity of their impact by the expert panel. Each threat was linked to a set of associated pollutant and environmental stressors and causes of those pollutants, as presented in Table 64.

TABLE 62: POLLUTANTS AND ENVIRONMENTAL STRESSORS IN THE WATERSHED

Pollutants/Stressors
Habitat loss
Sediment
Nutrients
Pesticides
Flow alteration
Other toxins (PCBs, endocrine disrupters, pharmaceuticals, etc.)
Oils, salts and heavy metals
Pathogens
Thermal pollution

List of most significant pollutants and environmental stressors that threaten watershed quality.

TABLE 63: RANKED STRUCTURAL/ACTION-BASED THREATS IN THE WATERSHED

Rank	Structural/Action-based Threat
1	Lake shoreline development/use
2	Impervious surface and stormwater runoff
3	Invasive species
4	Road stream crossings
5	Failing septic systems
6	Riverbank development/use
7	Agricultural runoff
8	Climate change
9	Industrial waste/oil and gas
10	Water control infrastructure
11	Recreational activity

List of threats developed and ranked by panel of experts. Rank 1 corresponds to the threat with the highest perceived negative impact.

TABLE 64: STRUCTURAL/ACTION-BASED THREATS, ASSOCIATED POLLUTANTS, AND IMPACTS

Rank	Structural/Action-based Threats	Associated Pollutants /Stressors and Rank	Causes of Pollutants/Stressors	Designated Uses Potentially Impacted
1	Lake shoreline development/use	Habitat loss (1)	Riparian vegetative buffer removal Deforestation Increased impervious surfaces	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Sediment (2)	Riparian vegetative buffer removal Deforestation Increased impervious surfaces	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Nutrients (3)	Riparian vegetative buffer removal Deforestation Increased impervious surfaces Excessive or improper fertilizer and pesticide application	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation
		Pesticides (4)	Riparian vegetative buffer removal Excessive or improper fertilizer and pesticide application	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
2	Impervious surface and stormwater runoff	Sediment (1)	Riparian vegetative buffer removal Inadequate treatment of stormwater Lack of infiltration opportunities Excessive or improper fertilizer and pesticide application	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Nutrients (2)	Riparian vegetative buffer removal Inadequate treatment of stormwater Lack of infiltration opportunities Excessive or improper fertilizer and pesticide application	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation
		Flow alteration (3)	Riparian vegetative buffer removal Lack of infiltration opportunities	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation Partial body contact recreation Full body contact recreation
		Oils, salts, and heavy metals (4)	Inadequate treatment of stormwater Lack of infiltration opportunities Road salting Vehicle discharges	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation
		Thermal pollution (5)	Lack of infiltration opportunities	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat

TABLE 64 CONTINUED: STRUCTURAL/ACTION-BASED THREATS, ASSOCIATED POLLUTANTS, AND IMPACTS

Rank	Structural/Action-based Threats	Associated Pollutants /Stressors and Rank	Causes of Pollutants/Stressors	Designated Uses Potentially Impacted
3	Invasive species	Habitat loss (1)	Inadequate boat cleaning Lack of restrictions on boat traffic Natural waterway connectivity Lack of public knowledge on impact Wildlife assisted transfer	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation Partial body contact recreation Full body contact recreation
		Flow alteration (2)	Inadequate boat cleaning Lack of restrictions on boat traffic Natural waterway connectivity Lack of public knowledge on impact Wildlife assisted transfer	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation Partial body contact recreation Full body contact recreation
4	Road stream crossings	Sediment (1)	Inadequate culvert size Inadequate erosion control Runoff from road surface	Navigation Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Habitat loss (2)	Lack of updates and maintenance Inadequate culvert size Inadequate erosion control	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Flow alteration (3)	Lack of updates and maintenance Inadequate culvert size Inadequate erosion control	Navigation Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Full body contact
		Nutrients (4)	Runoff from road surface Inadequate erosion control	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Oils, salts, and heavy metals (5)	Runoff from road surface Inadequate erosion control	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Thermal pollution (6)	Runoff from road surface	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
5	Failing septic systems	Nutrients (1)	Outdated/failing septic structures Inadequate waste regulatory legislation Lack of sewer infrastructure	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation
		Pathogens (2)	Outdated/failing septic structures Inadequate waste regulatory legislation Lack of sewer infrastructure	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation
		Other toxins (3)	Outdated/failing septic structures Inadequate waste regulatory legislation Lack of sewer infrastructure	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation

TABLE 64 CONTINUED: STRUCTURAL/ACTION-BASED THREATS, ASSOCIATED POLLUTANTS, AND IMPACTS

Rank	Structural/Action-based Threats	Associated Pollutants /Stressors and Rank	Causes of Pollutants/Stressors	Designated Uses Potentially Impacted
6	Riverbank development/use	Sediment (1)	Riparian vegetative buffer removal Deforestation Increased impervious surfaces	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Habitat loss (2)	Riparian vegetative buffer removal Deforestation Increased impervious surfaces	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Flow alteration (3)	Riparian vegetative buffer removal Deforestation Increased impervious surfaces	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Nutrients (4)	Excessive or improper fertilizer and pesticide application Riparian vegetative buffer removal Deforestation Increased impervious surfaces	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation
		Pesticides (5)	Excessive or improper fertilizer and pesticide application	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
7	Agricultural runoff and degradation	Pesticides (1)	Excessive or improper fertilizer and pesticide application	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Sediment (2)	Improper tilling practices Mowing practices Livestock use of waterbody	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Nutrients (3)	Excessive or improper fertilizer and pesticide application Improper management of animal waste Improper tilling practices Mowing practices Livestock use of waterbody	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation
		Habitat loss (4)	Mowing practices Improper tilling practices Excessive or improper fertilizer and pesticide application Livestock use of waterbody	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Pathogens (5)	Improper management of animal waste	Partial body contact recreation Full body contact recreation

TABLE 64 CONTINUED: STRUCTURAL/ACTION-BASED THREATS, ASSOCIATED POLLUTANTS, AND IMPACTS

Rank	Structural/Action-based Threats	Associated Pollutants /Stressors and Rank	Causes of Pollutants/Stressors	Designated Uses Potentially Impacted
8	Climate change	Habitat loss (1)	Increased dramatic rain events Increased summertime drought Early spring thaw Changes to temperature in water Phenology alterations	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat
		Sediment (2)	Increased dramatic rain events Early spring thaw	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Flow alteration (3)	Increased dramatic rain events	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation Public water supply Agriculture Industrial water supply
9	Industrial waste/oil and gas	Other toxins (1)	Legacy industrial waste disposal Industrial and fuel transport spills Pipeline failure	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation Agriculture Industrial water supply
		Oils, salts, and heavy metals (2)	Industrial and commercial emissions Legacy industrial waste disposal Industrial and fuel transport spills Pipeline failure	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Partial body contact recreation Full body contact recreation Agriculture Industrial water supply
10	Water control infrastructure	Flow alteration (1)	Manmade dam construction Beaver dam creation/removal	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Habitat loss (2)	Manmade dam construction Beaver dam creation/removal Inadequate dam maintenance Sediment accumulation	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Sediment (3)	Beaver dam creation/removal Inadequate dam maintenance Sediment accumulation	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation
		Thermal pollution (4)	Manmade dam construction Beaver dam creation/removal	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat

TABLE 64 CONTINUED: STRUCTURAL/ACTION-BASED THREATS, ASSOCIATED POLLUTANTS, AND IMPACTS

Rank	Structural/Action-based Threats	Associated Pollutants /Stressors and Rank	Causes of Pollutants/Stressors	Designated Uses Potentially Impacted
11	Recreational activity	Habitat loss (1)	Erosion at boat launches Foot traffic erosion Boat noise disruptions Wake-related erosion and habitat disruption	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation Partial body contact recreation Full body contact recreation
		Sediment (2)	Wake-related erosion and habitat disruption Erosion at boat launches Foot traffic erosion	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation Partial body contact recreation Full body contact recreation
		Oils, salts, and heavy metals (3)	Improper waste disposal Boat discharges	Warmwater and coldwater fisheries Indigenous aquatic life and wildlife habitat Navigation Partial body contact recreation Full body contact recreation
		Pathogens (4)	Improper waste disposal	Partial body contact recreation Full body contact recreation

Summary of threats assessed by expert panel with associated pollutants ranked by significant. Likely causes and impacted designated uses are also provided.
*k = known, s = suspected, u = unknown

4.4 CRITICAL AREAS ANALYSIS

CRITICAL COMPONENTS

The critical components identified in Figure 33 reflect the primary sources of nonpoint source pollution including agriculture, aquatic invasive species, urban areas, shoreline development, hydrologic manipulation (dams), severe impact road/stream crossings, recreational boat launches and septic systems. From this analysis, the surveys and data presented in chapters 1-3, and local expert opinions the ERCOL-WPIT identified a set of critical areas based on the concentrations of critical components. The identified critical areas, presented in Figure 34 and Table 65, are target areas within the ERCOL watershed for implementation of management efforts to achieve load reductions identified in this management plan. Critical areas are listed with assigned letters moving generally from north to south, not according to priority of importance for implementation strategies.

SITE SPECIFIC TIERS

Every significant area for remediation cannot be captured at the course scale of Figure 34. To address this concern, the following tiered ranking for any given specific site of interest can be utilized. Tiers are based on the following threat factors.

Threat Factors

1) Site is 1000 feet or less from a medium to high impact agricultural site
2) Site is 1000 feet or less from a medium to severe impact road stream crossing
3) Site is 1000 feet or less from a water control infrastructure
4) Site is 1000 feet or less from a human caused erosion feature
5) Site contains 50% or greater reduced riparian vegetation
6) Site, or general site area (such as city limits) contains 5% or greater impervious surface
7) Site is 1000 feet or less from a location where development is causing increased pollutant loading
8) Site is 1000 feet or less from a failing sewage or septic processing structure
9) Site is within 5 miles or less of a pollutant from the category "other toxins" found at a human health or habitat/native organism degrading level
10) Site is 1000 feet or less from a known invasive species
11) Site is 500 feet or less from an armored or otherwise altered stream/riverbank or lake shoreline
12) Site is 1000 feet or less from a location where pathogens have impaired a state designated use

Critical Area Tiers

A site may be classified as a level 1, 2 or 3 tier critical area if it meets a certain number of the threat factor criteria mentioned above. Tier 1 critical areas should be highest priority for some form of implementation to reduce, avoided or negate the impact of a threat factor. Tiers are classified as follows:

Tier 1 (high priority): Meets criteria for 5 or more threat factors
Tier 2 (mid priority): Meet criteria for 3-4 threat factors
Tier 3 (low priority): Meets criteria for 1-2 threat factors

In evaluating potential sites for remediation, this tiered approach should be utilized to prioritize discrete areas based on the number of identified threats.

CRITICAL COMPONENTS

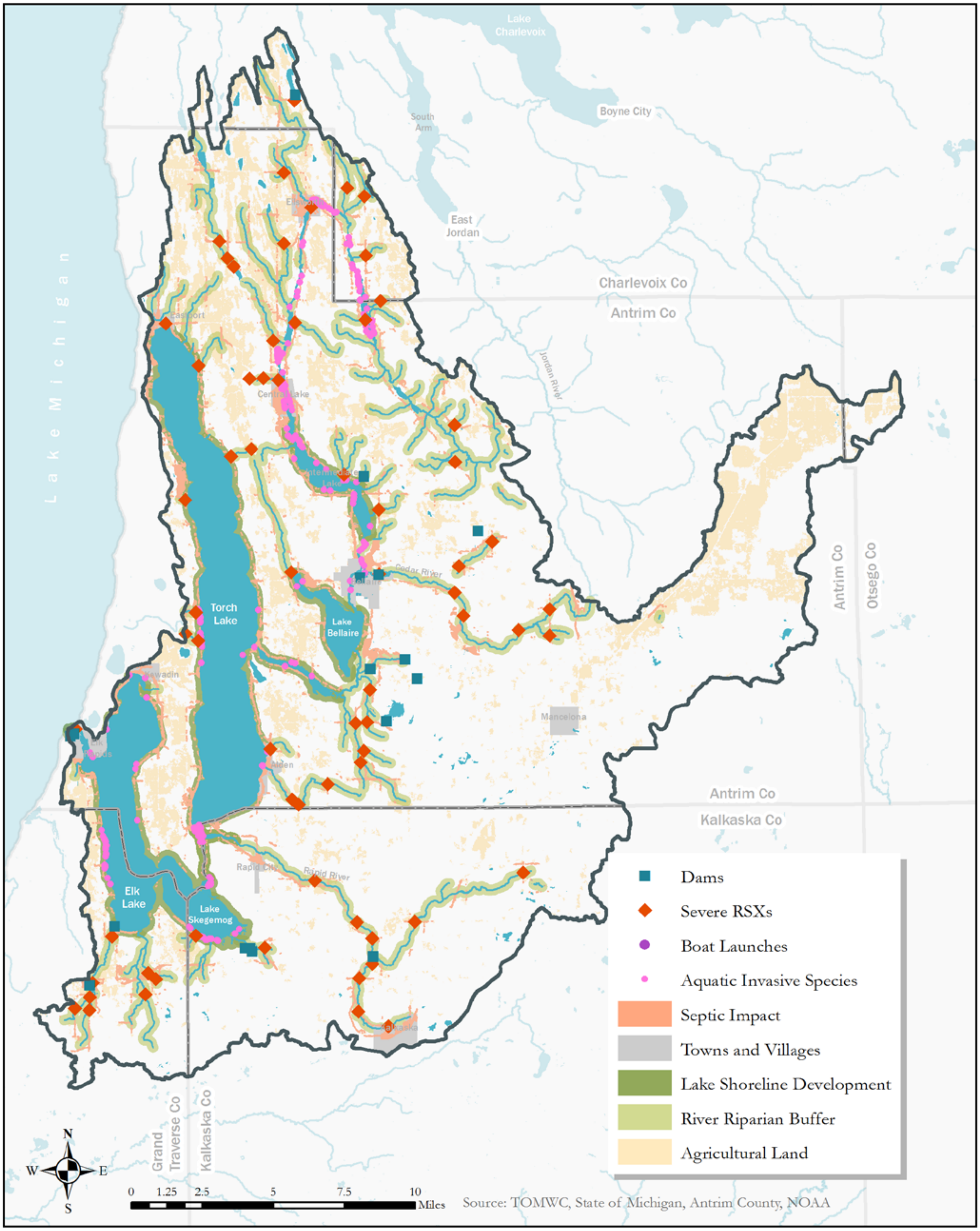


Figure 33: Critical components highlighting risk factors in the ERCOL watershed.

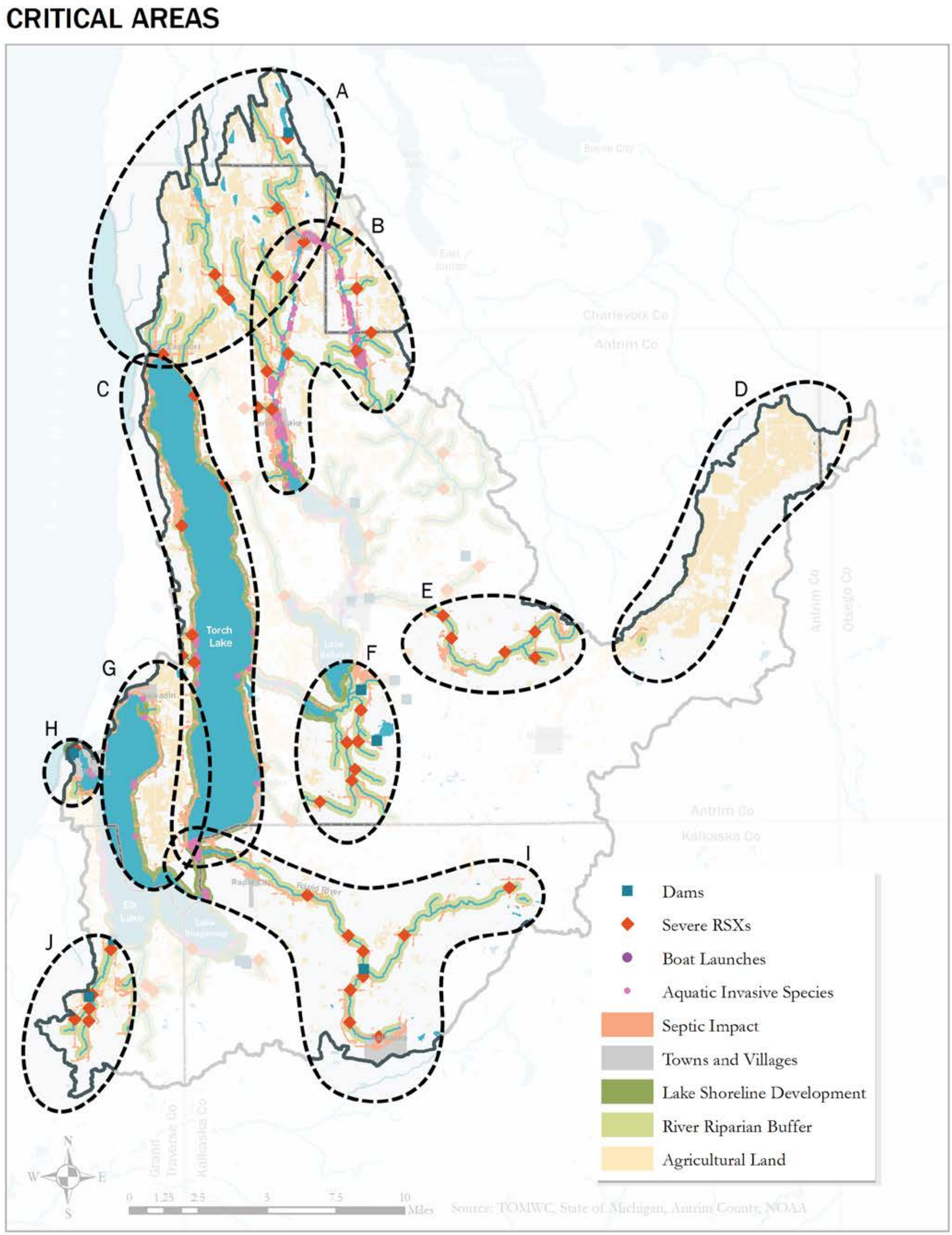


Figure 34: Critical areas for protection, intervention or remediation within the ERCOL watershed.

TABLE 65: SUMMARY OF CRITICAL AREAS

Critical Area	Reasons for Prioritization
A – Eastport to Ellsworth and northern tip of watershed	The area between and north of the villages of Eastport and Ellsworth is filled with a large number of agriculture parcels on sharply sloped terrain. While many farmers use best management practices to limit environmental impacts, others utilize techniques that cause environmental degradation and create risk to the designated uses of the watershed. Around half of the highest impact farms found in the agriculture survey were identified in this area. Problems could include tilling and mowing techniques that increase sediment and nutrient runoff, orchards that use high amounts of pesticides that quickly make their way into surface water, and livestock farms that do not contain manure and keep it out of the surface water pathways. The villages of Ellsworth and Eastport also contain high amounts of impervious surfaces and residential areas with minimal riparian buffers. A number of streams run through these villages, picking up the impacts of the impervious surfaces and reduced riparian vegetative buffers. Two creeks in this area have impaired designated uses due to high *E. coli* levels, possibly resulting from the issues mentioned above.
B – Scotts Lake to Central Lake: surface waters including lakes, connecting channels, and adjacent streams and tributaries	The lakes and connecting channels between Scotts Lake and Central Lake have a number of high priority structural/action based threats. These shallow lakes have a large number of sites in which invasive species can be found, primarily Eurasian watermilfoil and purple loosestrife. *Phragmites Australis* and Dreissenid mussels are also present in these lakes. At least 6 public boat launches in this area increase the risk of transfer and spread of non-native species. Small streams directly adjacent to a number of the lakes are also at risk for impairment from poor road stream crossing structures. Eleven structures with a severe impact rating are in this area, two of which rank in the top ten worst within the watershed. Numerous areas along the lakeshore in this area have reduced riparian vegetative buffers.
C – Torch Lake: riparian area and adjacent stream and tributaries	The areas around Torch Lake experience some of the most intense development pressures in the watershed, both historically and presently. New residencies and remodeling of existing properties has reduced riparian vegetative buffer zones in many areas. Many of these homes utilize synthetic fertilizers and pesticides for lawn care, together leading to an increase in sediment erosion and nutrient and pesticide loads along lakefront properties. Inadequate septic treatment is also potentially increasing nutrient and *E. coli* loads to the lake. The small streams and tributaries around the lake are found on highly steeped slopes running through sandy soils. At least three main culverts are not placed properly and have 1-3 feet perches on the downstream side. These were ranked as three of the worst crossings in the entire watershed. Eight public boat launches, several private marinas, and hundreds of private docks display the prevalence of recreational boating in this area. While boats can be low impact, high wakes, loud engines, and waste from recreational boats carry risk of negative impacts.
D – Far east arm of watershed: agricultural area along highway 131	A large number of potato farms and other agricultural crops are grown along the flat lands in this arm of the watershed. This area is an important groundwater recharge area for the watershed and improper use of fertilizers and pesticides could seriously jeopardize groundwater health.
E- Cedar River south branch	The south branch of the Cedar River has a number of severe impact road stream crossings. The highest sediment loads from a road come from a crossing near the headwaters of the river. Naturally high velocities combined with inadequately sized culverts creates increased sediment loads along the river.

TABLE 65 CONTINUED: SUMMARY OF CRITICAL AREAS

Critical Area	Reasons for Prioritization
F – Shanty, Cold and Finch Creeks and tributaries	These creeks have problems resulting from development pressures, water control infrastructures, and road stream crossing infrastructure. A significant acreage within these creeksheds has been converted from forest to human landscapes such as lawns, roads, and golf courses. Clearing of vegetation within the riparian buffer on residential properties leads to increased sediment and nutrient loading. Four small dams are in this area, two of which were found to be nearly completely failing while the other two each had structural integrity issues. The breaking or leaking of these dams also contributes to increased sediment loading. Five severe impact road stream crossings are in this area, with undersized culverts limiting fish passage. All three of these creeks are designated as coldwater fisheries, but sediment loading and fish habitat fragmentation put this use at high risk.
G – Area between Elk Lake and Torch Lake south to Kewadin	This area has topography with high elevation and steep slopes and a large number of high impact agricultural sites. Some of these sites are likely to have a negative impact on nearby surface waters. This problem is compounded by the fact that the lakeshore areas around this land are highly developed with limited riparian vegetative buffers.
H – City of Elk Rapids	Increased impervious surfaces and complexities of sewage treatment due to higher population density lead to impairments caused by nutrient and sediment pollutions. In addition a number of dams at the outlet of Elk Lake create a potential barrier to aquatic species and create habitat fragmentation.
I – Rapid River: connecting tributaries and riparian land area	The Rapid River faces risks of degradation from aging water control infrastructure and inadequate road stream crossing structures. The Rug Pond dam, just downstream of where the two main branches of the river converge, has faced problems from lack of maintenance and large sediment back-ups behind the dam. A failure of this dam could cause severe environmental degradation and impair many of the river's designated uses. Road stream crossings too narrow to accommodate the swift and wide river alter flow regimes and contribute to increased sediment loading, leading to sediment build up issues along several portions of the river.
J – Williamsburg Creek and community of Williamsburg	This creek has two dams and four severe impact road stream crossings, similar issues to the Rapid River on a smaller scale. In addition, the unincorporated community of Williamsburg is a small urban area that has been seeing increased development pressure potentially leading to increased nutrient, pesticide and sediment runoff.

4.5 PRIORITY PARCEL ANALYSES

Data driven, composite analyses are an effective method for prioritizing watershed management efforts. With limited resources available, actions organized around goals and objectives should be concentrated in the areas in which they will have the most beneficial impact. Two separate priority parcel analyses were completed within the ERCOL watershed. The first, *Priority Parcel Analysis – Watershed Protection*, was conducted by a team of graduate students from the University of Michigan School of Natural Resources and Environment in consultation with The Tip of the Mitt Watershed Council, and is principally focused on water resource protection. The second, *Priority Parcel Analysis – Land Conservation*, was conducted by the Grand Traverse Regional Land Conservancy and focuses on highlighting areas with highest conservation potential.

There are noticeable similarities between these two analyses, both in the criteria utilized and spatial output. Though it is important to present both within the context of this comprehensive management plan. Neither prescribe a narrow course of action, but suggest generalized spatial prioritization. Additional information regarding the criteria utilized and the analysis process, as well as the final maps for each composite analysis, are provided below. Both Analyses are intended to be updated on a regular basis to account for the most up-to-date spatial data available to TOMWC and GTRLC.

PRIORITY PARCEL ANALYSIS – WATERSHED PROTECTION

Properly preserving and managing waterways within the ERCOL warrants effective regulation and stewardship to limit the detrimental impacts of concentrated development, high impact land uses, and nonnative species. Permanent protection of lands with notable value to the health of the watershed is one of the most effective tools in watershed management.

The GIS-based multi-criteria Priority Parcel Analysis (PPA) layered multiple spatial data sets and calculated a preservation value score for each parcel in the watershed. While many of the data layers used in the ERCOL PPA are from public sources, the method of collecting, analyzing, and scoring the different ecological evaluations is novel and forward looking. For example, a unified scoring system helps quantitatively assess the impacts of development, the ecological value of groundwater recharge, and numerous other factors. This system is based on local knowledge and previous iterations of similar analyses in neighboring watersheds. The Tip of the Mitt Watershed Council has been conducting PPA analyses since 2006. Each iteration has refined the process in both the utilization of GIS functionality and calibrating the predictive power. A full description of assessed factors can be seen in Appendix E and a general description of the criterion is presented below:

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.

Ground Water Recharge Potential: Healthy groundwater recharge is essential for the maintenance of the coldwater fisheries that prevail in watersheds of the northern Lower Peninsula. Areas with highly permeable soils allow precipitation to percolate through the soils and recharge ground water supplies. Predominant soil type and associated permeability were determined for each parcel using the physical properties found in county soil surveys (available through Natural Resource Conservation Service). Parcels were scored based on the proportion of soils conducive to ground water 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 was utilized to determine the proportion of wetlands on each parcel and an associated score was assigned.

Lake and Stream Riparian Ecosystems: Activities on land immediately adjacent to a waterbody are critically important to maintaining water quality and ecological health. Parcels 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. High quantities 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: Parcels adjacent to protected lands, such as nature preserves or conservancy lands, have a high ecological value because they provide a buffer to these protected area, increasing the contiguous protected area and expanding biological corridors for species migration and interaction. Parcels bordering local or state government land and conservancy properties were identified and scored based upon the common perimeter shared with protected lands. Parcels 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 in the context of watershed protection as they serve as indicators of environmental quality. 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 assessed 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 significant gain in terms of ecosystem preservation. NOAA CCAP (Coastal Change Analysis Program) land cover data and verified 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 tends to contain a greater diversity of habitat and species, is more resilient to invasion by non-native species, and often holds more ecological value than developed land. NOAA CCAP land cover data was used to determine a percent coverage of natural land cover types for each parcel and was scored accordingly.

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 rain water. 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. This analysis defined these areas locally occurring conditions that are rare, vulnerable to degradation, and have high intrinsic value. Blue ribbon trout streams, old growth forests, and undeveloped lakes were accounted for in this criteria.

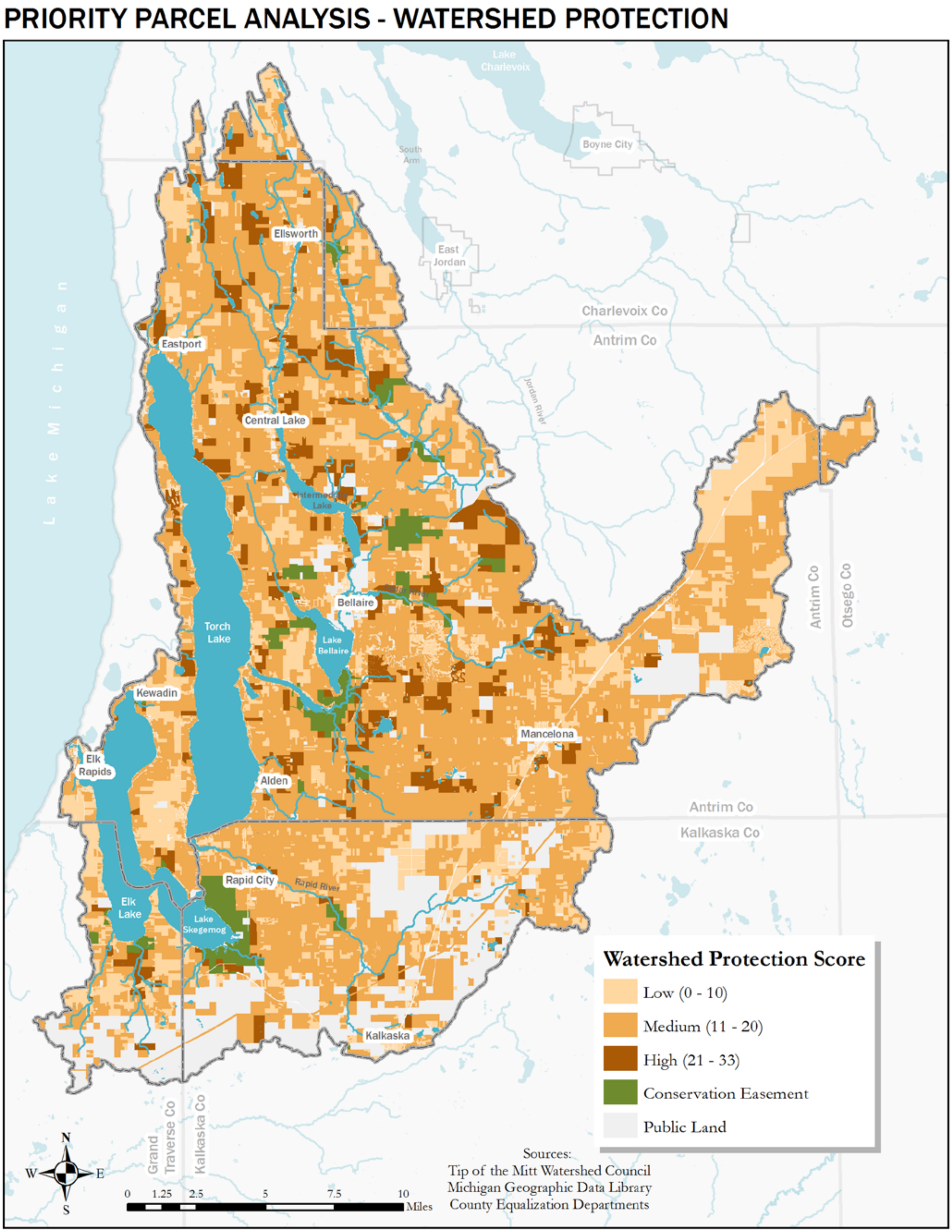


Figure 35: Priority Parcel Analysis targeting significant areas for conservation with regard to watershed protection.

PRIORITY PARCEL ANALYSIS – LAND CONSERVATION

Land conservation efforts are focused on permanently protecting crucial wildlife habitat and corridors; critical watersheds, which protect the water quality of our region; unique high-quality farm lands; valuable forestland; and ecologically significant dunes along Lake Michigan's beautiful and endangered shore. The Grand Traverse Regional Land Conservancy (GTRLC) seeks to accomplish these goals in several different ways:

- Working with landowners to permanently protect private land through voluntary conservation easements
- Acquiring high quality natural lands by purchase or donation to create Conservancy owned nature preserves which are open to the public
- Assisting local units of government in creating or expanding public parks and natural areas that result in enhanced public access to nature and improved recreational opportunities
- Providing technical assistance to local units of government with the administration of farmland protection programs

Antrim, Grant Traverse, and Kalkaska counties account for a large portion of the ERCOL watershed. GTRLC has conducted an analysis of the parcels within these three counties with regards to each parcel's potential value in permanent protection for purposes stated above. A general description of the criteria is listed below:

Parcel Size: Large areas of land are more likely to support and sustain ecosystems and their associated functions. Additionally, temporal and monetary resources required to preserve a parcel have little relation to parcel size. Therefore, preserving large parcels is a more effective way of achieving GTRLC's land preservation goals. Only parcels greater than 18 acres in size were considered in this analysis with larger parcels receiving a higher score.

Adjacency to Protected Land: Areas that are already protected provide a valuable framework from which to expand conservation efforts. Building on protected areas increases the spatial integrity and connectedness of natural lands while reducing the potential for habitat fragmentation. In this analysis, protected land includes areas protected by GTRLC, owned by State, County, or Township governments, or other areas designated for open space of nature preservation by various organizations.

Size and Contiguity of Wetlands: Wetlands serve many functions including flood mitigation, nutrient and pollution sequestration, and provide recreational opportunities. Wetlands that are hydrologically connected to groundwater may play a role in the recharge and discharge of aquifers. Parcels containing wetlands were scored based on the size of wetland and whether such wetlands were part of a connected system. Data from the National Wetlands Inventory was used for this analysis.

Length of Shoreline: Riparian systems provide important wildlife corridors and are often sources of high species diversity and productivity. Furthermore, these areas play a critical role in protecting water quality by acting as a buffer between terrestrial and aquatic ecosystems. Scores were based on the length of shoreline contained within a parcel.

Habitat Fragmentation: Fragmented landscapes increase the occurrence of isolated systems and contribute to a loss of biodiversity. Fragmentation may also result in a loss of genetic diversity in wildlife populations, increased susceptibility to invasive species, and reduced dispersal rates. Habitat fragmentation is included in this analysis to account for ecosystem integrity.

PRIORITY PARCEL ANALYSIS - LAND CONSERVATION

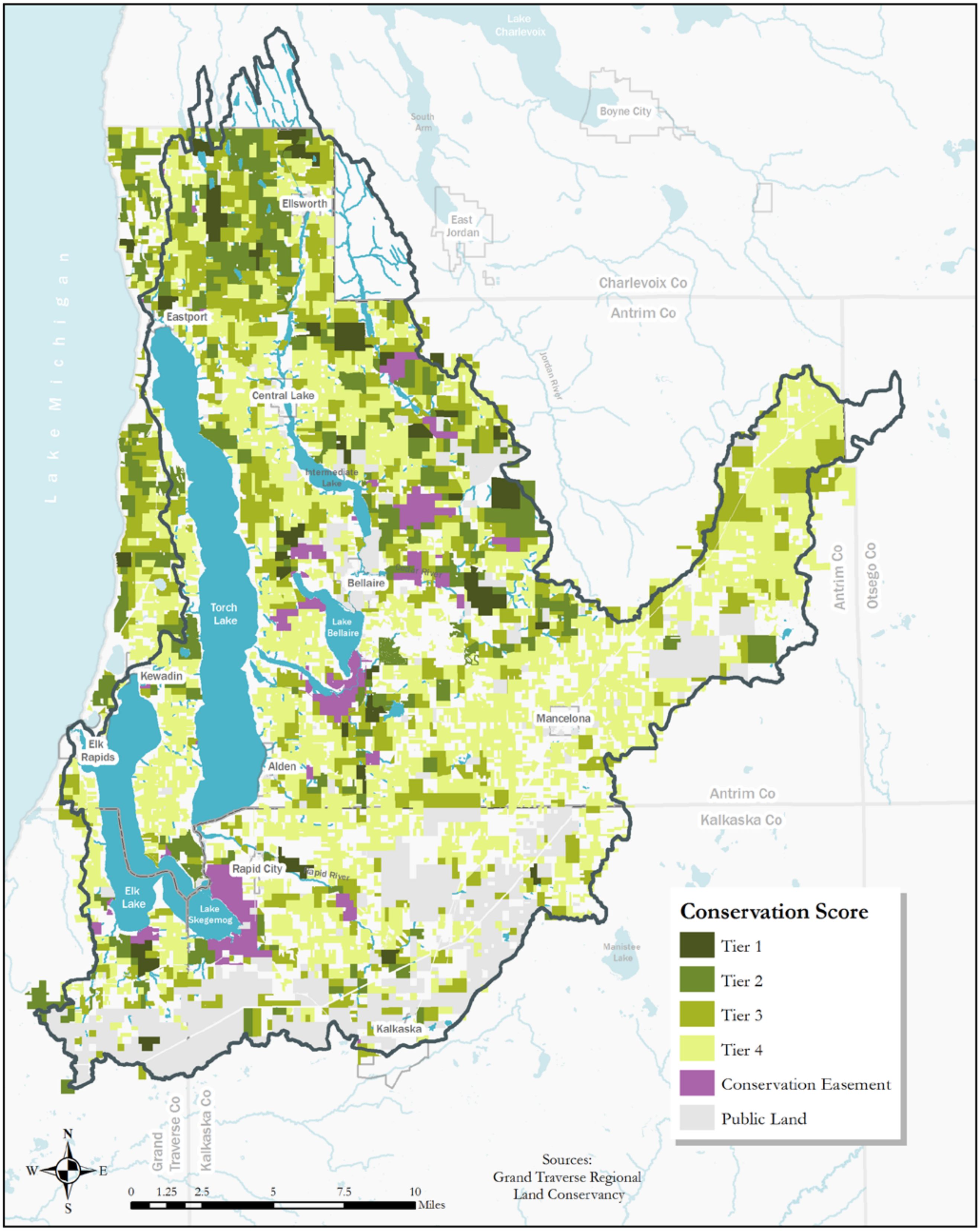


Figure 36: Priority Parcel Analysis targeting significant areas for conservation with regard to land protection.

CHAPTER 5
PREVIOUS EFFORTS IN THE WATERSHED

CHAPTER 5: PREVIOUS EFFORTS IN THE WATERSHED

5.1 INTRODUCTION

There are numerous organizations working within the Elk River Chain of Lakes Watershed to improve and maintain water quality and ecological habitat and provide educational opportunities to local stakeholders. This chapter seeks to highlight these types of activities conducted by local non-profit and municipal organizations over the ten years prior to the writing of the watershed management plan. This information was garners from of the Elk River Chain of Lakes Watershed Plan Implementation Team (ERCOL-WPIT) member organizations and a thorough examination of their web-based resources. Efforts were categorized into structural and non-structural 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. They 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. 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, protect sensitive areas such as wetlands and riparian areas, and maintain 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.

5.2 STRUCTURAL BEST MANAGEMENT PRACTICES

Road Stream Crossing Improvement - Aarwood Road Bridge on the Rapid River

The Aarwood Road crossing had a deteriorating 60 foot undersized bridge that was restricting the natural movement of the river, contributing to a substantial amount of sediment and degrading habitat. As the lowest crossing on the Rapid River, it was a barrier to aquatic species movement along the entire river. The bridge was replaced in 2012 with a 108 ft. channel-spanning concrete bridge. The new bridge is a significant improvement matching the Rapid River's natural hydraulics and channel form and improving the passage of fish and other aquatic species by opening up an additional 45 miles of river (Conservation Resource Alliance, 2013)

Road Stream Crossing Improvements - Hanson Road, Kellogg Road, Deal Road

Three critical road stream crossings were improved using a DEQ Nonpoint Source Pollution - Clean Michigan Initiative (CMI) grant's funding, through The Watershed Center. The first of the two road projects completed adjacent to the Rapid River was at Kellogg Road, where a 3,600 ft. stormwater conveyance channel, infiltration ditch, and stabilized outlet to the river were installed. The second project was along Hanson Road where a 1.8-acre sediment basin was constructed to capture sediment from road runoff before entering Rapid River. The crossing of Deal Road at Battle Creek, which empties into Elk Lake, had significant sedimentation issues and a culvert which was too short for the width of the road. CMI funds were used to replace the culvert, stabilize the outlets, and re-grade and pave the road. It's estimated that more than 800 tons of eroded sediment have been prevented as an outcome of these three RSX improvements. (The Watershed Center, n.d.)

Road Stream Crossing Improvements – Road Commissions

A comprehensive list of RSX improvements completed by Antrim and Kalkaska County road commissions is included in Appendix G.

Riparian Buffer Improvements - Twin Birch Golf Course, Helena Township, Milton Township

The Watershed Center Grand Traverse Bay coordinated several critical riparian buffer improvements to help prevent excess erosion and nutrient runoff. These efforts included bank stabilization and planting vegetative riparian buffers along 700 ft. of the Boardman River at Twin Birch Golf Course outside the town of Kalkaska, on the southern arm of the watershed. Additional riparian vegetative buffer zones were installed at Valleau Landing in Helena Township and the Waring Road Extension in Milton Township, both projects helping to protect water quality on Torch Lake. (TWC, 2009)

Stormwater Management - Rugg Pond

Rugg Pond is positioned on Rapid River, one of the largest river courses in the ERCOL watershed. Two stormwater management projects were completed by The Watershed Center Grand Traverse Bay and the Kalkaska Conservation District to manage runoff into the pond and river. The Rugg Pond parking bioretention basin was constructed with 1,570 cubic feet of storage, and the new boat ramp includes 350 square feet of pervious pavement. It is estimated that the cumulative benefit of these projects is 67 tons of prevented sedimentation and nutrient loading reductions of: 266 pounds of phosphorus and 111 pounds of nitrogen. (TWC, n.d.)

Loon platforms

Intermediate Lake Association, Friends of Clam Lake, Six Mile Lake Association and Three Lakes Association collaborated with the Loon Network on the installation of artificial nesting islands (ANI) for loons. Twenty-one ANIs have been installed on 11 lakes. In addition, 12 buoys have been installed on 4 lakes and 27 signs have been installed at boat launches and marinas to caution boaters to not disturb loon habitat. (Loon Network, n.d.)

Large Woody Debris (LWD) Demonstration Project

A Waterways Work Group in Antrim County is coordinating the efforts of several organizations, including Grass River Natural Area, Three Lakes Association, Elk-Skegemog Lakes Association, and Antrim Conservation District to install a pilot project of several log structures (large woody debris) along the banks of the Grass River between Lake Bellaire and Clam Lake on the Elk River Chain of Lakes. This is a small-scale demonstration project designed to do two things: First, to determine if log structures can improve the aquatic habitat of a river laden with a heavy load of sediment. Second, to determine if log structures along the banks of Grass River could be a useful technique to improve the navigability of a connecting river by deepening portions of the channel that have become shallow, due to the buildup of sediment. If successful, the log-structures technique could be applied at a number of sites on the connecting channels throughout the Chain of Lakes. This project is based on recommendations from river sedimentation studies carried out by the ERCOL-WPIT in prior years. (Three Lakes Assocation, n.d.; Tip of the Mitt Watershed Council, 2014)

Fish shelters

An ongoing initiative has been undertaken by Three Lakes Association, The Watershed Center Grand Traverse Bay, Friends of Clam Lake, Antrim Conservation District, Tip of the Mitt Watershed Council, Elk-Skegemog Lakes Association, and Intermediate Lake Association to improve the recreational fisheries of the watershed's lakes. Beginning in 2012, this five-year program planned to deploy fish shelters at 80 sites in 15 to 20 feet of water in 5 of the watershed's lakes. This project is taking place in Torch Lake, Clam Lake, Lake Bellaire, Intermediate Lake, and Elk Lake. Fish structure deployment has already begun within the watershed (see Figure 37 for installed fish shelter locations) and it is the hope of all organizations involved that the program will continue until all fish structures have been placed. Positive results have already been seen at fish shelter sites as a variety of fish species are rapidly colonizing many of the structures (Varga, 2012). In the future the project may be expanded to include aquatic habitat improvement in shallow water.

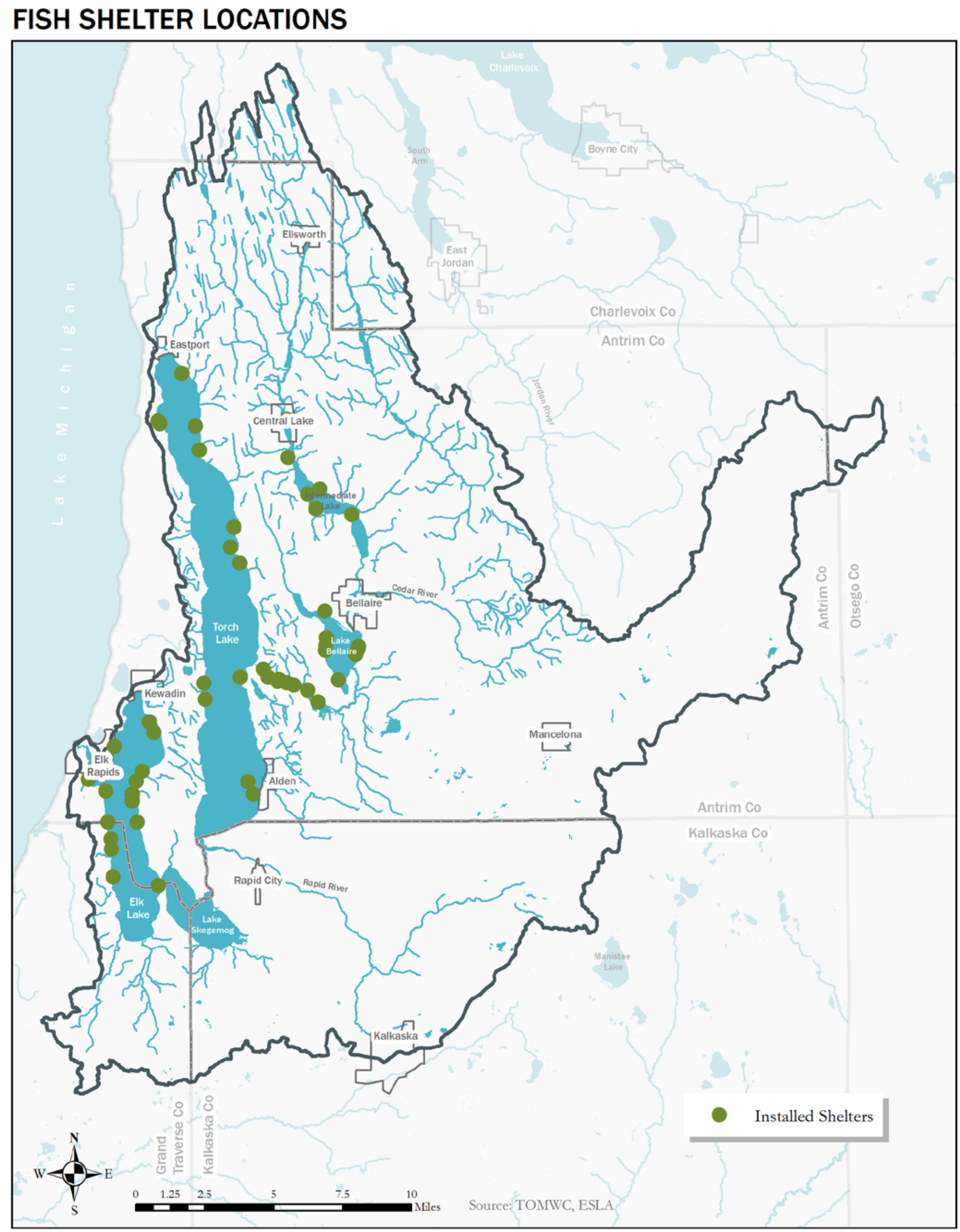


Figure 37: Fish shelters installed in the ERCOL watershed.

5.3 NON- STRUCTURAL BEST MANAGEMENT PRACTICES

EDUCATION AND OUTREACH

Science Education Outreach Program

The Three Lakes Association (TLA) Science Education Outreach Program (SEOP) was started in 2008. The goal of the program is to help develop future stewards of the water of Northwest Michigan. TLA has provided almost $60,000 for science education, including class trips on the Inland Seas Schoolship for each school district. (TLA, n.d.)

Water Awareness Day

In July 2014, Three Lakes Association sponsored its first Water Awareness Day. This was an educational event for the community which included a variety of exhibits around the topics of fish habitat/shelters, invasive species, and local pollution. Proceeds from this event supported the TLA Science Education Outreach Program. Water Awareness Day is planned as an annual event. (TLA, n.d.)

Paddle Antrim Festival

Paddle Antrim is quickly gaining recognition for bringing awareness to the amazing treasures of Antrim County's Chain of Lakes and the wonderful communities along the water trail. The first Paddle Antrim Festival was held on September 18 and 19, 2015. The event was highlighted by a two-day kayak paddle through Antrim County's Chain of Lakes and five communities.

The two day paddle included most of the Upper Chain of Lakes, beginning in Ellsworth. The first day meandered along a peaceful 15 miles course through many small lakes from Ellsworth to Bellaire, a must-see with waters calm enough for beginning kayakers to enjoy. The second day was a 27 mile paddle from Bellaire through the Lower Chain of Lakes including the picturesque Torch Lake to Elk Rapids.

Paddle Antrim is dedicated to giving back by providing mini-grants for projects focused on water resources education, stewardship, and increasing access to the water for everyone. (Paddle Antrim, n.d.)

Local Government Workshops

The ERCOL-WPIT has held four Annual Local Government Education and Outreach Events. These events update Local Elected Officials about progress made in implementing management plans. They also highlight opportunities for local governments to participate in watershed plan implementation, including on-the-ground projects and writing letters of support. (TOMWC, n.d.)

Invasive Species Education and Boater Outreach

The Watershed Center has engaged in various education and outreach programs regarding invasive species control and proper boating practices. These activities include newsletters to all riparian residents, handing out information at boat launches and marinas, conducting regional meetings on invasive phragmites management, and installation of educational signage throughout the watershed. (TWC, n.d.)

Elk-Skegemog Lakes Association performs education and outreach regarding invasive species including newsletters and information on their website. They also conduct boater safety education. (Elk-Skegemog Lakes Association, n.d.)

Joint Education Events

Several lake associations including Three Lakes Association, Torch Lake Protection Alliance, Friends of Clam Lake, and Intermediate Lake Association in partnership with Grass River Natural Area, Antrim Conservation District, and Tip of the Mitt Watershed Council host joint education events approximately twice a year. Past topics have included riparian rights and responsibilities, fishing, boater safety, dams and water levels, updates on the Mancelona TCE (trichloroethylene) plume and hydraulic fracturing for gas and oil exploration. (Friends of Clam Lake, n.d.)

Torch Conservation Center Information

The Torch Conservation Center is a newly formed organization with excellent resources for landowners and visitors to lead a water-friendly lifestyle. Their website (www.conservetorch.org) includes helpful education information regarding watershed and water quality in the Waterpedia section, and also promotes child focused activities such as: The Magical History Tour, 11 Adventures Before you Turn 11, and the Backyard Treasure Hunt, which encourage children to learn and appreciate the assets in and around Torch Lake. (Torch Conservation Center, n.d.)

Low Impact Development Workshop

On May 1st 2015 the Watershed Council Grand Traverse Bay hosted a Low-Impact Development (LID) seminar for engineers, architects, landscape architects, and other affiliated professions. Leading stormwater management experts presented the all-day program, which included a wealth of information regarding LID techniques, economics, and case studies. (TWC, n.d.)

Stormwater Management Tour

In August 2015, The Watershed Center Grand Traverse Bay hosted a Watershed Protection Tour for local government officials. The tour included visiting the Little Traverse Bay watershed's water resources while emphasizing the best management practices needed for water quality protection. (TWC, n.d.)

Summer Intern Program

Since 2004, Three Lakes Association has sponsored a high school summer internship program under the direction of their executive director. Each year, the interns study the aquatic environment. The internship includes over 300 hours of research, training, and sampling. (TLA, n.d.)

Elk-Skegemog Lakes Association sponsors three interns each year. Past internship programs have included collecting and analyzing water quality chemistry and flow data, macroinvertebrate sampling, and invasive species assessment. (ESLA, n.d.)

Other Classes and Events

Grass River Natural Area offers a wide selection of classes and events for all ages. Past classes include butterfly, bird and tree identification, maple tree tapping, natural history, and art, literacy and exercise related to the natural environment. (Grass River Natural Area, n.d.)

Road Cleanups

Six Mile Lake Association organizes yearly road cleanups of M-66 and Old State Road as part of its participation in the Michigan Department of Transportation's (MDOT) Adopt-A-Highway program. (Six Mile Lake Association, 2016). Adopt-A-Highway is an MDOT program designed to help keep the state's highway roadsides clean and attractive. Participants adopt both sides of a section of state highway roadside to clean up over a two-year period. (Michigan Department of Transportation, n.d.)

ASSESSMENT AND MONITORING

Loon Monitoring

The Loon Network, a project of Michigan Audubon, is working to re-establish common loons in the Elk River Chain of Lakes watershed. Intermediate Lake Association, Elk-Skegemog Lakes Association, Friends of Clam Lake and Six Mile Lake Association collaborate with the Loon Network and Common Coast Research & Conservation, Inc. on monitoring, banding, and public education. Seventy-two loons (33 adult and 39 juvenile) common loons have been color-marked between 2010 and 2015. Because common loons are a threatened species in Michigan, this activity is undertaken with the utmost care and respect for the safety and health of the birds. This banding activity is conducted late at night, with a proven safe and effective capture method that has been used for 20 years.

Feather and blood samples are taken during banding in order to test for mercury levels. Botulism is another threat to migrating loons on Lake Michigan. Beach rangers monitor 25 miles of Lake Michigan shoreline in Antrim County and report dead loons. The Loon Network cooperates with The Watershed Center Grand Traverse Bay and the Northern Lake Michigan Botulism Network to monitor loon die-offs. (Loon Network, n.d.)

Six Mile Lake – Special Assessment District for Invasive Species Treatments

Six Mile Lake Association (SLMA) members came together in 2013 to finalize a plan to implement a Special Assessment District (SAD) to address invasive species that threaten or alter lake quality. SMLA worked closely with both Echo and South Arm Townships to ensure the passage of the SAD, which raises funds from lakefront and non-front (with shared access) property owners and allows the lake to be managed as a whole. The funds raised are used to treat excessive algae and invasive species such as Eurasian watermilfoil. Since its passage of the SAD, SMAL has partnered with PLM Lake Management (PLM) to treat Six Mile Lake. PLM completed an Aquatic Vegetation Assessment Site (AVAS) survey in 2012 as part of its initial assessment of the lake. As of June 2012 Eurasian watermilfoil was estimated to have a cumulative cover of 31.97%, and variable leaf milfoil had a cumulative cover of 10.89%. Further water quality monitoring and aquatic plant surveys are included as part of PLM's management plan. (PLM Lake & Land Management, 2012; SMLA, n.d.)

Torch Lake Sandbar - Collaborative Water Quality Monitoring

Local residences have raised concerns over potentially unsafe water conditions on the Torch Lake Sandbar during the 4th of July festivities. In the absence of water quality information on the Sandbar, a study was jointly undertaken by the Three Lakes Association and the Torch Lake Protection Alliance over this holiday weekend in 2015. The purpose was to determine the impact of high human occupancy during the holiday on E. coli and ammonia levels. Water samples for E. coli analysis were collected from 12 sites and water samples for ammonia were collected from 3 sites. Both morning and afternoon water samples on July 3rd and the morning water samples on July 4th ranged from 0-7 cfu/100ml. E. coli counts increased in the water samples collected during the afternoon of July 4th and in samples collected in the morning and afternoon of July 5. Most of the water samples had E. coli counts ranged from 7-185 cfu/100ml but two water samples had E. coli counts above 300 cfu/100 ml (one at 308 cfu/100 ml and one at 1300 cfu/100 ml). (Three Lakes Association / Torch Lake Preservation Alliance)

Comprehensive Water Quality Monitoring Program

The Comprehensive Water Quality Monitoring Program was launched by Tip of the Mitt Watershed Council in 1987, with subsequent field data collection in 1992, 1995, 1998, 2001, 2004, 2007, and 2010. Initially, physical and chemical data were collected on 10 lakes but the program has progressively expanded and, as of the 2010 field season, 143 samples were collected from 60 sites on 55 lakes and streams. Typically, data for nine parameters (temperature, dissolved oxygen, pH, conductivity, clarity, total phosphorous, total nitrogen, nitrate-nitrogen, and chloride) are collected at the surface, middle, and bottom of the water column in each water body. This highly-accurate water quality data for lakes and rivers in Northern Michigan, collected consistently for the last 20+ years, have been compiled into a single database that can be used by staff to evaluate aquatic ecosystem health, examine trends within or among water bodies, and identify specific problems. (TOMWC, n.d.)

MiCorps Cooperative Lakes Monitoring Program

Three Lakes Association participates annually with the MiCorps Cooperative Lakes Monitoring Program (CLMP) to assess water quality in Lake Bellaire, Clam Lake and Torch Lake. Please see Chapter 2 for more information about this project. (TLA, n.d.)

Lake Characterization and Trophic Status

Data collected by volunteers in the Volunteer Lake Monitoring program are used by Watershed Council staff to determine the current level of productivity or the "trophic status" of a lake. Lakes are classified according to their trophic status, which ranges from oligotrophic (low productivity) to eutrophic (high productivity). Rapid changes in lake productivity over time can be a sign of human induced nutrient loading via nonpoint source pollution or a sign of changes to a lakes food web. (TWC, n.d.)

Aquatic Vegetation Surveys – Lake Bellaire and Clam Lake

During the summer and fall of 2013, Tip of the Mitt Watershed Council staff collected specimens and documented plant densities at 420 sites throughout Bellaire and Clam Lakes, 241 sites in Bellaire, and 170 in Clam. A total of 27 aquatic plant taxa were documented on Lake Bellaire while 28 taxa were found on Clam Lake. Aquatic plant communities were delineated directly in the field using a GPS or indirectly through interpolation or extrapolation of sample site data. Plant community data showed that a majority of Lake Bellaire (82%) contained little or no aquatic vegetation. Conversely, nearly 70% of Clam Lake contained aquatic vegetation. (TOMWC, n.d.)

Torch Lake Buffer Survey

In 2007, The Watershed Center Grand Traverse Bay conducted a survey of Torch Lake's 41-mile shoreline to assess its greenbelt buffer. The shoreline zone extends 50 feet inland from the ordinary high water mark. Funding for this survey of Michigan's largest inland lake was provided by the Michigan Department of Environmental Quality. All 1,752 properties were surveyed around the lake. The Watershed Center contracted with White Pine Associates and 20 volunteers from the Torch Lake Protection Alliance and Three Lakes Association provided field assistance.

Some general results of the survey show that:

- 86% of the shoreline is developed
- 32% of the greenbelt buffer is in very good to excellent condition; 44% is in poor to very poor condition
- 7% of the shoreline erosion is severe

Public Land Riparian Survey

In 2008 The Watershed Center Grand Traverse Bay, in partnership with the Grand Traverse Conservation District, inventoried riparian buffers on all public lands in the watershed. This survey assessed the physical condition of the riparian edge of all public and semi-public lands with the Grand Traverse Bay watershed, which encompasses the ERCOL watershed. (TWC, n.d.)

Small Dam Inventory

In June 2014 The Watershed Center Grand Traverse Bay conducted an inventory of small dams on both public and private property (with permission). This included measuring dam height, the habitat types above and below the dams, and water velocity. Support for this project was provided by the Grand Traverse Bay Watershed Stormwater and Restoration Initiative project funded by the Michigan Department of Environmental Quality. One of the goals of the project was to identify small, unpermitted dams and help interested homeowners obtain grant money to maintain or remove those dams. (TWC, n.d.)

Grass and Rapid River Road Stream Crossing Inventory

The Grass and Rapid Rivers Road/Stream Crossings Inventory was coordinated by The Watershed Center (TWC) and Tip of the Mitt Watershed Council (TOMWC). Volunteers carried out the inventory during the summer of 2011 following a training session in methodologies provided by TWC. The Grass River inventory was conducted by volunteers from Three Lakes Association and Friends of Clam Lake, whereas the Rapid River inventory was performed by volunteers from the Elk-Skegemog Lakes

Association. Volunteers used methods outlined in the Great Lakes Road Stream Crossing Inventory Instructions booklet (TOMWC, 2013).

Lake Bellaire Shoreline Survey Summary Report

During the summer of 2008, a survey was conducted of the greenbelt buffer along the entire 10.6 mile shoreline zone of Lake Bellaire. This survey was carried out by Three Lakes Association with high school interns from Elk Rapids, Central Lake, and Bellaire. Throughout the summer, 293 properties were surveyed. For the purposes of the survey, the shoreline zone extended 25 feet inland from the ordinary high water mark. Data was recorded on a survey sheet by trained observers. A survey form was completed and a photograph was taken of each property. (TLA, n.d.)

Clam Lake Boat Capacity Study

Friends of Clam Lake (FOCL) conducted an annual survey of the number of watercraft on Clam Lake in 2008 and 2010-2015. These surveys also documented traffic entering or leaving the lake on Clam River or Rapid River. The purpose of these surveys were to establish a baseline of water traffic during a typical summer day, which FOCL hopes any interested party such as local government officials can use as a reference point. (Friends of Clam Lake, n.d.).

Clam Lake Shoreline Survey

During the summer of 2008, trained volunteers from the Friends of Clam Lake and Three Lakes Association conducted a greenbelt buffer survey around the 8.8 miles of Clam Lake shoreline. The purpose for this survey was to:

1. Establish a baseline status of the current shoreline greenbelt.
2. Build awareness about the value of shoreline greenbelts among lake front property owners, both public and private.

The survey consisted of:

- An objective record of the current shoreline through observation, lakeside photographs and aerial photography.
- A subjective evaluation of the 25 ft greenbelt buffer based on a methodology developed by the Tip of the Mitt Watershed Council and The Watershed Center.
- The methodology did not evaluate docks, the number of boats in the water at these docks, or the number of boats at moorings.

Shoreline Algal Survey of Torch Lake, Clam Lake, and Lake Bellaire

In the summer of 2010 the Three Lakes Association, with the support of the Grand Traverse Regional Community Foundation, conducted the latest in a series of Cladophora surveys on Torch Lake, Clam Lake, and Lake Bellaire. A team of TLA volunteers and high school interns using kayaks examined the entire shoreline of these lakes. Wherever Cladophora or Cladophora-like algae was found near the shore, the locations were logged with a Global Positioning System (GPS), the size of the bloom noted, and samples taken. This survey was carried out weekly over the course of five weeks. The goal was to locate places where phosphorus nutrients are coming into the lakes and use them as a roadmap for future examinations of the sources. A similar algal survey was conducted in 2004. Due to the large variability noted in the 2004 and 2010 surveys, the 2010 report recommended both taking more frequent surveys and to take additional measurements such as phosphorous concentration. (TLA, 2010)

MODELING AND REPORTS

Chain of Lakes Progress Reports

In 2009 and 2010, annual reports were created to chronicle activities and success stories within the Chain of Lakes. These reports captured education, management, and project installation activities, and also served as an educational tool for high school students, farmers, volunteers, and management professionals. They were produced and distributed by The Watershed Center Grand Traverse Bay. (TWC, n.d.)

Stormwater Assessments - Local Towns and Villages

In 2013 and 2014 staff from The Watershed Center Grand Traverse Bay and the Antrim Conservation District conducted initial stormwater runoff assessments for six communities in Antrim and Kalkaska Counties - Elk Rapids, Ellsworth, Central Lake, Bellaire, Alden, and the Village of Kalkaska. The purpose was to help local governments in Antrim and Kalkaska Counties begin to address pollution stemming from stormwater runoff in their communities to protect water quality. (TWC, n.d.)

Grass and Rapid River Sedimentation Studies

In 2012, a study was initiated to better understand the nature of the issues of both Rapid River and Grass River. The project team consisted of researchers, technicians, and students from Michigan State University and the State University of New York Brockport along with employees of the Natural Resources Department of the Grand Traverse Band of Ottawa and Chippewa Indians and Tip of the Mitt Watershed Council. Field efforts, later analysis, and consideration of recommendations were greatly aided by the volunteer efforts of Dean Branson and Fred Sittel from the Three Lakes Association and Bob Kingon from the Elk--Skegemog Lakes Association. (TLA, n.d.) The sections below include portions of the conclusions from each report. The Soil Water Assessment Tool (SWAT) reports for both the Grass and Rapid River note erosion occurring around culverts as well as potential erosion from unpaved roads in the watershed. The reports suggest road stream crossings "should be addressed by watershed planners in order to reduce the sediment loads coming from these tributaries". (Richards, 2012)

Report: Understanding the Hydrologic Landscape to Assess Trajectories of Sediment Sources and Stream Condition in the Grass and Rapid River Watersheds

Field data collection and combined aerial imagery analysis demonstrate that several key areas in the Grass River, all of the lower Rapid River, and portions of upper Torch River are affected by shallow channel depths. These depths lead to restrictions in two-way motorized watercraft traffic, even potentially impeding upstream navigation completely. Certain areas of the Torch River that have not experienced changes have been spared from widening and shallowing due to bank armoring put in place before restrictions on seawalls took effect, and at a time when houses could be built on low-lying areas with little setback from streams. These engineered banks have preserved recreational use of the water, but often compromise the benefits of natural stream function from an ecological and geomorphic perspective and leave little to no value for wildlife habitat or aesthetic value. (Kendall, Fessell, & Cronk, 2014)

Grass River Soil Water Assessment Tool

A hydrologic model developed for the three major tributaries of the Grass River suggest that the tributaries contribute significant volumes of sediment to the river. Finch Creek was most important, contributing 401 tons of sediment per year, on average. The Finch Creek inlet is near the outlet of the Grass River at the eastern end of Clam Lake. Cold Creek contributes the second highest amount of sediment at 166.8 tons per year. Shanty Creek contributes 50.1 tons of sediment per year, not far upstream from where Cold Creek empties into Grass River. It is likely that all three of these tributaries are partly responsible for the sedimentation issues seen by stakeholders in the Grass River. Together, these tributaries introduce 363 cubic meters of sediment every year to the river. This is equivalent to over 47 dump truck volumes of sediment. Actual sediment loads from these tributaries are probably higher, as the model does not account for groundwater inputs which were observed in the field. Including groundwater inputs into the model will increase sediment loads, however, it is not possible now due to the paucity of field data. Further work should collect additional field data in order to parameterize the model to account for groundwater inputs and fully calibrate the model for water balance and sediment. (Richards, 2012)

Rapid River Soil Water Assessment Tool

A hydrologic model developed for the Rapid River suggests that much of the sediment that makes it to the outlet comes from the urban/agricultural corridor surrounding the main river downstream of Underhill Road. This stretch of river however does sequester some sediment and is braided and double channeled in places. Sediment flux peaks at Kellog Road (the outlet of subbasin 16) and then decreases toward the outlet. Based on a five year simulation, an average of 75% of the sediment is sequestered by the time the flow reaches the outlet. The average flux of sediment at the outlet is 1040 kg/year. This is equivalent to 613.8 cubic meters of sediment. If Rapid River has groundwater inputs like Grass River, it is likely the actual sediment loads from these tributaries are probably higher, as this model does not account for groundwater inputs. Based on field evidence and that the model does not parameterize the reservoir at Rugg pond, this site may sequester more sediments than what is estimated by the model. Further work should collect additional field data in order to improve the model for water balance and sediment. […] The high sedimentation rates predicted by the model in the main branch downstream of Rapid City Road may have implications on the quality of stream habitat from the standpoint of fish and macroinvertebrates. Watershed planners may wish to consider additional work to explore this possibility. (Richards, 2012)

LOCAL GOVERNMENT COLLABORATION

Township Water Quality Action Plans

In 2010, Action Plans were created for each township within the ERCOL to address three major topics regarding water quality: parking lots and roads, lot design and development, and protecting natural features. Three workshops were conducted for the ERCOL townships, villages, and interested residents to help educate stakeholders on the contents of the Action Plans and how the suggested information could be incorporated into development standards and ordinances. (TWC, 2010)

Milton Township Septic 'Time of Transfer Ordinance'

Several organizations within the ERCOL watershed coordinated with Milton Township on an ordinance requiring the inspection of septic systems at the time of title transfer. It was successfully passed in May of 2012 and will help manage phosphorus loading into lakes and stream in the ERCOL. This ordinance is seen as a model for other townships in the region to follow as septic fields becomes a more widely understood source of water quality issues. (TOMWC, 2012.)

Conservation Land Activities

The Grand Traverse Regional Land Conservancy works to protect land through three primary methods: conservation easements, municipal assets, and direct purchase or donations. The table below summaries the conservation activities and acquisitions within the ERCOL watershed. It represents 3,080 acres of new conservation land and 50,063 feet of riparian frontage protected from development (Grand Traverse Land Conservancy).

TABLE 66: CONSERVATION ACTITIES IN THE WATERSHED

Property Name	Type	Total Acres Frontage on	Frontage (ft)
Arnold and Shirlt Bauer Nature Preserve Addition-Cabin	Preserve Addition	11.36 acres (water)	963
Arnold and Shirlt Bauer Nature Preserve Addition-Smith and Pfeifle	Preserve Addition	110 acres	-
Battle Creek Natural Area	Assist-Trust Fund	252.9 acres (water)	6,650
Cedar River Group	Conservation Easement	80 acres (water)	2,700
Crow Creek	Conservation Easement	130 acres (water)	3,200
Eddy School Pond	Conservation Easement	193.86 (water and road)	6,210
Glacial Hills Pathway and Natural Area	Assist-Trust Fund	345 acres	-
Harrier Plains	Conservation Easement	126 acres	-
Hitchcock Swamp-Old State	Conservation Easement	43.14 acres (water)	6,300
Hitchcock Swamp-Skinkle	Conservation Easement	96.61 acres	6,300
Hitchcock Swamp-Spence Creek	Conservation Easement	74.79 acres (water)	6,300
Hitchcock Swamp-Taylor Creek	Conservation Easement	80 acres (water)	3,500
Lessard Farm	Conservation Easement	182.18 acres (water)	1,400
North Branch Cedard River Headwaters	Conservation Easement	176 acres (water)	2,500
Palastra-Holm Nature Preserve Addition - Emery	Preserve Addition	6.29 acres	-
Palastra-Holm Nature Preserve Addition - Emery	Preserve Addition	16.73 acres	-
Reiley	Conservation Easement	1,080 acres	-
St. Clair Lake-Six Mile Lake Nature Preserve Addition-Hersha	Preserve Addition	66 acres (water)	4,000
Weiss-GRNA	Transfer	10 acres (water)	40

Loon Network Habitat Protection Program

More than six miles of shoreline have been protected as a part of the Loon Network Habitat Protection Program. Nearly 500 people contributed to the first township-owned loon nursery in the country. The total project cost was more than $300,000 to protect 31.6 acres on Lake Bellaire in Antrim County, Michigan. In 2002, Forest Home Township received government grants from the Michigan Natural Resources Trust Fund, the National Wetlands Conservation Council and the Great Lakes Aquatic Habitat Network & Fund. Additional grants were received from the Biederman Foundation, Hildreth Foundation and Carls Family Foundation. WILDHEARTS, the volunteer committee, raised the remaining funds in the community. The Grand Traverse Regional Land Conservancy has been invaluable in helping to protect critical wetland habitat for loons. Their staff worked with local units of government to acquire critical wetland parcels, which keep the shoreline undeveloped and protects water quality. (Loon Network, n.d.)

Grass River Natural Area Land Conservation Activities

On December 18, 2015 Grass River Natural Area, Inc. (GRNA) purchased an additional 9.066 acres of forested wetland located on the south shore of Clam Lake – an ecologically significant peninsula contiguous with existing GRNA land. This important addition enlarges GRNA's protected lands from 1443 to 1452 total acres. This acquisition was made possible by a substantial matching challenge grant from the J.A. Woollam Foundation, significant matching funds from Mr. and Mrs. Matt and Deb Knudstrup of Rapid City, MI, as well as many generous donors who have given to the Land Protection Fund over the years. (GRNA, n.d.)

CHAPTER 6
GOALS AND OBJECTIVES

CHAPTER 6: GOALS AND OBJECTIVES

6.1 INTRODUCTION

The Elk River Chain of Lakes watershed contains a network water bodies of exceptional high quality and the implementation goals and objectives speak to the desire to maintain them as such. The ultimate purpose of the ERCOL watershed management plan is to have all lakes, rivers, and streams within the watershed support appropriate designated uses while maintaining their distinctive environmental characteristics and aquatic health. To do this we must engage in proactive management steps that protect and enhance the quality of resources, while working to address the systems most impacted by human development.

The goals and objectives outlined below represent suggestions and consensus gained through stakeholder meetings, review of precedent watershed plans, and peer auditing by experts within the fields of watershed management and water quality. They serve as the guiding framework for subsequent chapters that provide more detail in regards to implementation (Chapter 7), outreach (Chapter 8), and assessment (Chapter 9). However, the detailed management activities outlined in these chapters would be misguided without clear, forward-looking goals and quantifiable objectives. The overarching goals of this plan are outlined as follows.

Implementation Goals:

1. Protect the diversity of aquatic habitats
2. Protect and improve water quality
3. Enhance and maintain recreational opportunities that preserve water quality and support the local economy
4. Promote sustainable land management practices that conserve and protect the natural resources, character, and heritage of the watershed
5. Develop and maintain effective education and outreach efforts to support watershed protection
6. Integrate climate-resilient practices and efforts throughout the watershed

The following section outlines the State established designated uses, structural/action-based threats, and pollutants/environmental stressors associated with each goal. For more information in these components, please refer to Chapter 4. This is then followed by a list of specific objectives intended to address each goal.

6.2 GOALS AND OBJECTIVES

GOAL 1: PROTECT THE DIVERSITY OF AQUATIC HABITATS

Designated Uses Identified: agriculture, warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, fish consumption

Pollutants / Environmental Stressors Identified: nutrients, sediment, pesticides, thermal pollution, habitat loss

Structural / Action-based Threats Identified: impervious surface and stormwater runoff, invasive species, water control infrastructure

Objectives:

1.1 Inventory and monitor aquatic habitats to document conditions and changes

1.2 Protect and restore diverse lake and stream habitats

1.3 Protect and restore riparian corridors, floodplains and wetland areas

1.4 Create new habitats and habitat structures to support important wildlife populations

1.5 Protect and restore natural hydrologic connectivity and integrity

1.6 Monitor and manage invasive species populations to promote the integrity of native populations

GOAL 2: PROTECT AND IMPROVE WATER QUALITY

Designated Uses Identified: warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, fish consumption

Pollutants / Environmental Stressors Identified: all (see Table 62)

Structural / Action-based Threats Identified: all (see Table 63)

Objectives:

2.1 Establish effective, standardized water quality monitoring procedures

2.2 Reduce nutrient inputs to surface waters and groundwater

2.3 Reduce sediment inputs to surface waters

2.4 Reduce chemical contaminants and other harmful inputs to surface waters and groundwater

2.5 Maintain dissolved oxygen levels that support fish and other aquatic life

2.6 Minimize harmful bacteria levels in all water bodies

2.7 Control and reduce thermal pollution from developed areas

GOAL 3: ENHANCE AND MAINTAIN RECREATIONAL OPPORTUNITIES THAT PRESERVE WATER QUALITY AND SUPPORT THE LOCAL ECONOMY

Designated Uses Identified: warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, fish consumption

Pollutants / Environmental Stressors Identified: all (see Table 62)

Structural / Action-based Threats Identified: all (see Table 63)

Objectives:

3.1 Maintain boating navigability

3.2 Support fisheries for quality sport, commercial and tribal fishing opportunities

3.3 Create and maintain infrastructure to help limit spread of invasive species

3.4 Promote Clean Marinas program and low-impact boating infrastructure

3.5 Create infrastructure and promote regulations that encourage recreational stewardship

3.6 Ensure safe and sufficient access to beaches, lakes, and streams for public use that does not jeopardize the integrity of the resource

GOAL 4: PROMOTE SUSTAINABLE LAND MANAGEMENT PRACTICES THAT CONSERVE AND PROTECT THE NATURAL RESOURCES, CHARACTER, AND HERITAGE OF THE WATERSHED

Designated Uses Identified: warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife

Pollutants / Environmental Stressors Identified: nutrients, sediment, oils, pesticides, thermal pollution

Structural / Action-based Threats Identified: lake shoreline development/use, impervious surface and stormwater runoff, invasive species, riverbank development/use, water control infrastructure, recreational activity

Objectives:

4.1 Preserve rural character and sites of cultural importance that do not compromise watershed quality

4.2 Maintain quality viewsheds while supporting landowner desires for property use, privacy, and security

4.3 Maintain open space, parks, greenways, and natural areas for public enjoyment

4.4 Protect priority areas to preserve ecological integrity and watershed quality

4.5 Promote low impact development techniques and green infrastructure throughout the watershed

4.6 Increase awareness of developers and local governments on the impacts of development on natural resources and biological communities

4.7 Promote regulatory tools that prevent or reduce environmental degradation in riparian zones, drainage areas, and sensitive landscapes

4.8 Promote voluntary best management practices that prevent or reduce environmental degradation in riparian zones, drainage areas, and sensitive landscapes

4.9 Protect groundwater recharge areas

GOAL 5: INTEGRATE CLIMATE-RESILIENT PRACTICES AND EFFORTS THROUGHOUT THE WATERSHED

Designated Uses Identified: agriculture, industrial water supply, warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife

Pollutants / Environmental Stressors Identified: nutrients, flow alteration, habitat loss

Structural / Action-based Threats Identified: impervious surface and stormwater runoff, invasive species, road stream crossings, water control infrastructure

Objectives:

5.1 Maintain a working knowledge of models and projections that describe regional climate changes within the context of historic climate data

5.2 Develop adaptive management strategies based on climate predictions and observed patterns

5.3 Develop infrastructure resilient to increased storm severity and climate variability

5.4 Promote and sustain biodiversity and ecological integrity in light of changing environmental conditions

GOAL 6: DEVELOP AND MAINTAIN EFFECTIVE EDUCATION AND OUTREACH EFFORTS TO SUPPORT WATERSHED PROTECTION

Designated Uses Identified: all (see Table 58)

Pollutants / Environmental Stressors Identified: all (see Table 62)

Structural / Action-based Threats Identified: all (see Table 63)

Objectives:

6.1 Maintain a working knowledge of current and emerging issues affecting the ERCOL watershed

6.2 Regularly inform public about research, projects, and opportunities for contribution/collaboration within the watershed

6.3 Develop and maintain innovative programs to engage ERCOL stakeholders in preventative actions that address current and emerging issues in the watershed

6.4 Develop and maintain innovative programs to engage ERCOL stakeholders in mitigation activities that address current and emerging issues in the watershed

6.5 Develop and facilitate place based learning and organized citizen science opportunities

6.6 Align programs and stakeholder activities and develop effective communication pathways

CHAPTER 7
IMPLEMENTATION STRATEGIES

CHAPTER 7: IMPLEMENTATION STRATEGY

7.1 INTRODUCTION

The following implementation strategy plan provides a comprehensive approach to reducing existing sources of nonpoint source pollution and preventing future impairments to the watershed. Prioritizing implementation actions while continuing to build partnerships, helps coordinate efforts across stakeholder groups and leverage competitive funding opportunities. The implementation steps outlined in this chapter are organized around goals and objectives laid out in chapter 6. Goal 6 is housed in chapter 8.

Implementation Goals:

1. Protect the diversity of aquatic habitats
2. Protect and improve water quality
3. Enhance and maintain recreational opportunities that preserve water quality and support the local economy
4. Promote sustainable land management practices that conserve and protect the natural resources, character, and heritage of the watershed
5. Integrate climate-resilient practices and efforts throughout the watershed
6. Develop and maintain effective education and outreach efforts to support watershed protection

Effective watershed management relies upon an integrative approach to address the need for: 1) best management practices; 2) partnerships, community consensus building, and work with local governments; and 3) information and education components.

7.2 PROPOSED BEST MANAGEMENT PRACTICES

Best management practices (BMPs) are techniques, measures, or structural controls designed to minimize or eliminate runoff and pollutants from entering surface and ground waters. Structural and non-structural BMPs should be employed in tandem throughout the watershed to achieve maximum reductions of non-point source (NPS) pollutants and manage stormwater runoff (Chesapeake, 2014). BMPs should be selected according to their potential to reduce targeted NPS pollutants, while accounting for cost, maintenance requirements, available space, and other factors. Examples of possible BMPs for common sources threats and stressors are listed in Table 66. BMP recommendations for the ERCOL are located in the set of tables provided in section 7.7.

Non-structural BMPs

Non-structural BMPs are preventative actions involving management and source controls, where institutional, educational, and ordinance-driven requirements are implemented to limit stormwater runoff and pollutant loads (Chesapeake, 2014). Examples include education programs for local stakeholders on daily water protection actions and regulations limiting impervious surfaces and minimizing soil disturbance. Additional information regarding education and outreach efforts can be found in chapter 8.

Structural BMPs

Structural BMPs are physical systems constructed to reduce impacts of development and runoff on water quality. These can include stormwater facilities and filtration and infiltration practices focused on managing stormwater through manmade wetlands, filter strips, and various other practices.

TABLE 67: BEST MANAGEMENT PRACTICES TO ADDRESS THREATS AND STRESSORS

Threat Code	Structural/Action-Based Threat	Pollutant Stressors/Causes	Potential System of BMPs
LDU	Lake shoreline development/use	Riparian vegetative buffer removal Excessive or improper fertilizer and pesticide application Deforestation Increased impervious surfaces	Biotechnical erosion control Vegetative buffer strips Rock riprap Tree revetments Land conservation easements Zero-phosphorus fertilizers Soil testing
STR	Impervious surface/stormwater runoff	Inadequate treatment of stormwater Lack of infiltration opportunities Road salting Vehicle discharges Excessive or improper fertilizer and pesticide application	Rain gardens (bioretention) Runoff diversions Infiltration basins or trenches Sand filters Oil/grit separators Pervious pavers
IS	Invasive species	Inadequate boat cleaning Lack of restrictions on boat traffic Natural waterway connectivity Lack of public knowledge on impact	Install boot brush structures at public access sites Educational kiosks at boat launches Boat wash stations Wader wash stations near streams/river access points
RSX	Road stream crossings	Lack of updates and maintenance Inadequate culvert size Inadequate erosion control Road runoff	Extend or enlarge culverts Install runoff diversions to direct runoff Install box culverts or elliptical culverts Install clear-span bridges
FSS	Failing septic systems	Lack of sewer infrastructure Inadequate waste regulatory legislation Outdated septic structures	Regular maintenance Replace failing septic structures
RDU	Riverbank development/use	Riparian vegetative buffer removal Excessive or improper fertilizer and pesticide application Deforestation Increased impervious surfaces	Biotechnical erosion control Vegetative buffer strips Rock riprap Tree revetments Land conservation easements Zero-phosphorus fertilizers Soil testing

TABLE 67 CONTINUED: BEST MANAGEMENT PRACTICES TO ADDRESS THREATS AND STRESSORS

Threat Code	Structural/Action-Based Threat	Pollutant Stressors/Causes	Potential System of BMPs
ARU	Agricultural runoff/use	Excessive or improper fertilizer and pesticide application Improper management of animal waste Improper tilling practices	Fencing Alternative watering devices Vegetative buffer strips Land conservation easements Conservation tilling Reduced pesticide/fertilizer use where feasible Nutrient management Animal waste storage Manure application plan
CC	Climate change	Vehicle emissions Industrial and commercial emissions Animal production and consumption Energy use	
IWO	Industrial waste/oil and gas	Industrial and fuel transport spills Industrial and commercial emissions Inadequate disaster response Pipeline failure	
WCI	Water control infrastructure	Manmade dam construction Inadequate dam maintenance Sediment accumulation Beaver dam creation/removal	
RA	Recreational activity	Improper waste disposal Erosion at boat launches Foot traffic erosion Boat discharges Wake-related erosion and habitat disruption	Runoff diversions, walkways/stairways Parking lot barriers Canoe landings Biotechnical erosion control Rock riprap Tree revetments

Table of best management practices best suited to address specific structural/action-based threats.

7.3 BMP EFFECTIVENESS

The effectiveness of a BMP is determined by the size of the implemented practice (e.g. acres of stormwater detention ponds) and quantity of pollution reduction. Table 67 (Huron River Watershed Council, 2003) lists estimated pollutant removal efficiencies for a variety of stormwater BMPs.

TABLE 68: BEST MANAGEMENT PRACTICE EFFECTIVENESS ESTIMATES

Management Practice	Total Phosphorus	Total Nitrogen	Total Suspended Solids	Metals	Bacteria	Oil & Grease
High-powered street sweeping	30-90 %		45-90 %			
Riparian buffers Forested: 20-40m width Grass: 4-9 m width	Forested: 23-42 % Grass: 39-78 %	Forested: 85 % Grass: 17-99 %	Grass: 63-89 %			
Vegetated roofs	Structural addition of plants over a tradition roof system. 70-100 % runoff reduction, 40-50 % of snow/rainfall. 60 % temperature reduction.					
Vegetated filter strips 7.5m length 45m width	40-80 %	20-8 0%	40-90 %			
Bioretention	65-90 %	49 %	81 %	51-71 %	90 %	
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 %		

Table of estimated pollutant removal efficiencies for common stormwater-borne pollutants.

7.4 LOCATION OF BMPS

The locations of structural BMPs are contingent upon site conditions. Table 68 lists general guidelines for the placement of structural BMPs that have been adapted from the rapid assessment protocol of the Center for Watershed Protection (Huron River Watershed Council, 2003).

TABLE 69: BEST MANAGEMENT PRACTICE PLACEMENT GUIDELINES

	Undeveloped	Developing	Developed
Philosophy	Preserve	Protect	Retrofit
Amount of Impervious Surface	<10%	11-26%	>25%
Water Quality	Good	Fair	Fair-poor
Stream Biodiversity	Good-excellent	Fair-good	Poor
Channel Stability	Stable	Unstable	Highly unstable
Stream Protection Objectives	Preserve biodiversity and channel stability	Maintain key elements of stream quality	Minimize pollutant loads delivered to downstream waters
Water Quality Objectives	Sediment and temperature	Nutrients and metals	Bacteria
BMP Selection and Design Criteria	Maintain pre-development hydrology		Maximize pollutant removal and quality control
	Minimize stream warming and Sedimentation	Maximize pollutant and nutrient removal	Remove nutrients, metals, and toxics
	Emphasize filtering systems		

7.5 LOW IMPACT DEVELOPMENT

Low impact development (LID) is a stormwater management approach based on natural systems, emphasizing local management end-of-pipe treatment. These practices can be integrated into diverse sites, from small residential areas to large commercial complexes. LID techniques continue to be developed and improved to increase efficiencies and outcomes, and promoting these efforts can engage local stakeholders in preventative watershed management.

7.6 GREEN INFRASTRUCTURE

Green infrastructure utilizes a network of open space, wildlife habitat, parks, and other natural areas to promote ecological integrity. S scientific and community-based approach is used to target locations, accounting for conservation goals, land development, and built infrastructure planning. According to the New Designs for Growth manual "Planning for Green Infrastructure":

> Green infrastructure planning helps to maintain or repair natural systems and defines a framework for future development patterns. It encompasses a wide variety of natural and restored native ecosystems and landscape features that make up a system of "hubs" and "links."

The following figures depict green infrastructure techniques throughout Charlevoix, Antrim, Kalkaska, and Grand Traverse counties as presented within this manual.

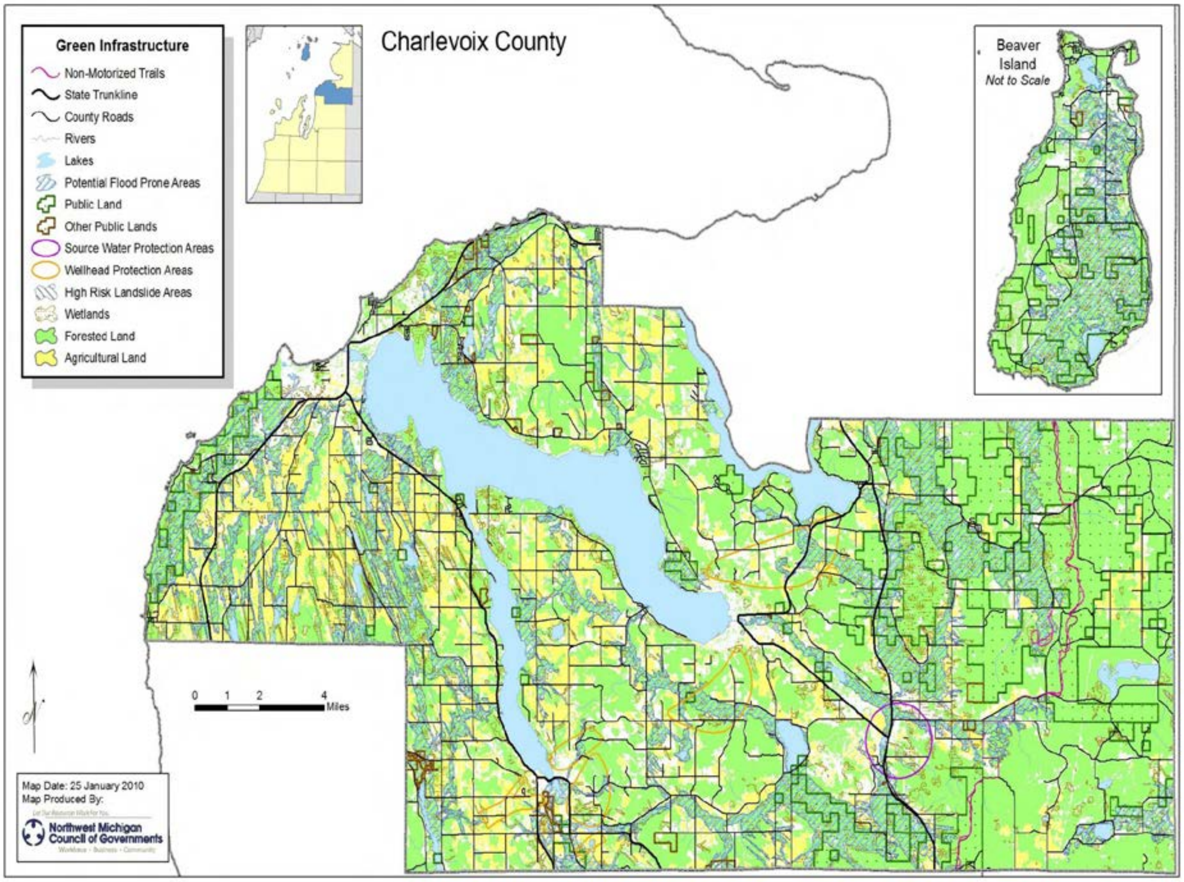


Figure 38: Green infrastructure map of Charlevoix County.

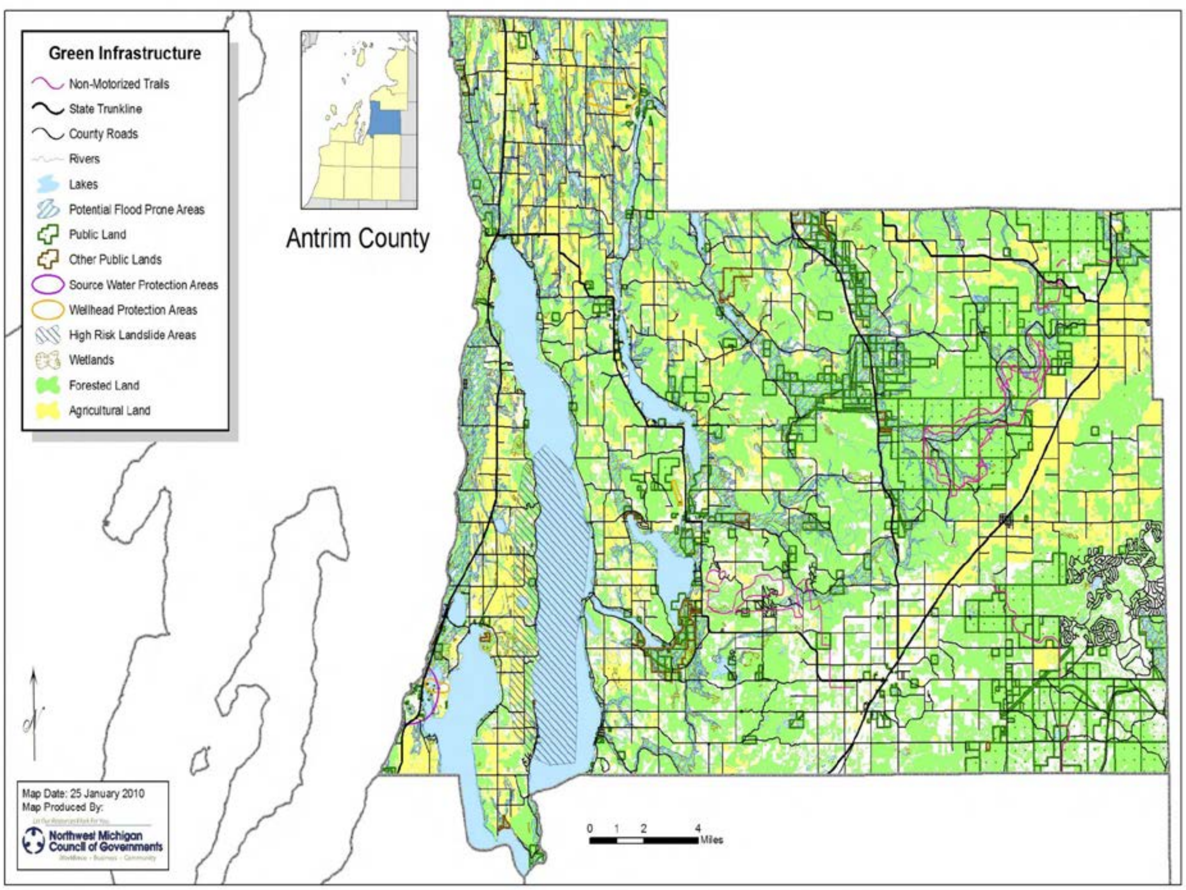


Figure 39: Green infrastructure map of Antrim County.

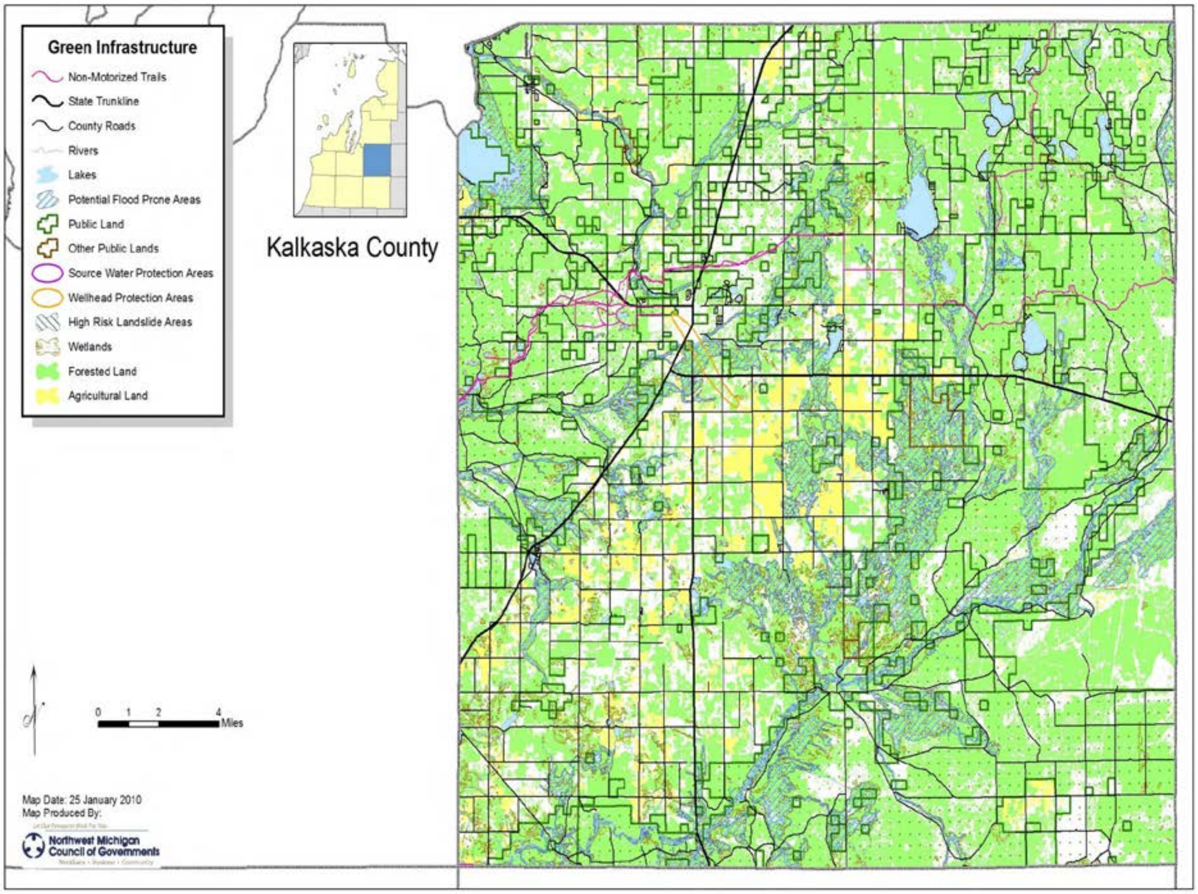


Figure 40: Green infrastructure map of Kalkaska County.

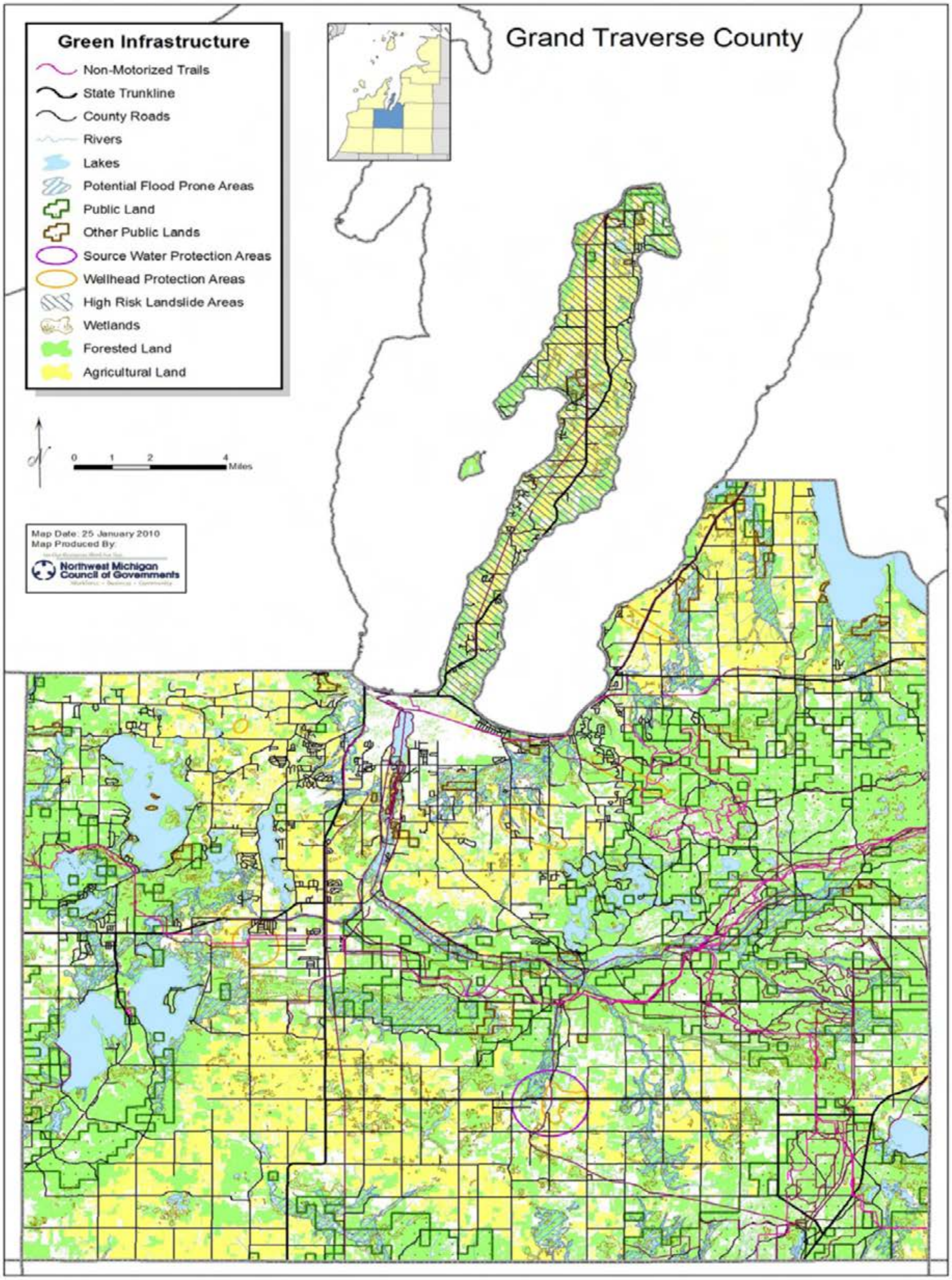


Figure 41: Green infrastructure map of Grand Traverse County.

7.7 IMPLEMENTATION TASKS AND ACTIONS

Recommended implementation tasks and actions, categorized by goals from chapter 6, are organized into detailed tables for reference. For each goal, one table details implementation tasks and their associated costs, potential project partners, and potential funding sources, while a second table provides a 10-year timeline with specific milestones. Each task is assigned a code for the given goal and task number (e.g. G1.1 = goal 1, task 1) and is given the following information:

Objective(s) addressed: Each implementation task/action aims to support the objectives laid out in Chapter 6, helping identify gaps in addressing management goals.

Threat(s) addressed: Each implementation goal is associated with specific threats/stressors, allowing for evaluation of progress in threat remediation. Each threat is given a reference code in Table 67.

Priority level: Each task/action is assigned a priority level based on the following factors: urgency for mitigation or prevention, availability of funds and partners, and practical time constraints. Assigned levels include; high (H), medium (M), and low (L).

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

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 ERCOL-WPIT.

Abbreviations:

Antrim Conservation District (ACD)

Antrim County Planning Dept. (ACP)

Antrim County Road Commission (ACRC)

Conservation Resource Alliance (CRA)

Grand Traverse Regional Land Conservancy (GTRLC)

Little Traverse Bay Band of Odawa Indians (LTBB)

MI Dept. of Environmental Quality (MDEQ)

MI Dept. of Natural Resources (MDNR)

MI State University Extension (MSUE)

Natural Resource Conservation Service (NRCS)

Northwest MI Council of Governments (NWMCOG)

Tip of the Mitt Watershed Council (TOMWC)

Potential funding sources: Potential funding sources for each task or action include, but are not limited to: private foundations (PF); state grants (SG); federal grants (FG); local governments (LG); partner organizations (PO); revenue generated (RG); private cost-share (CS); and local businesses (LB).

Milestones: Milestone(s) are identified when possible to establish measurable benchmarks for specific tasks or actions.

Timeline: A ten year timeline is laid out with year of initiation and completion noted for specific tasks, with some actions spanning the full ten years.

TABLE 70: IMPLEMENTATION TASKS FOR GOAL 1 - PROTECT THE DIVERSITY OF AQUATIC HABITATS

Designated Uses Identified: agriculture, warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, fish consumption

Pollutants/Environmental Stressors Identified: nutrients, sediment, pesticides, thermal pollution, habitat loss

Structural/Action-based Threats Identified: impervious surface and stormwater runoff, invasive species, water control infrastructure

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G1.1	Establish a periodic monitoring schedule							
G1.2	Plan for removal/replacement of obstructions (perched culverts, dams)							
G1.3	Public relations campaign to encourage best management practices and discourage monoculture landscapes (shore-scapes)							
G1.4	Establish plan for invasive species treatment							
G1.5	Stay current with invasive species BMPs							
G1.6	Work with marinas and bait shops to educate fishermen on habitat needs and invasive species							
G1.7	Strengthen TWP zoning to improve shoreline protection for terrestrial animals and fish							

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G1.8	Establish loon nesting platforms							
G1.9	Installation programs for fish shelters and large woody debris							
G1.10								
G1.11								
G1.12								

Task/ Action Code	Milestones	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
G1.1											
G1.2											
G1.3											
G1.4											
G1.5											
G1.6											
G1.7											
G1.8											
G1.9											
G1.10											
G1.11											
G1.12											

TABLE 71: IMPLEMENTATION TASKS FOR GOAL 2 - PROTECT AND IMPROVE WATER QUALITY

Designated Uses Identified: warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, fish consumption

Pollutants/Environmental Stressors Identified: all (see Table 62)

Structural/Action-based Threats Identified: all (see Table 63)

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G2.1	Establish standardized method for monitoring							
G2.2	Update road stream crossing inventory every 10 years							
G2.3	Restore priority road crossing sites							
G2.4	Meet with zoning commissions to improve best management practices (for RSX sites)							
G2.5	Complete streambank erosion survey for streams lacking one and update every 10 years							
G2.6	Stabilize priority streambank and shoreline erosion sites							
G2.7	Establish riparian buffers (greenbelts) in priority areas							
G2.8	Update buffer survey/inventory							

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G2.9	Conduct water quality monitoring on ERCOL throughout the years and add 2 lakes by 2026							
G2.10	Tributary monitoring							
G2.11	Identify turbidity plume locations after storm events							
G2.12	Continue permanent land protection efforts throughout the watershed							
G2.13	Obtain cost-management laboratory support for water testing							
G2.14	Work with TWP planning commissions to establish a water quality chapter in the zoning ordinance							
G2.15	Promote "Shoreland Stewardship" program website with riparians through lake association							
G2.16	Mandate 20/50 real buffer/countywide ordinance							

Task/ Action Code	Milestones	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
G2.1											
G2.2											
G2.3	1 road stream crossing site per year										
G2.4											
G2.5											
G2.6											
G2.7											
G2.8											
G2.9											
G2.10	X lake systems added by 2026.										
G2.11											
G2.12											

TABLE 72: IMPLEMENTATION TASKS FOR GOAL 3 - ENHANCE AND MAINTAIN RECREATIONAL OPPORTUNITIES THAT PRESERVE WATER QUALITY AND SUPPORT THE LOCAL ECONOMY

Designated Uses Identified: warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, fish consumption

Pollutants/Environmental Stressors Identified: all (see Table 62)

Structural/Action-based Threats Identified: all (see Table 63)

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G3.1	Establish water trail in the ERCOL							
G3.2	Acquire lakefront parcels for public use							
G3.3	Install fish shelters							
G3.4	Identify road end properties which can be enhanced for public use							
G3.5	Create promotional guide of ERCOL sustainable recreation opportunities							
G3.6	Woody debris placement for habitat and for sediment control to maintain navigability in connecting waterways							
G3.7	Identify DNR responsibilities and establish committee liaison with DNR							

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G3.8	Develop Rugg Pond Management Plan							
G3.9	Create Environmentally responsible road ends (buffer with signs, stormwater control with signs, erosion control, native plants)							
G3.10								
G3.11								
G3.12								

Task/ Action Code	Milestones	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
G3.1											
G3.2											
G3.3											
G3.4											
G3.5											
G3.6											
G3.7											
G3.8											
G3.9											
G3.10											
G3.11											
G3.12											

TABLE 73: IMPLEMENTATION TASKS FOR GOAL 4 - PROMOTE SUSTAINABLE LAND MANAGEMENT PRACTICES THAT CONSERVE AND PROTECT THE NATURAL RESOURCES, CHARACTER, AND HERITAGE OF THE WATERSHED

Designated Uses Identified: warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife

Pollutants/Environmental Stressors Identified: nutrients, sediment, oils, pesticides, thermal pollution

Structural/Action-based Threats Identified: lake shoreline development/use, impervious surface and stormwater runoff, invasive species, riverbank development/use, water control infrastructure, recreational activity

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G4.1	Identify priority parcels for protection							
G4.2	Distribute information on land conservation to encourage land protection							
G4.3	Assist local governments in acquiring priority parcels							
G4.4	Promote MAEAP to encourage efforts throughout the watershed							
G4.5	Support public funding to purchase conservation easements and priority parcels							
G4.6	Promote greenbelts at 1st line of defense to protect water quality							
G4.7	Promote maintaining natural shoreline							

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G4.8	Promote rerouting drainpipes away from lakes and streams							
G4.9	Highlight good examples of LMPs							
G4.10	Repair eroding road ends to control sediments							
G4.11	Work with TWP planning commissions to create a water quality chapter in zoning ordinance							
G4.12	Promote low impact zoning and planning							
G4.13	Residential developments (PRDs) in zoning ordinances							
G4.14	Create buffer ordinance for ERCOL (work with counties, townships, and lake associations)							
G4.15	Sediment and stormwater ordinance to focus on water quality, not just erosion control							
G4.16	Create demonstration projects to show "can have cake and eat it too"							

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G4.17	Host town hall meeting to showcase good examples of sustainable land management practices							
G4.18	Update the local ordinance gaps analysis for guidance for local officials on planning/zoning efforts							
G4.19	Cost share to show BMPs with townships							

Task/ Action Code	Milestones	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
G4.1											
G4.2											
G4.3											
G4.4											
G4.5											
G4.6											
G4.7											
G4.8											
G4.9											
G4.10											
G4.11											
G4.12											

TABLE 74: IMPLEMENTATION TASKS FOR GOAL 5 - INTEGRATE CLIMATE-RESILIENT PRACTICES AND EFFORTS THROUGHOUT THE WATERSHED

Designated Uses Identified: agriculture, industrial water supply, warmwater fishery, colder water fishery, other indigenous aquatic life and wildlife

Pollutants/Environmental Stressors Identified: nutrients, flow alteration, habitat loss

Structural/Action-based Threats Identified: impervious surface and stormwater runoff, invasive species, road stream crossings, water control infrastructure

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G5.1	Adjust culvert sizes for critical road-stream crossings							
G5.2	Promote riparian vegetation restoration with riparian land owners with a goal of 3 riparian buffers restored per year							
G5.3	Public relations campaign, similar to the "Pure Michigan" campaign, featuring images of landscapes using the environmental BMPs							
G5.4	Work with local governments to address adaptation strategies to help bear the brunt of increasingly severe and frequent storms							

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources
G5.5	Assess current water quality monitoring programs and adapt/modify to include parameters necessary to assess climate change impacts (1-2 programs assessed and modified per year)							
G5.6	Adapt stormwater BMPs to account for climate change							
G5.7	Add/include water column peak seasonal temperature measurements to water quality monitoring plans							
G5.8	Create landscape hydrology model to assess climate change impacts to watershed and restoration projects							
G5.9								
G510								
G5.11								
G5.12								

Task/ Action Code	Milestones	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
G5.1											
G5.2											
G5.3											
G5.4											
G5.5											
G5.6											
G5.7											
G5.8											
G5.9											
G5.10											
G5.11											
G5.12											

CHAPTER 8
EDUCATION AND OUTREACH

CHAPTER 8: EDUCATION AND OUTREACH

8.1 INTRODUCTION

The most valuable assets in protecting the ERCOL watershed are the residents and tourists who live, work and play within its boundaries. As demonstrated in previous chapters, a wide range of community members are already deeply involved in protecting the lakes, rivers and streams within the watershed. But in order to achieve commitment to the large scale vision laid out within this watershed management plan there will need to be a concerted effort to organize, communicate, and educate community members around the shared vision of protecting water resources. The goal below, laid out in Chapter 6, highlights this plan's commitment to developing and maintaining effective education and outreach strategies.

GOAL 6: DEVELOP AND MAINTAIN EFFECTIVE EDUCATION AND OUTREACH EFFORTS TO SUPPORT WATERSHED PROTECTION

Objectives:

6.1 Maintain a working knowledge of current and emerging issues affecting the ERCOL watershed

6.2 Regularly inform public about research, projects, and opportunities for contribution/collaboration within the watershed

6.3 Develop and maintain innovative programs to engage ERCOL stakeholders in preventative actions that address current and emerging issues in the watershed

6.4 Develop and maintain innovative programs to engage ERCOL stakeholders in mitigation activities that address current and emerging issues in the watershed

6.5 Develop and facilitate place based learning and organized citizen science opportunities

6.6 Align programs and stakeholder activities and develop effective communication pathways

This goal and objective can be realized through the following set of assessments and strategies.

8.2 SOCIAL INDICATORS SURVEY

A social indicators survey will be administered over the course of 2016-2017 by Tip of the Mitt Watershed Council to understand community members' and leaders' stance on issues surrounding ERCOL watershed resources. The results of this survey will be summarized here upon completion and will be used to inform the following sections of the watershed protection plan.

8.3 COMMUNICATIONS STRATEGY

Effective communication is the vehicle for education that can ultimately change attitudes leading toward better water quality protection efforts. Seasonal and permanent riparian property owners, landscape professionals, local government officials, developers, and many other groups comprise the overall ERCOL Watershed audience; however, more targeted audiences should be addressed through the lens of appropriate information and education. Below is a more comprehensive catalogue of audiences who utilize watershed resources and can be engaged through targeted communication strategies.

AUDIENCES

Households: The general resident population has a unique commitment to the Chain of Lakes.

Riparian property owners: Due to their proximity to a specific waterbody, the education needs of riparian landowners should be more comprehensive.

Business owners: There is a fairly diverse mix of business and industry segments within the watershed. Tourism, agriculture, retail and other service industries dominate the mix, with manufacturing and construction following; very little heavy industry is present.

Contractors, developers, realtors: Members of the development industry segment play a crucial role in economic growth and providing ongoing education opportunities about their role in protecting water quality and environmental health is critical.

Agriculture industry: Agriculture represents a significant economic segment within the ERCOL watershed. Fruit orchards and vineyards account for a significant portion of the landscape, as well as row crops such as potatoes and corn, and a variety of livestock operations have a notable presence in the watershed.

Tourists: Tourism is one of the largest industries in the ERCOL region. This region is known for scenic beauty and recreational opportunities. A seasonal influx of people puts a noticeable strain on area infrastructure and often the environment. There is a growing concern that this important economic segment is possibly degrading the very reason why it exists, and that the region's tourism "carrying capacity" may soon be reached. Steering committee members and attendees at both public and government stakeholder meetings cited the need to "educate tourists about their role in protecting our environment."

Boaters: The ERCOL watershed is home to a large number of private motorized watercraft owned and operated both by full time and seasonal residents as well as tourists. Special messages targeted directly at this audience can help to reduce the impact of motorized watercraft on the surface waters.

Anglers: Whether from a boat on the open water, in a small shack through a hole in the ice, or standing in waders in a secluded trout stream, the ERCOL provides a wealth of angling opportunities. Providing targeted communications to help limit the spread of invasive species, limit physical impacts to waterbodies and riparian zones, and to bring anglers in as partners in conservation and restoration activities would be well advised.

Quiet water recreation enthusiasts: Kayaking, sailing, canoeing, winder surfing, paddleboarding, etc. These are just a few of the non-motorized types of activities that take place on the surface waters of the ERCOL. This segment of enthusiasts should be targeted with communication strategies to help limit impact of these activities as well as to bring alongside partners for collaborative activities.

Educators: Area educators and students, from K-12 primary education to community colleges and local universities.

Partner organizations: The ERCOL watershed region benefits from impressive list of watershed partners with a broad range of expertise and important ongoing protection, restoration and education programs. Providing learning opportunities to watershed partner organizations regarding current research, BMPs, emerging issues and trends is important to keep implementation work moving forward.

Local government officials: There are a wide variety of village, township and county officials who work within the ERCOL watershed. These include individuals both elected and appointed ranging from county road commissioners to city planners.

Table 75 outlines how each of these audiences can be targeted with a specific communications strategy.

TABLE 75: COMMUNICATIONS STRATEGY

Audience	Associated Structural / Action Based Threats	Messages	Potential Delivery Mechanisms	Potential Evaluation
Households	All			
Riparian property owners	Lake shoreline development/use Impervious surface and stormwater runoff Invasive species Failing septic systems Riverbank development/use Climate change Recreational activity			
Business owners	Lake shoreline development/use Impervious surface and stormwater runoff Invasive species Riverbank development/use Climate change Recreational activity			
Contractors, realtors, developers	Lake shoreline development/use Impervious surface and stormwater runoff Failing septic systems Riverbank development/use			
Agriculture industry	Agricultural runoff Climate change			
Tourists	Recreational activity			
Boaters	Invasive species Recreational activity			
Anglers	Invasive species Recreational activity			
Quiet water Recreation enthusiasts	Invasive species Recreational activity			

TABLE 75 CONTINUED: COMMUNICATIONS STRATEGY

Audience	Associated Structural/Action-Based Threats	Messages	Potential Delivery Mechanisms	Potential Evaluation
Educators	All			
Partner organizations	All			
Local government officials	All			

Table of local stakeholders and strategic elements for engagement.

8.4 EDUCATION AND OUTREACH IMPLEMENTATION STRATEGY

Education and outreach implementations will be created using the general lesson planning principles of backwards design, a well-supported method for designing effective education lesson plans. This methodology is broken into three main components

1. **Objective creation:** Each education and outreach implementation task, while fitting underneath a broad goal for the watershed plan, should have a specific objective for that particular implementation task. These may be the objectives that are outlined in the watershed plan, but will often need to be more specific to the particular event or material being prepared. Objectives should be clear, measurable, and describe an actionable behavioral or physical outcome desired from participants of the implementation task.

2. **Evaluation method:** After creating an objective, a process or method of evaluating the achievement of that objective should be created. This could take the form of pre and post surveys, behavior or action monitoring, or personal interviews. Evaluation methods should directly evaluate the achievement of a specific objective.

3. **Education and outreach lesson/event plan**: After a clear objective and evaluation method have been outlined, the event or lesson or materials should then be created. The plan should be clear and concise and should allow for the carrying out of that particular education and outreach implementation.

Following these three steps to creating an education and outreach implementation will help increase the chance for a successful experience.

A comprehensive list of proposed education and outreach tasks and actions is included in Table 71. Tasks and actions are organized by category to facilitate easy reference. The recommendations are based on a 10 year timeline (201X-201X). Each task and action identifies the following:

Audience(s) addressed: Target audience for this effort as described in Table 70.

Evaluation Method: Proposed method and/or metric for evaluating effectiveness of project/event.

Additional information regarding the other table attributes can be found in the Section 7.7, Implementation Tasks and Actions.

TABLE 76: IMPLEMENTATION TASKS FOR GOAL 6 – DEVELOP AND MAINTAIN EFFECTIVE EDUCATION AND OUTREACH EFFORTS TO SUPPORT WATERSHED PROTECTION

Designated Uses Identified: all (see Table 58)

Pollutants/Environmental Stressors Identified: all (see Table 62)

Structural/Action-based Threats Identified: all (see Table 63)

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources	Audience Addressed	Evaluation Method
G6.1	Contractor workshops for low-impact techniques									
G6.2	Create a "stormwater matters" public education campaign to teach individuals and businesses about stormwater BMPs									
G6.3	Create an outreach effort aimed at young people to teach "watershed 101"									
G6.4	Assist in development of secondary school curriculum regarding water quality									

Task/ Action Code	Task/Action	Threat Addressed (Code)	Objectives Addressed	Priority	Unit Cost	Estimated Total Cost	Potential Project Partners	Potential Funding Sources	Audience Addressed	Evaluation Method
G6.5	Implement reward system for well-done property maintenance or improvement that promotes water quality protection									
G6.6	Promote "shoreland stewardship" program and website with riparian areas through lake associations									
G6.7	Share newsletter									
G6.8	Establish scholarship program for budding environmentalists									
G6.9										
G6.10										
G6.11										
G6.12										

Task/ Action Code	Milestones	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
G6.1											
G6.2											
G6.3											
G6.4											
G6.5											
G6.6											
G6.7											
G6.8											
G6.9											
G6.10											
G6.11											
G6.12											

CHAPTER 9
EVALUATION

CHAPTER 9: EVALUATION

9.1 INTRODUCTION

An effective evaluation plan is critical to assessing the impact of watershed management actions taken according to the goals, objectives, and implementation tasks laid out in this document. The evaluation strategy presented here sets standards and procedures to assess the effectiveness of implementation and monitoring efforts.

The evaluation strategy focuses on three measurable categories to determine successful efforts:

1. Progress in completing recommended implementation tasks
2. Effectiveness in improving and maintaining water quality throughout the watershed
3. Effectiveness in improving and protecting land resources and habitat throughout the watershed

9.2 EVALUATING PROGRESS IN COMPLETING IMPLEMENTATION TASKS

Progress toward completing the recommended implementation tasks outlined in Chapter 7 should be reviewed annually by the Elk River Chain of Lakes Watershed Plan Implementation Team (ERCOL-WPIT). Evaluating the completion of discrete implementation tasks/projects, such as targeted road stream crossing improvements or passage of time-of-purchase septic inspection ordinances, can be completed by the committee each year. Associated timelines and milestones will be discussed in greater detail and implementation strategies will be adapted as needed.

Progress toward completing the recommended education and outreach implementation tasks outlined in Chapter 8 should be reviewed an annual basis by the ERCOL-WPIT. Not only should the number of implementation tasks completed be measured, but also the success of each of those tasks. Since each task has its own specific objective, and integrated evaluation method, it will be possible to rank the success of each education and outreach implementation.

Every five years a more robust assessment will be conducted by the ERCOL-WPIT, assessing cumulative tasks that have been completed over the last five years, and reviewing the status and priority of particular actions. As tasks are addressed, it can be expected that a new set of priorities will be compiled to keep the management plan current and actionable lower priority actions will be promoted to higher priority levels. Further implementation tasks may be added in response to new stressors, concerns, or information.

9.3 EVALUATING EFFECTIVENESS IN IMPROVING AND MAINTAINING WATER QUALITY

Evaluating the effectiveness of improving and maintaining water quality throughout the watershed will be assessed through the results of monitoring efforts relative to established criteria. In order to accurately assess the state of waters within the ERCOL it is necessary to implement efficient water quality monitoring programs and coordinate efforts. The following recommendations are provided as guidelines to improve regional water quality monitoring and enable clear assessments of relevant trends and conditions within the watershed. The criteria are provided as indicators of the degree to which watershed management efforts successfully impact water quality.

WATER QUALITY MONITORING RECOMMENDATIONS

1. **Target monitoring efforts based on assessment of risks to water quality from land use, biological, and societal factors**
    a. Assess which lakes have most significant threats to water quality based on recent land use surveys, biological assessments, and social trends
    b. Prioritize depth over breadth for monitoring efforts, focusing on effectively sampling targeted lakes
    c. Reassess which lakes are most at risk on an annual basis to account for current and emerging issues within the watershed

2. **Prioritize efficient water quality parameters with maximum decision-making influence**
    a. Synchronize monitoring efforts around unified target parameters, considering those outlined in Chapter 2 as a guiding framework
    b. Focus on sampling water quality parameters that have the ability to inform management decisions and answer specific questions
    c. Transition time-intensive and costly monitoring efforts without limited decision-making impact toward more efficient and targeted practices

3. **Increase frequency and targeting of monitoring efforts to account for temporal variation**
    a. Refine spatial extent of monitoring to lakes that can be effectively observed for variation throughout the year
    b. Increase frequency of monitoring to capture seasonal trends throughout the year

c. Prioritize sampling in the direct aftermath of storm events to capture magnitude of nutrient and sediment loads due to runoff

4. **Establish effective monitoring programs on major streams within the watershed**
   a. Select target sites near outflow of major streams into ERCOL lakes and install simple staff gauges with measurements to record variations in stream water level
   b. Measure discharge and gauge height at low, medium, and high flows events across a multi-year period to establish a reference curve for relating water level to stream flow
   c. Record relevant parameters at target sites throughout the year, recording gauge height for each measurement and relating to discharge via the reference curve

CRITERIA FOR EFFECTIVE WATER QUALITY PROTECTION

1. **Dissolved oxygen levels remain above 7 mg/l in Torch Lake and Elk Lake, the state-designated coldwater lakes**

   The MDEQ requires a 7 mg/l minimum concentration of dissolved oxygen throughout the water column for all waters designated as coldwater habitat. Torch Lake and Elk Lake are the only lakes within the ERCOL that are assigned this designation.

2. **Dissolved oxygen levels remain above 5 mg/l in all other ERCOL lakes without special designation**

   The MDEQ requires a 5 mg/l minimum concentration of dissolved oxygen throughout the water column for all waters not designated as coldwater habitat. Torch Lake and Elk Lake are the only lakes in the ERCOL that assigned as coldwater habitat.

3. **Reduce and maintain *E. coli* concentrations in ERCOL tributaries to compliance with MDEQ regulations**

   Of the 27 streams observed for *E. coli*, 12 were in exceedance of the 130 cfu/100ml 30-day average limit set for total body recreation, 17 exceeded the one-time maximum limit for total body recreation of 300 cfu/100ml, and six of these streams exceeded the 1,000 cfu/100ml for partial body recreation for at least one observation.

4. **Improve and maintain stream quality throughout ERCOL tributaries as measured through benthic macroinvertebrate community health**

   Of the 15 streams within the ERCOL watershed observed for community health, 11 were recorded in fair condition or worse. Only 2 streams, Eastport Creek and Williamsburg Creek, were recorded in good condition with 2 streams recorded as good/fair.

5. **Maintain reasonable levels of chlorophyll a in all ERCOL lakes**

   Chlorophyll a concentrations do not seem to be problematic based on monitoring data, although some lakes in the Upper Chain slightly exceed the ecoregion recommendation given by the EPA. Lower concentrations would be expected in the primarily oligotrophic lakes within the Lower Chain. Further monitoring is needed to examine reported blooms of algal activity within the region.

6. **Reduce and maintain the level specific conductivity in all ERCOL lakes**

   Although current concentrations of dissolved solids—as approximated by specific conductivity—are not problematic, they are elevated in many of the ERCOL lakes relative to reference conditions throughout the ecoregion and state of Michigan.

7. **Reduce and maintain chloride levels in all ERCOL lakes**

   Although likely not problematic, many lakes with the ERCOL exhibit elevated chloride levels relative to ecoregion and state reference levels. This may be an indication of increased developmental pressure in these regions.

8. **Maintain water clarity and physical character of ERCOL lakes**

   Several lakes within the ERCOL are well known for their high water clarity and it is recommended to maintain secchi depth at levels that approximate the mean values given in Chapter 2. Water clarity will vary naturally based on productivity between lakes and precipitation events within lake basins, but attention should be paid to significant tends in water clarity.

9.4 HABITAT AND LAND RESOURCE PROTECTION

Assessment of habitat and land resource protection will be conducted through regular surveys of land characteristics within the watershed. The development of measurable indicators will be a critical part of determining success in land resource protection efforts. Implementation tasks that relate directly to land protection can serve as specific goals for this component of the evaluation strategy. These monitoring efforts can be divided into the following categories.

HABITAT

With a limited set of established habitat data in the watershed, it is most important to build a baseline understanding of existing lake, stream, riparian, and wetland habitat. Over the next 10 years it is recommended that surveys are conducted to assess the broad-scale quality of habitat throughout the watershed and highlight discrete areas that harbor threatened species and species of interest. Identifying at-risk habitats should also be a large component of this analysis. Existing stream habitat surveys and biological surveys can be refined and incorporated into a more comprehensive database of ERCOL habitat quality and distribution.

RIPARIAN ZONES

Stream bank erosion surveys and greenbelt surveys will be continued throughout the watershed to assess problem areas that may contribute to increased erosion loading. Bank alterations, erosion areas, and areas prone to nutrient runoff will be documented and survey results will be used to target activities with riparian property owners to encourage corrective actions. Comprehensive surveys are recommended at least every 5 years to accurately assess the current state of riparian zones. TOMWC will be conducting an extensive streambank erosion survey during the next few years.

WETLANDS

Wetland monitoring will be conducted as part of the land use change monitoring procedure using remotely sensed imagery. High value wetlands will be identified and highlighted as areas for protection and assessed at least every 10 years for changes in spatial extent and quality. Wetlands are also incorporated into the watershed protection priority parcel analysis in Chapter 4.

INVASIVE SPECIES

Monitoring of invasive species will consist primarily of surveys of aquatic invasive species throughout the ERCOL waters. TOMWC conducted an extensive survey of the distribution of a number of significant invasive species throughout the main channels of the ERCOL in 2015 and additional surveys are recommended in the main tributaries to the system as well as the main channel every 10 years. The survey data presented in Chapter 4 will be used as a baseline for comparisons of future distributions to determine rough trends in colonization and spread.

LAND USE

Land use trends will be carefully monitored using remote sensing imagery and ground-truthing where necessary. The data used to generate land cover maps and statistics for this plan is from the NOAA C-CAP dataset from 2010. Land use monitoring will consist of updating these figures and statistics if/when new large-scale datasets become available, with a priority focus on assessing land cover in detail at least every 10 years. Additional agricultural surveys are recommended throughout this time frame to better understand distributions, trends, and impacts of farmland.

LAND PROTECTION AND MANAGEMENT

The priority parcel analyses presented in Chapter 4 will serve as the primary tool for measuring success of protection efforts. These figures will be updated at least every five years to incorporate new conservation easements and acquisitions. High priority areas within the watershed protection analysis and Tier 1 areas within the land protection analysis will be of most significant conservation consideration. Updates should also include the addition of any new areas placed under protection.

GROUNDWATER

Potential groundwater recharge areas are determined by the slope and permeability of soils within the watershed. Areas that have been highlighted for groundwater recharge as seen in Chapter 1 need to be protected to ensure healthy replenishment of aquifers, streams, and lakes in the ERCOL watershed. It is unlikely that these areas will change significantly moving forward and it is important to collaborate with zoning officials to ensure minimal expansion of impervious surfaces into valuable groundwater recharge areas. Groundwater recharge is also considered within the watershed protection priority parcel analysis in Chapter 4, lending additional significance to conservation of these high priority parcels.

STORMWATER

A survey of significant stormwater outfalls, generally concentrated in town and villages, is needed to assess the impacts of stormwater runoff on ERCOL waters. Cataloging the location of these areas and sampling water quality at the outfall will provide baseline information on the magnitude and character of stormwater issues. Sampling outfalls in the direct aftermath of storm events will provide critical information about the effectiveness of stormwater infrastructure.

ROAD STREAM CROSSINGS

Road-stream crossings will be assessed in a thorough survey of major sites at least every 10 years according to the established Great Lakes Road Stream Crossing Inventory procedure. Priority will be placed on monitoring known problem sites and areas of high or fluctuating streamflow. In addition to monitoring efforts, there must be significant collaboration effort with county governments and road commissions to address existing severe road-stream crossing sites. The identified top 10 sites will be of priority consideration for structural improvements, but all severe sites must remain in strong consideration.

RECREATION, HEALTH, AND SAFETY

Close monitoring of health advisories throughout the region and concentrations of toxic substances in ERCOL waters is necessary to ensure the health of the people within the watershed. *E. coli*, mercury, TCE, and other factors with harmful effects on humans will require additional sampling and it is recommended that further surveys be conducted to assess their impact on ERCOL waters and human users. Priority will be placed on ensuring the safe recreational use and consumption of water and fish throughout the watershed, addressing unsafe areas and protecting threatened areas.

SOCIAL FACTORS

The effectiveness of educational efforts and involvement of local residents, tourists, and officials will be assessed primarily through social surveys and feedback from town hall meetings. TOMWC will be conducting an extensive social survey of local officials and stakeholders in 2016, which will be used to establish a baseline status of many social factors throughout the watershed. Continued monitoring of socio-economic factors in the region will be conducted using available census data at least every 5 years.

9.5 SUMMARY

The evaluation strategy presented here provides a framework for assessing the effectiveness of implementation and monitoring efforts through the watershed. As further issues and information emerge, additional tasks and monitoring efforts will certainly be added to those laid out within this chapter and those previous. Improving monitoring standards and establishing new programs where necessary will help develop robust datasets to inform management actions and educate local citizens, officials, and tourists on their role in watershed health.

Regular meetings of the ERCOL-WPIT and other concerned citizens to address current and emerging issues within the watershed and assess the ongoing effectiveness of this management plan will be critical in extending the lifespan of its usefulness. The tools presented here and throughout the previous chapters are intended to provide baseline data, decision-making tools, and goals to protect the resources in the ERCOL watershed for many years to come.

REFERENCES

Allan, J.D. (2004). Landscapes and riverscapes: the influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution, and Systematics*. 35:257-284.

Antrim County Planning Commission. (2012). Antrim County Master Plan 2012.

Ardizone, Katherine A. and Mark A. Wyckoff, FAICP. 2003. Filling the Gaps: Environmental Protection Options for Local Governments. Michigan Department of Environmental Quality Coastal Management Program with financial assistance from National Oceanic and Atmospheric Administration, authorized by the Coastal Zone Management Act of 19722. June 2003.

Boutt, D.F., Hyndman, D.W., Pijanowski, B.C., and D.T. Long. (2001). Identifying potential land use-derived solute sources to stream baseflow using ground water models and GIS. *Groundwater*. 39(1):24-34.

Center for Watershed Protection (CWP). (1998). (Reprint 2001.) Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds. Center for Watershed Protection: Ellicott City, MD.

Clement, T.A. (2016). *Grass River Natural Area Stream Monitoring Report.*

ESLA. (n.d.). Retrieved February 29, 2016, from Elk-Skegemog Lakes Association: http://www.elk-skegemog.org/

Farrand, W.R. (1988). The Glacial Lakes around Michigan. Bulletin 4. Geological Survey Division. Michigan Department of Environmental Quality.

Friends of Clam Lake. (n.d.). Retrieved March 2, 2016 from Friends of Clam Lake: http://www.focl.info/

Frankenberger, J., McLoud, S., and A. Faulkenburg. (2002). Watershed Inventory Workbook for Indiana: A guide for watershed partnerships. Retrieved from https://engineering.purdue.edu/SafeWater/watershed/inventoryf.pdf.

Fuller, L.M., & Minnerick, R.J. (2008). *State and regional water-quality characteristics and trophic conditions of Michigan's inland lakes, 2001–2005: U.S. Geological Survey Scientific Investigations Report 2008–5188*.

Grass River Natural Area (GRNA). (n.d.). Retrieved March 2, 2016, from Grass River Natural Area: http://www.grassriver.org

Great Lakes Integrated Sciences Assessments (GLISA). (2014). Climate Change in the Great Lakes Region. Retrieved from http://glisa.umich.edu/media/files/GLISA_climate_change_summary.pdf.

Kendall, A., Fessell, B., & Cronk, K. (2014). *Understanding the Hydrologic Landscape to Assess Trajectories of Sediment Sources and Stream Condition in the Grass and Rapid River Watersheds.*

Kling, G.W., Hayhoe, K., Johnson, L.B., Magnuson, J.J., Polasky, S., Robinson, S.K., Shuter, B.J., Wander, M.M., Wuebbles, D.J., D.R. Zak. (2003). Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems. Union of Concerned Scientists & Ecological Society of America. UCS Publications, Two Brattle Square, Cambridge, MA.

Loon Network. (n.d.). Retrieved February 29, 2016, from Loon Network: http://loonnetwork.org/

Legislative Council, State of Michigan (B). (2016). Michigan Planning Enabling Act: Act 33 of 2008. Retrieved from http://www.legislature.mi.gov/documents/mcl/pdf/mcl-Act-33-of-2008.pdf.

Legislative Council, State of Michigan. (2016). Michigan Zoning Enabling Act: Act 110 of 2006. Retrieved from http://www.legislature.mi.gov/(x3eqqx2ix0ez34nsk1zysl45)/documents/mcl/pdf/mcl-Act-110-of-2006.pdf.

Mao, X.F. and L.J. Cui. (2012). Reflecting the importance of wetland hydrologic connectedness: a network perspective. *Procedia Environmental Sciences.* 13:1315-1326.

Michigan Association of Planning. (n.d.). Public Acts. Retrieved from http://www.planningmi.org/publicacts.asp.

Michigan Department of Environmental Quality. (2006). *Administrative Rules, Part 4. Water Quality Standards, Promulgated pursuant to Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.*
Michigan Department of Natural Resources (MDNR). (2015). Learn about Michigan's World-Class Fishing. Retrieved from http://www.michigan.gov/dnr/0,4570,7-153-10364_52259-330626--,00.html.

Michigan Department of Natural Resources (MDNR). (2016) Fish Stocking Database. Retrieved from http://www.michigandnr.com/fishstock/.

Michigan Department of Technology, Management and Budget (DTMB). (2016). 2010 Census Data for Michigan. Retrieved from http://www.michigan.gov/cgi/0,4548,7-158-54534-252541--,00.html.
Michigan Geographic Data Library (MiGDL). (2002). Michigan Fish Atlas (Shapefile). Retrieved from https://www.mcgi.state.mi.us/mgdl/?rel=ext&action=sext.

Michigan Natural Features Inventory (MFNI). (n.d.). Rare Species Explorer. Retrieved from http://mnfi.anr.msu.edu/explorer/search.cfm.

Non-Strucutural BMP Maintenance and Inspection. Chesapeake Stormwater Network, 2014.
Huron River Watershed Council. *2003. Mill Creek Subwatershed Management Plan.* Ann Arbor, MI.
An Implementation Resource of the New Designs for Growth Guidebook. Northwest Michigan Council of Governments, 2010

Networks Northwest. (2015). County Business Patterns 1998 through 2013. Retrieved from ftp://www.nwmcog.org/CBP/MI-Counties/CBP_1998-2013_Antrim.pdf.

Networks Northwest (B). (2015). Employment and Unemployment Statistics. Retrieved from http://www.northernlakes.net/wp-content/uploads/2015/07/NLEA1.pdf.

Paddle Antrim. (n.d.). About Paddle Antrim. Retrieved from http://www.paddleantrim.com/.

Richards, P. L. (2012). *The Grass River Soil Water Assessment Tool: A Model for Predicting Sources and Sinks of Sediment.* The College at Brockport, Dept of Earth Sciences. Retrieved February 22, 2016, from http://www.3lakes.net/wp-content/uploads/2007/12/Grass-River-SWAT-model_final_report-1-21-12.pdf

Richards, P. L. (2012). *The Rapid River Soil Water Assessment Tool: A model for predicting sources and sinks of sediment.* The College at Brockport , Dept of Earth Sciences. Retrieved February 22, 2016, from http://www.elk-skegemog.org/wp-content/uploads/2014/05/SWAT.pdf

Ritter, M. E. (2006). The Physical Environment: an Introduction to Physical Geography. Retrieved from http://www.earthonlinemedia.com/ebooks/tpe_3e/title_page.html.

Scott, R.W. and F.A. Huff. 1997. Lake Effects on Climatic Conditions in the Great Lakes Basin. Illinois State Water Survey. Atmospheric Sciences Division. Champaign, Illinois. Contract Report 617 (Midwestern Climate Center Research Report 97-01). Retrieved from http://www.isws.illinois.edu/pubdoc/cr/iswscr-617.pdf .

Three Lakes Association (TLA). (n.d.). Retrieved February 22, 2016, from Three Lakes Association: http://3lakes.com

The Watershed Center (TWC). (n.d.). Retrieved February 29, 2016, from The Watershed Center Grand Traverse Bay: http://www.gtbay.org

Tip of the Mitt Watershed Council (TOMWC). 2005. Elk River Chain of Lakes Watershed Project-CMI. Retrieved from https://www.michigan.gov/documents/deq/ess-nps-fs-elk-river_208801_7.pdf.

Tip of the Mitt Watershed Council (TOMWC). (2010). Elk River Chain of Lakes: Lakes Profile 2010 Report. Retrieved from http://www.watershedcouncil.org/uploads/7/2/5/1/7251350/elk_river_chain_of_lakes_-_profile_2010.pdf.

Tip of the Mitt Watershed Council (TOMWC). 2016. Retrieved from http://www.watershedcouncil.org/.

TownCharts. (2016). Antrim County, MI Economy Data. Retrieved from http://www.towncharts.com/Michigan/Economy/Antrim-County-MI-Economy-data.html.

United States Department of Agriculture (USDA). 1966. Soil Survey: Grand Traverse County Michigan. U.S. Government Printing Office. Series 1958, No. 34.

United States Department of Agriculture (USDA). (2012). 2012 Census Publications. Michigan State and County Profiles. Retrieved from http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Michigan/.

U.S. Fish & Wildlife Service. (2015). Endangered Species: Michigan County Distribution of Federally-Listed Threatened, Proposed, and Candidate Species. Retrieved from http://www.fws.gov/midwest/endangered/lists/michigan-cty.html.

United States Geological Survey (USGS). (n.d.). Mineral Resources On-Line Spatial Data. Retrieved from http://mrdata.usgs.gov/geology/state/state.php?state=MI.

United States Geological Survey (USGS). (2013). USGS Groundwater Information: The Importance of Ground Water in the Great Lakes Region Water, Water Resources Investigations Report 00-4008. Retrieved from http://water.usgs.gov/ogw/pubs/WRI004008/groundwater.htm.

U.S. Census Bureau. State and County Quick Facts. (2015). Retrieved from http://quickfacts.census.gov/qfd/states/26/26137.html
.
US Climate Data. (2015). Retrieved from http://www.usclimatedata.com/climate/kalkaska/michigan/united-states/usmi0444People.

United States Environmental Protection Agency. (1986). *Quality Criteria for Water.*

United States Environmental Protection Agency. (2000). *Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria for Lakes and Reservoirs in Nutrient Ecoregion VII.*

United States Environmental Protection Agency (2012). *Recreation Water Quality Criteria.*

Varga, L. (2012). Three Lakes Association Fish Shelter Project Handbook. Retrieved from http://3lakes.com/wp-content/uploads/2012/09/TLA-FIsh-Shelter-Handbook.pdf.

Weatherspark. Average weather for Bellaire, Michigan, USA. (n.d.). Retrieved from https://weatherspark.com/averages/29565/Bellaire-Michigan-United-States.

APPENDICES

APPENDIX A: RIVER/STREAMBANK SEDIMENT EROSION TABLES

The two tables below summarize stream bank erosion features and their sediment erosion loads in tons per year. Loads in the first table were measured during road stream crossing surveys. These surveys looked for erosion features that were within line of site when standing upon the road stream crossing structure. Typically this included 30-70 feet of the stream up and down stream of the crossing. Erosion features were measured in 3 dimensions, eroded material was noted, and a total sediment erosion load was calculated using the access database provided by the Great Lakes Road Stream Crossing Inventory. The second table are erosion features noted during stream bank erosion surveys. These surveys took place on foot by walking 500 feet up stream and 500 feet downstream of a road stream crossing. In addition one 4.5 mile kayak survey was done on the lower section of the rapid river. The survey data sheet for this method was compiled by Tip of the Mitt Watershed Council, and included measurements in 2 dimensions, qualitative severity ranking, and cause of erosion estimates. Erosion loads were calculated from this data by using the following formula. Sediment erosion load (tons/year) = length * height * average density of sandy loam * annual sediment erosion estimator. This final variable was taken from the following reference : https://deq.mt.gov/Portals/112/Water/WQPB/CWAIC/TMDL/C03-TMDL-02a.pdf in appendix C.

EROSION LOAD METHODOLOGY

Sediment erosion load (tons/year) range	Severity Ranking
0-1	1
1.1-4	2
4.1-10	3
10.1-15	4
15.1-20	5

ROAD STREAM CROSSING INVENTORY SEDIMENT EROSION FEATURES AND LOADS

Site ID	GPS Location	Average Length of Eroded Bank	Soil Texture	Severity	Erosion Load (Tons/Year)	Severity Ranking
CL04	44.978615, -85.210123	15.00	Gravel	Moderate	0.5712	1
CL09	44.90246, -85.21107	15.00	Loam	Minor	0.095	1
CL10	44.893985, -85.21049	6.50	Loam		0.2022	1
CL11	44.88841, -85.20781	8.00	Sand	Severe	4.092	3
CL12	44.882464, -85.207653	4.00	Gravelly Loam		0.084	1
CL18	44.941526, -85.281975	19.33	Sand	Moderate	10.857	4
ER03	44.850389, -85.327604	15.00	Gravel	Minor	0.12	1
ER05	44.794779, -85.326788	5.75	Gravelly Loam	Minor	0.0062	1
ER10	44.772788, -85.355466	40.00	Sandy Loam	Moderate	0.2016	1
ER17	44.7638, -85.403475	9.00	Gravelly Loam	Moderate	2.38	2
ER18	44.758088, -85.414213	18.50	Gravel	Moderate	2.73	2
ER19	44.757231, -85.403704	5.50	Gravelly Loam	Moderate	0.1348	1
HL03	45.18222, -85.26528	1.42	Sand	Minor	0.0049	1
HL09	45.14901, -85.30595	34.50	Loam	Moderate	0.425	1
HL10	45.14839, -85.28609	10.50	Loam	Moderate	0.9499	1
HL13	45.14018, -85.30004	7.00	Gravel	Minor	0.014	1
HL18	45.107269, -85.251976	100.00	Sand	Severe	15.4	5
HL23	45.07891, -85.27308	34.00	Sand	Severe	3.0129	2
HL24	45.07794, -85.26422	32.50	Loam	Severe	4.488	3
HL25	45.09822, -85.26745	4.65	Loam	Moderate	0.0862	1
HL26	45.22444, -85.25194	23.50	Loam	Moderate	0.5544	1
HL31	45.16556, -85.23986	45.50	Sand		3.63	2
HL33	45.14, -85.247433	10.00	Gravel	Minor	0.08	1
IR02	45.03033, -85.21888	17.50	Sand	Moderate	0.7726	1
IR08	44.98965, -85.11846	30.00	Gravelly Loam	Severe	8.4	3
IR09	44.982034, -85.1363	21.00	Loam	Moderate	0.1294	1
IR11	44.97528, -85.16249	30.00	Sandy Loam	Moderate	0.4032	1
IR13	44.95697, -85.132839	40.00	Loam	Moderate	1.9712	2
IR14	44.94224, -85.12211	30.75	Sand	Minor	0.0677	1
IR16	44.94597, -85.07099	9.00	Sandy Loam	Minor	0.0259	1
RR08	44.75517, -85.21089	14.50	Gravel	Moderate	1.7548	2
RR10	45.801, -85.16959	23.00	Gravel	Minor	0.326	1

Site ID	GPS Location	Average Length of Eroded Bank	Soil Texture	Severity	Erosion Load (Tons/Year)	Severity Ranking
RR13	44.82533, -85.09161	4.50	Gravel	Moderate	0.434	1
SC04	45.140886, -85.200457	33.33	Silt	Severe	3.4	2
SC05	45.115981, -85.194377	6.00	Silt	Severe	0.102	1
SC06	45.120861, -85.210674	15.00	Loam	Severe	2.64	2
SC10	45.064392, -85.171584	100.00	Sandy Loam	Moderate	0.336	1
TL02	45.121537, -85.335729	30.00	Loam	Moderate	0.7078	1
TL09	45.107223, -85.345161	24.00	Sand	Severe	2.112	2
TL10	45.097209, -85.332847		Sand	Severe	6.16	3
TL12	45.094843, -85.325491		Sandy Loam	Moderate	0.3696	1
TL14	45.04287, -85.284125		Loam	Moderate	0.0934	1
TL16	45.017151, -85.332019		Loam	Severe	1.488	2
TL18	44.959707, -85.324869		Sandy Loam	Severe	1.6128	2
TL20	44.945385, -85.323358		Gravelly Loam	Severe	0.757	1
TL21	44.889607, -85.272277		Sandy Loam	Severe	9.6	3
TL23			Gravel	Moderate	1.1386	2

STREAM BANK EROSION SURVEY EROSION FEATURES AND SEDIMENT LOADS

Site ID	GPS Location*	Average Length of Eroded Bank	Soil Texture	Severity	Erosion Load (Tons/Year)	Load Category
TL06_U1		30.00	Sand	Moderate	1.001466	2
TL06_U2		30.00	Sand	Moderate	1.001466	2
TL06_U3		25.00	Sand	Moderate	0.834555	1
TL06_U4		31.00	Sand	Moderate	0.6898988	1
TL06_U5		60.00	Sand	Moderate	1.335288	2
TL06_D1		20.00	Sand	Moderate	0.667644	1
TL06_D2		90.00	Sand	Moderate	2.503665	2
SC13_UD		0.00		Low	0	1
SC12_UD		0.00		Low	0	1
SC14_U1		10.00	Sand	Moderate	0.166911	1
SC14_U2		200.00	Sand	Moderate	3.33822	2
SC14_D1		400.00	Sand	Moderate	6.67644	3
SC15_D1		500.00	Sand	Severe	17.05395	5
SC15_U1		20.00	Sand	Low	0.14514	1
IR14_UD		0.00		Low	0	1

Site ID	GPS Location*	Average Length of Eroded Bank	Soil Texture	Severity	Erosion Load (Tons/Year)	Load Category
IR18_D1		100.00	Sand	Moderate	4.45096	3
IR15_D2		13.30	Sand	Severe	3.78029225	2
IR15_D3		20.00	Sand	Moderate	0.333822	1
IR18_U1		0.00	Sand	Low	0	1
IR13_D1		60.70	Gravel	Low	0.4404999	1
IR13_D2		30.00	Gravel	Low	0.14514	1
IR13_U1		50.00	Gravel	Severe	3.41079	2
IR13_U2		25.00	Gravel	Severe	2.842325	2
IR11_U1		120.00	Gravel	Low	1.30626	2
IR11_D1		300.00	Gravel	Low	4.3542	3
RR12_UD		0.00		Low	0	1
CL12_U1		56.00	Sand	Low	0.541856	1
CL12_D1		10.00	Sand	Low	0.09676	1
CL08_D1		57.50	Loam	Low	1.66911	2
TL08_U1		34.20	Sand	Low	0.3309192	1
TL08_U2		15.00	Sand	Low	0.14514	1
TL02_U1		49.00	Gravel	Moderate	1.6357278	2
TL08_D1		35.00	Loam	Moderate	1.168377	2
TL08_D2		60.00	Loam	Moderate	2.002932	2
RR07_U1		0.00			0	1
RR02_D1		80.00	Gravel	Moderate	26.70576	5
RR02_D2		0.00			0	1
RR14_D1		0.00			0	1
RR14_D2		100.00	Loam	Moderate	16.6911	5
RR03_U1		0.00		Low	0	1
RR03_D2		125.00	Loam	Low	2.419	2
RR03_D3		100.00	Loam	Low	5.8056	3
RR03_D1		0.00		Low	0	1
RR03_D4		70.00	Loam	Moderate	15.57836	5
ER15_U1		30.00	Sand	Low	0.29028	1
ER15_D1		7.00	Sand	Moderate	0.1557836	1
ER11_U1		250.00	Sand	Low	1.608635	2
TL23_ D1		49.50	Sand	Severe	16.8834105	5
TL23_D2		16.00	Gravel	Severe	5.457264	3
TL23_D3		17.50	Gravel	Severe	5.9688825	3
TL23_D4		100.00	Sand	Severe	11.3693	4
TL23_U1		36.00	Gravel	Severe	14.7346128	4
TL23_U2		100.00	Gravel	Severe	6.82158	3
TL09_U1		0.00		Low	0	1
CL09_U2		0.00		Low	0	1

*GPS location recorded on a GPS unit at TOMWC.

APPENDIX B: ROAD STREAM CROSSING INVENTORY DATA SHEET

Stream Crossing Data Sheet

Site ID: ____________

General Information

Stream Name: ______________________ **Road Name:** ______________________

Name of Observer(s): ______________________ **Date:** ____________

GPS Waypoint: ____________ **GPS Lat/Long:** ______________________

County: ____________ **Township:** ________ **Range:** ________ **Sec:** ________

Adjacent Landowner Information: ____________ **Additional Comments:** ____________

Crossing Information

Crossing Type: Culvert(s) no.: ______ Bridge Ford Dam Other: ____________

Structure Shape: Round Square/Rectangle Open Bottom Square/Rectangle Pipe Arch Open Bottom Arch Ellipse

Inlet Type: Projecting Mitered Headwall Apron Wingwall 10-30° or 30-70° Trash Rack Other

Outlet Type: At Stream Grade Cascade over Riprap Freefall into Pool Freefall onto Riprap Outlet Apron Other

Structure Material: Metal Concrete Plastic Wood

Substrate in Structure: None Sand Gravel Rock Mixture

General Condition: New Good Fair Poor

Plugged: ______ % Inlet Outlet In Pipe

Crushed: ______ % Inlet Outlet In Pipe

Rusted Through? Yes No **Structure Interior:** Smooth Corrugated

Multiple Culverts/Spans

Number the culverts/spans left to right, facing downstream.
Include #s in site sketch on back page

Culvert/ Span #	Width (ft)	Length (ft)	Height (ft)	Material

Structure Length (ft):[1] ________ **Structure Width (ft):**[1] ________ **Structure Height (ft):**[1] ________

Structure Water Depth (ft):[1] **inlet** ________ **outlet** ________ **Perch Height (ft):**[1] ________ or NA

Embedded Depth of Structure (ft):[1] **inlet** ________ **outlet** ________

Structure Water Velocity (ft/sec):[1] **inlet** ________ **outlet** ________

Structure Water Velocity Measured: At Surface or ______ **ft Below Surface** **Measured With:** Meter or Float Test

Stream Information

Stream Flow: None < ½ Bankfull < Bankfull = Bankfull > Bankfull

Scour Pool (if present) Length: ____ **Width:** ____ **Depth:** ____ **Upstream Pond (if present) Length:** ____ **Width:** ____

Riffle Information (measured in a riffle outside of zone of influence of crossing)

Water Depth (ft): ______ **Bankfull Width (ft):** ______ **Wetted Width (ft):** ______ **Water Velocity (ft/sec):** ______

Dominant Substrate: Cobble Gravel Sand Organics Clay Bedrock Silt **Measured With:** Meter or Float Test

Road Information

Type: Federal State County Town Tribal Private Other:

Road Surface: Paved Gravel Sand Native Surface **Condition:** Good Fair Poor

Road Width at Culvert (ft): ________ **Location of Low Point:** At Stream Other **Runoff Path:** Roadway Ditch

Embankment: **Upstream** **Fill Depth (ft):** ________ **Slope:** Vertical 1:1.5 1:2 >1:2

Downstream **Fill Depth (ft):** ________ **Slope:** Vertical 1:1.5 1:2 >1:2

Left Approach: **Length (ft):** ________ **Slope:** 0% 1-5% 6-10% >10% **Ditch Vegetation:** None Partial Heavy

Right Approach: **Length (ft):** ________ **Slope:** 0% 1-5% 6-10% >10% **Ditch Vegetation:** None Partial Heavy

[1] - Fill out for primary culvert (culvert #1). If multiple culverts are used, number each and use embedded table. Form Date: February 28, 2011

Erosion Information

Use a new row for each distinct gully/erosion location. Note prominent streambank erosion within 50 feet of crossing.

Location of Erosion Ditch, approach, or streambank Left or right facing downstream	**Erosion Dimensions (ft)**			**Eroded Material Reaching Stream?**		**Material Eroded** Sand, Silt, Clay, Gravel, Loam, Sandy Loam or Gravelly Loam.
	Length	**Width**	**Depth**			
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	

If there is erosion occurring, can corrective actions, such as road drainage measures, be installed to address the problem? **Y N**

Extent of Erosion: Minor Moderate Severe Stabilized

Erosion Notes:

Photos – enter photo number in blank corresponding to location

❑ Site ID ______ ❑ Upstream Conditions ______ ❑ Downstream Conditions ______

❑ Inlet ______ ❑ Outlet ______ ❑ Road Approach – Left ______ ❑ Road Approach – Right ______

Summary Information

Would you consider this a priority site? Fish Passage Erosion Why?

Would you recommend a future visit to this site? Yes No **Why?**

Were any non-native invasive species observed at the site? Yes No **If yes, what species were observed?**

Site Sketch

Draw an overhead sketch of crossing. Be sure to mark North on the map and to indicate the direction of flow. Include major features documented on form, such as erosion sites, multiple culverts, scour pool, impounded water, etc.

Form Date: February 28, 2011

APPENDIX C: ROAD STREAM CROSSING INVENTORY RESULTS

Below are 3 tables to help share additional information on road stream crossing inventory results. The first table is an estimated sediment erosion load resulting from road stream crossings for each sub-watershed. While this table is limited in its usability due to incomplete sampling of all crossings, and a potential bias introduced by spot checks (see comment below table), the table is still an adequate represetion of where acute problems lie within the ERCOL. The second table is a summary of the top 3 worst road stream crossing for each sub-watershed. This can be used as a tool to help prioritize crossing improvement work. The final table is a comprehensive data table for road stream crossings surveyed using the Great Lakes Road Stream Crossing Inventory Method (see Appendix B for data sheet).

SUBWATERSHED SEDIMENT EROSION LOADS FROM ROAD STREAM CROSSINGS

Sub-Watershed	RSX Sediment Erosion Loads (Tons/Year)	Number of Road Stream Crossings	Average Erosion Per Crossing*	Number of Spotchecks
Clam Lake	20.0895	12	1.67	6
Elk River	15.1958	14	1.08	7
Hanley Lake	59.9148	26	2.30	3
Intermediate River	33.111	16	2.07	2
Rapid River	11.4838	13	0.88	2
St Clair Lake	11.3893	12	0.95	7
Torch Lake	45.1201	20	2.26	8

*This value should not be taken as a cumulative. Not all crossings were sampled for each sub watershed. In addition a potential bias is imparted on this data due to the fact that sites that did not appear sever were often marked as spot checks, and sediment erosion loads were not calculated for that site. Therefore the more spot checks within a subwatershed, the more potential there is for a skew in the data towards high erosion load crossings.

TOP 3 WORST ROAD STREAM CROSSINGS PER SUBWATERSHED

Site ID	Stream Name	Road Name	GPS Location	Primary Issues
CL08	Cold Creek	Comfort Rd	44.91926, -85.20055	High erosion from lack of buffer, undersized culvert
CL11	Finch Creek	Elder Rd	44.88841, -85.20781	Extreme erosion from native road surface and lack of buffer, evidence of road washout, undersized culvert
CL16	Crow Creek	Elder Rd	N/A	Extreme erosion from native road surface and lack of buffer, evidence of road washout, undersized culvert
ER05	Unknown	Hoiles Drive Northwest	44.79477, -85.32678	High perch, scour pool
ER15				High perch, scour pool, undersized
ER17	N Branch of Bissel Creek	Williamsburg Road	44.7638, -85.403475	High erosion from lack of buffer and undersized culvert, high perch
HL10	King Creek	Essex Road	45.14839, -85.28609	Extremely undersized, flooding potential, high erosion from foot traffic on bank
HL18	Benway Creek	Rushton Rd	45.10726, -85.25197	Small dam just upstream, extreme erosion on bank from lack of vegetation, undersized crumbling concrete structure
HL23	Coulter Creek	HWY 88	45.07891, -85.27308	High erosion due to lack of buffer and riparian vegetation, high perch
IR06	Unknown	Derenzy Rd	45.01154, -85.19286	High perch, lack of buffer
IR08	Cedar River (N Branch)	County Rd 620	44.98965, -85.11846	Road washed out and destroyed, destroyed structure, extreme erosion from native surface road
IR18	Cedar River	Cedar River Rd	44.95948, -85.07078	Extreme erosion from sand surface road, undersized culvert
RR06	Rapid River	Hanson Rd NW	44.77945, -85.20082	High erosion from sand surface road, undersized culvert
RR08	Little Rapid River	N Birch St	44.75517, -85.21089	High erosion from gravel road, extremely undersized culvert, potential road flooding
RR09	Little Rapid River	Old M72 NW	44.74759, -85.18925	High erosion from gravel road, extremely undersized culvert, potential road flooding
SC06	Unknown	Six Mile Lake Rd	45.12086, -85.21067	Extremely high perch, undersized, high erosion due to lack of vegetation
SC14	Taylor Creek	Old State Rd	45.05410, -85.13768	High perch, undersized culvert
SC16	Spence Creek	Skinkle Rd	45.05382, -85.15929	Extremely high perch, extremely undersized culvert, water withdrawal for agriculture
TL14	Unknown	N Buhland Road	45.04287, -85.28412	Extremely high perch, erosion due to lack of vegetation, undersized culvert
TL16	Unknown	NE Torch Lake Drive	45.01715, -85.33201	Extremely high perch, erosion due to lack of vegetation, undersized culvert
TL20	Unknown	NW Torch Lake Drive	44.94538, -85.32335	Extremely high perch, erosion due to lack of vegetation, undersized culvert

TOTAL ROAD STREAM CROSSING DATA

Site ID	Stream Name	Road Name	Latitude	Longitude	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
CL01	Grass Creek	Davock Rd.			culvert(s)				Moderate	
CL02	Grass Creek	S. Eckhardt Rd.	44.990203	-85.261567	culvert(s)	2.2637	2.2636	0.9	Moderate	45
CL03	Grass Creek	Bellaire Hwy	44.980261	-85.254014	culvert(s)	0.0378	0.0378	0	Severe	100
CL04	Intermediate River (Connecting channel between Intermediate & Bellaire Lakes)	Bridge St.	44.978615	-85.210123	Bridge	0.0952	0.6664	0.5	Moderate	145
CL05	Intermediate River	Cayuga St	44.975369	-85.213363	Bridge	0.2935	0.2936	1	Minor	0
CL06	Shanty Creek	Route 88	44.7652	-85.19864	culvert(s)	0.0522	0.0522	0.9	Minor	10
CL07	Shanty Creek	Grass River Rd.	44.7652	-85.19864	culvert(s)	0.0382	0.0382	0.9	Minor	
CL08	Cold Creek	Comfort Rd	44.91926	-85.20055	culvert(s)	1.1002	1.1002	0	Severe	135
CL09	Finch Creek	Alden Highway	44.90246	-85.21107	culvert(s)	0.0738	0.1687	0	Severe	110
CL10	Finch Creek	Finch Creek Rd	44.893985	-85.21049	culvert(s)	0.125	0.3252	0.5	Moderate	70
CL11	Finch Creek	Elder Rd	44.88841	-85.20781	culvert(s)	0.0362	4.1282	0	Severe	250
CL12	Finch Creek	Finch Creek Rd	44.882464	-85.207653	culvert(s)	0.0141	0.0982	0	Severe	100
CL13	Finch Creek	Bebb Rd.			culvert(s)					
CL14	Finch Creek	Bebb Rd								
CL15	Cold Creek	Alden Highway						0	Severe	
CL16	Crow Creek	Elder Rd.								
CL17										
CL18	Clam Lake Outlet to Torch Lake	South East Torch Lake Drive	44.941526	-85.281975	Bridge	0.0602	10.9172	0.9	Minor	25

*Spotchecks are highlighted in gray and contain no quantitative data.

Site ID	Stream Name	Road Name	Latitude	Longitude	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
ER01	Unknown	Cherry Ave								
ER02	Unknown	Elk Lake Rd			culvert(s)					
ER03	Torch Lake Outlet	Crystal Beach Rd	44.850389	-85.327604	Bridge	0.0219	0.1419	0.9	Moderate	20
ER04	Williamsburg Creek	Ayers Rd	44.7946278	-85.387311	culvert(s)	0.1225	0.1225	0	Severe	100
ER05	Unknown	Hoiles Drive Northwest	44.794779	-85.326788	culvert(s)	0.0282	0.0344	0	Severe	110
ER06	Unknown	Baggs Rd Northwest								
ER07	Desmond Creek	Rapid City Rd Northwest	44.7876639	-85.2777417	culvert(s)	0.3793	0.3792	0	Severe	100
ER08	Barker Creek	M-72	44.7798139	-85.3243	culvert(s)	0.002	0.002	0.5	Moderate	35
ER09	Unknown									
ER10	Battle Creek East Branch	Watson Rd	44.7727889	-85.3554667	culvert(s)	0.292	0.4937	0.5	Severe	70
ER12	Battle Creek	M72	44.7759194	-85.3616667	culvert(s)	1.8512	1.8512	0.5	Moderate	70
ER13	Williamsburg Creek	Old State Highway 72	44.7729833	-85.4004861	culvert(s)	0.3302	0.3302	0	Severe	100
ER14	Williamsburg Creek	M72	44.7711917	-85.4012972	culvert(s)	1.681	1.6809	0.5	Moderate	70
ER15	Unknown				culvert(s)			0	Severe	
ER16	Battle Creek	Deal Road	44.7650667	-85.364325	culvert(s)	0.8153	0.8153	0	Severe	110
ER17	N Branch of Bissel Creek	Williamsburg Road	44.7638	-85.403475	culvert(s)	0.0323	2.4124	0	Severe	170
ER18	N. Branch of Bissel Creek	Moore road	44.7580889	-85.4142139	culvert(s)	3.9339	6.6639	0.5	Severe	170
ER19	S. Branch of Bissel Creek	Williamsburg Road	44.757231	-85.403704	culvert(s)	0.1185	0.2533	0	Severe	135
ER23	Unknown				culvert(s)					
ER24	Williamsburg Creek	Church Street	44.768745	-85.402389						
ER25	Elk Lake Outlet	Walking bridge	44.898009	-85.415892	culvert(s)	0.0149	0.0149	0	Severe	100

Site ID	Stream Name	Road Name	Latitude	Longitude	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
HL01	Mason Creek	Phelps Rd	45.22194	-85.27056	culvert(s)	1.5397	1.5397	0.5	Moderate	70
HL02	Little Torch/Mud Lake Connector	Atwood	45.18528	-85.31556	culvert(s)	1.5794	1.5795	0.9	Moderate	45
HL03	Skinner Creek Tributary	Eaton	45.18222	-85.26528	culvert(s)	0.3472	13.6455	0	Severe	110
HL04	Skinner Creek	Best Rd	45.18139	-85.26194	culvert(s)	0.3808	0.3808	1	Minor	0
HL06	Skinner Creek	Lake Street	45.16944	-85.24194	Bridge	0.1934	0.1933	0.5	Moderate	35
HL09	Toad Creek	Essex Rd	45.14901	-85.30595	culvert(s)	0.3255	0.7505	0	Severe	145
HL10	King Creek	Essex Rd	45.14839	-85.28609	culvert(s)	0.0462	0.9961	0.9	Moderate	55
HL11	Vonstraten Creek	Ellsworth Rd	45.14772	-85.25919	culvert(s)	0.136	0.136	0	Severe	100
HL12	King Creek	Dennis Rd	45.14568	-85.28466	culvert(s)	0.3868	0.3868	0.5	Moderate	35
HL13	Toad Creek	Peebles Rd	45.14018	-85.30004	culvert(s)	4.9985	5.0125	0.9	Severe	30
HL14	Toad Creek	Toad Lake Rd	45.13601	-85.29548	culvert(s)	0.6479	0.6479	0	Severe	100
HL15	King Creek	Ellsworth Road (C-65)	45.12762	-85.26451	culvert(s)	0.7073	0.7073	0.5	Moderate	45
HL16	Ogletree Creek	Bennett Hill Rd	45.11944	-85.2786	culvert(s)	0.1454	0.1455		Minor	45
HL18	Benway Creek	Rushton Rd	45.107269	-85.251976	culvert(s)	0.5195	15.9195	0	Severe	100
HL19	Benway Creek	Mohrmann Bridge Rd	45.103482	-85.243911	culvert(s)	2.4992	2.4992	0.9	Moderate	45
HL20	Ogletree Creek	Chessie Lane	45.09788	-85.26224	culvert(s)	0.1121	0.1121	0.5	Moderate	100
HL21	Ogle Tree Creek	Mohrman Bridge and Roberts Rd								
HL23	Coulter Creek	HWY 88	45.07891	-85.27308	culvert(s)	0.0719	3.0849	0	Severe	250
HL24	Coulter Creek	HWY 88	45.07794	-85.26422	culvert(s)	0.0098	4.4978	0	Severe	250
HL25	Ogletree Creek	Ellisworth Rd / County Rd 65	45.09822	-85.26745	culvert(s)	0.0992	0.1854	0	Severe	135
HL26	Marion Creek	Phelps Rd	45.22444	-85.25194	culvert(s)	0.365	0.9194	0	Severe	145
HL27	Kings Creek	Toad Lake Rd								
HL28	Eaton Lake/ Vonstraten Creek	Essex Rd	45.16235	-85.27091	culvert(s)	1.1471	1.1471	0.9	Moderate	45
HL29	Skinner Creek	Marion Center Rd	45.18944	-85.26333	culvert(s)	0.2214	0.2215	0.5	Moderate	35
HL31	St. Clair/Elsworth Lake Connector	Bridge St	45.16556	-85.23986	culvert(s)	0.5514	3.6354	0.9	Severe	20
HL32	Intermediate River	Mohrmann Bridge Rd	45.096492	-85.25744	Bridge	0.014	0.014	0.9	Minor	10
HL33	Intermediate River	Clay Pit Bridge	45.14	-85.247433	Bridge	1.2226	1.3026	0.9	Moderate	55
HL34	Intermediate River	State St	45.070163	-85.258965	Bridge	0.2545	0.2545	0.9	Minor	10

Site ID	Stream Name	Road Name	Latitude	Longitude	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
IR01	Unknown	M-88	45.04287	-85.25944	culvert(s)	0.5115	0.5114	0.5	Moderate	45
IR02	Fisk Creek	S Intermediate Lake Rd	45.03033	-85.21888	culvert(s)	0.0243	0.7969	0	Severe	25
IR03	Unknown				culvert(s)					
IR04	Openo Creek	Derenzy Rd	45.02564	-85.19254	culvert(s)	0.0358	0.0358	0.9	Minor	10
IR05	Openo Creek	S Intermediate Lake Rd	45.02199	-85.20151	culvert(s)	0.1466	0.1466	0.9	Minor	10
IR06	Unknown	Derenzy Rd	45.01154	-85.19286	culvert(s)	0.8004	0.8003	0	Severe	110
IR07	Unknown	S Derenzy Rd	44.99581	-85.19305	culvert(s)	0.0473	0.0473	0.5	Moderate	10
IR08	Cedar River (N Branch)	County Rd 620	44.98965	-85.11846	culvert(s)	0.7272	9.1273	0	Severe	250
IR09	Cedar River (N Branch)	Oslund Rd	44.982034	-85.1363	culvert(s)	0.0932	0.2226	0	Severe	135
IR10	Cedar River	S. Derenzy Rd.	44.978261	-85.193105	Bridge	0.0694	0.0694	0	Severe	100
IR11	Cedar River	Burrel Rd	44.97528	-85.16249	Bridge	0.0582	0.4615	0.5	Moderate	10
IR12	Cedar River	Beeman Road	44.9692	-85.13874	culvert(s)	0.4205	0.4205	0	Severe	100
IR13	Cedar River	Schuss Mountain Road	44.95697	-85.132839	culvert(s)	0.1768	2.1479	0	Severe	170
IR14	Cedar River	Schuss Mt Rd	44.94224	-85.12211	culvert(s)	1.7449	1.8125	0.5	Moderate	145
IR15	Cedar River	Doerr Rd	44.94911	-85.09345	culvert(s)	0.1463	0.1463	0	Severe	100
IR16	S Tributary of Cedar River	Cedar River Rd	44.94597	-85.07099	culvert(s)	0.1406	0.1665	0	Severe	110
IR17	Tributary of Cedar River	Cedar River Rd			culvert(s)					
IR18	Cedar River	Cedar River Rd	44.95948	-85.07078	culvert(s)	16.1984	16.1983	0	Severe	200

Site ID	Stream Name	Road Name	Latitude	Longitude	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
RR01	Rapid River	Aarwood Rd			Bridge	0.0168	0.0167	0.9	Minor	10
RR02	Rapid River	Rapid City Rd	44.83737	-85.28266	Bridge	0.0234	0.0234	0.5	Moderate	35
RR03	Rapid River	Kellogg Rd	44.82256	-85.24167	culvert(s)	0.0367	0.0367	0	Severe	100
RR04	Rapid River	Underhill Rd			Bridge					
RR05	Rapid River	Wood Rd NW			culvert(s)	1.232	1.232	0	Severe	100
RR06	Rapid River	Hanson Rd NW	44.779456	-85.200823	culvert(s)	0.797	0.797	0	Severe	110
RR07	Little Rapid River	Seely Rd	44.772349	-85.210145	culvert(s)	0.476	0.476	0	Severe	100
RR08	Little Rapid River	N Birch St	44.75517	-85.21089	culvert(s)	0.4944	2.2492	0	Severe	170
RR09	Little Rapid River	Old M72 NW	44.74759	-85.18925	culvert(s)	2.8394	2.8394	0	Severe	200
RR10	Rapid River	Wood Road NE	45.801	-85.16959	culvert(s)	0.2243	0.5503	0	Severe	100
RR11	Rapid River	US 131	44.81552	-85.1397	culvert(s)	0.2737	0.2737	0.5	Moderate	35
RR12	Rapid River	Day Road NE	44.81587	-85.13274	culvert(s)	1.8424	1.8425	0.5	Moderate	70
RR13	Rapid River	Priest Road	44.82533	-85.09161	culvert(s)	0.1389	0.573	0	Severe	110
RR15	Rapid River	Dundas Rd	44.80078	-85.21148	Bridge	0.5739	0.5739	0	Severe	110
RR27	Elk Lake	Dexter Rd								

Site ID	Stream Name	Road Name	Latitude	Longitude	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
SC01	Saint Clair Creek	Detour Rd	45.17555	-85.21338	culvert(s)	1.3087	1.3087	0	Severe	135
SC02	NE Tributary of St. Clair Creek	Miles Rd.	45.1714	-85.20087	culvert(s)	0.054	0.054	0	Severe	100
SC03	St. Clair Creek	Elsworth Rd.	45.16293	-85.21524	culvert(s)	0.1384	0.1385	0.5	Moderate	35
SC04	Liscon Creek	Miles Rd	45.140886	-85.200457	culvert(s)	0.6474	4.0474	0.9	Severe	160
SC05	Unknown	Dingman School Rd	45.115981	-85.194377	culvert(s)	0.189	0.2911	0	Severe	150
SC06	Unknown	Six Mile Lake Rd	45.120861	-85.210674	culvert(s)	0.1226	2.7627	0	Severe	250
SC07	Unknown	Six Mile Lake Rd.			culvert(s)	0.5468	0.5468	1	Minor	10
SC08	Unknown	Six Mile Lake Rd			culvert(s)					
SC09	Unknown	Kidder Rd			culvert(s)					
SC10	Beals	Six Mile Lake Rd @ Echo Lane	45.064392	-85.171584	culvert(s)	0.5963	0.9323	0.5	Moderate	50
SC11	Unknown		45.06094	-85.14711						
SC12	Unknown	Wold St/Kidder Rd			culvert(s)					
SC13	Intermediate	Old State Rd	45.06032	-85.15715	culvert(s)	0.3109	0.3109	0.9	Moderate	20
SC14	Taylor Creek	Old State Rd	45.054101	-85.137687	culvert(s)	0.229	0.2291	0	Severe	100
SC15	Unknown		45.03501	-85.13776	culvert(s)					
SC16	Spence Creek	Skinkle Rd	45.05382	-85.15929	culvert(s)	0.6102	0.6102	0	Severe	145
SC17	Unknown				culvert(s)					
SC18	NE Tributary of St. Clair Creek	Miles Rd.								
SC19	Unknown	Dingman School Rd / Six Mile Lake Rd	45.09336	-85.19372	culvert(s)	0.1576	0.1576	0.5	Moderate	35

Site ID	Stream Name	Road Name	Latitude	Longitude	Crossing Type	Sediment Load from Road	Total Sediment Load	Fish Passability Score	Severity Rating	Severity Score
TL01	Wilkonson Creek	Church Rd	45.12382	-85.315395	culvert(s)	0.2836	0.2836	0.5	Moderate	35
TL02	Eastport Creek	Farrell Rd	45.121537	-85.335729	culvert(s)	0.1091	0.8169	0.5	Moderate	80
TL03	Unknown	Old Dixie Highway	45.121469	-85.351848						
TL04	West arm of Eastport Creek	Highway 31	45.108952	-85.351289	culvert(s)	1.5526	1.5527	0.9	Moderate	45
TL05	Wilkinson Creek	Bennett Hill Rd	45.120659	-85.320839						
TL06	West Tributary of Eastport Creek	Highway 31	45.123597	-85.350012	culvert(s)	0.0992	0.0992	0.5	Moderate	
TL07	Unknown	Pearl Street	45.108944	-85.350185	culvert(s)					
TL08	Wilkinson	M-88	45.107514	-85.329859	culvert(s)	0.2618	0.2618	0.5	Moderate	35
TL09	Eastport Creek	M-88	45.107223	-85.345161	culvert(s)	1.1864	3.2984	0	Severe	185
TL10	Wilkinson Creek	NE Torch Lake Drive	45.097209	-85.332847	culvert(s)	0.0251	0.2452	0.9	Moderate	160
TL11	Unknown									
TL12	Unknown	NE Torch Lake Drive	45.094843	-85.325491	culvert(s)	0.1205	0.4901	0	Severe	135
TL13	Unknown	NE Torch Lake Drive	45.085544	-85.321608	culvert(s)	0.0098	0.0098	1	Minor	110
TL14	Unknown	N Buhland Road	45.04287	-85.284125	culvert(s)	0.5954	0.6889	0	Severe	145
TL15	Unknown	NE Torch Lake Drive	45.038991	-85.298946	culvert(s)	0.0192	0.0192	0	Severe	100
TL16	Unknown	NE Torch Lake Drive	45.017151	-85.332019	culvert(s)	0.032	1.52	0	Severe	185
TL18	Unknown	NW Torch Lake Drive	44.959707	-85.324869	culvert(s)	0.0746	1.6874	0	Severe	185
TL19	Unknown	Powell Road	44.94891	-85.332353	culvert(s)	0.2112	0.2113	0.5	Severe	35
TL20	Unknown	NW Torch Lake Drive	44.945385	-85.323358	culvert(s)	0.1288	0.8857	0	Severe	160
TL21	Unknown	Torch Lake Rd	44.889607	-85.272277	culvert(s)	3.5782	13.1782	0.9	Severe	160
TL22	Spencer Creek	SE Torch Lake Drive	44.880838	-85.276631	Bridge	0.0517	0.0517	0.9	Minor	10
TL23	Spencer Creek	Smaller Street	44.879187	-85.272301	Bridge	0.1027	1.2413	0.9	Moderate	80
TL24	Spencer Creek	Valley Rd			culvert(s)					
TL25	Spencer Creek	McPherson	44.871694	-85.231497	culvert(s)	18.5206	18.5207	0	Severe	200
TL26	Unknown	Valley Road	44.863925	-85.257072	culvert(s)	0.058	0.058	0	Severe	120
TL27	Spencer Creek	Valley Rd			culvert(s)			0	Severe	
TL28	Spencer Creek	Valley Rd			culvert(s)					
TL29	Unknown	Birch Road	45.110815	-85.353432	culvert(s)					

APPENDIX D: COLDWATER LAKES AND STREAMS IN THE STATE OF MICHIGAN

The State of Michigan has designated coldwater lakes and streams in the state of Michigan in the 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).

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 LAKES AND STREAMS IN THE WATERSHED

Lakes	Tributaries of Torch Lake upstream to Intermediate Lake	Tributaries in Intermediate Lake area	Tributaries of Lake of the Woods	Tributaries in Elk and Skegemog Lake area
Torch Lake Elk Lake	Grass River (T29N, R8W, S13) Antrim Wilkinson Creek (T31N, R8W, S7) Antrim Finch Creek (T29N, R8W, S13) Antrim Bonnie Brook (T29N, R8W, S21) Antrim Spencer Creek (T29N, R8W, S28) Antrim Cedar River (T30N, R7W, S20) Antrim Cold Creek (T29N, R7W, S7) Antrim Shanty Creek (T29N, R7W, S7) Antrim Eastport Creek from mouth (T31N, R8E, S31) Antrim Intermediate River from Lake Bellaire up to Bellaire Dam (T30N, R7W, S31) Antrim	Skinner Creek (T32N, R8W, S13) Antrim, Charlevoix Mason Creek (T32N, R8W, S11) Antrim, Charlevoix Marion Creek (T32N, R8W, S2) Antrim, Charlevoix Fish Creek (T30N, R8W, S1) Antrim Ogletree Creek (T31N, R8W, S11) Antrim Intermediate River (T31N, R7W, S28) Antrim	Saloon Creek (T29N, R7W, S17) Antrim Unnamed Creek (T29N, R7W, S17) Antrim	Williamsburg Creek (T28N, R9W, S27) Grand Traverse Battle Creek (T28N, R9W, S26) Grand Traverse Barker Creek (T28N, R8W, S30) Kalkaska Desmond Creek (T28N, R8W, S29) Kalkaska Vargason Creek (T28N, R8W, S28) Kalkaska 4 Unnamed Creeks (T28N, R8W, S29) Kalkaska Rapid River and tributary (T28N, R8W, S6) Kalkaska Torch River (T28N, R8W, S18) Antrim, Kalkaska

APPENDIX E: PRIORITY PARCEL ANALYSIS SCORING CRITERIA

Parcel Size:

< 10 Acres (0 Points)

10 – 20 Acres (1 Points)

20 – 40 Acres (2 Points)

40 – 80 Acres (3 Points)

> 80 Acres (4 Points)

Ground Water Recharge Potential:

< 1% Permeable Soil (0 Points)

1 – 30% Permeable Soil (1 Points)

30 – 50% Permeable Soil (2 Points)

50 – 80% Permeable Soil (3 Points)

> 80% Permeable Soil (4 Points)

Wetlands:

< 10% Wetland Coverage (0 Points)

10 – 25% Wetland Coverage (1 Points)

25 – 50% Wetland Coverage (2 Points)

50 – 70% Wetland Coverage (3 Points)

> 70% Wetland Coverage (4 Points)

Lake Shoreline:

< 100 ft. Lake Frontage (0 Points)

100 – 200 ft. Lake Frontage (1 Points)

200 – 400 ft. Lake Frontage (2 Points)

400 – 600 ft. Lake Frontage (3 Points)

> 600 ft. Lake Frontage (4 Points)

Stream Shoreline:

< 100 ft. Stream Frontage (0 Points)

100 – 500 ft. Stream Frontage (1 Points)

500 – 1,000 ft. Stream Frontage (2 Points)

1,000 – 2,000 ft. Stream Frontage (3 Points)

> 2,000 ft. Stream Frontage (4 Points)

Steep Slopes:

<20% Slope within Parcel (0 Points)

20 – 30% Slope within Parcel (1 Points)

30 – 35% Slope within Parcel (2 Points)

35 – 40% Slope within Parcel (3 Points)

> 40% Slope within Parcel (4 Points)

Protected Land Adjacency:

> 250 ft. from Protected Parcel (0 Points)

< 250 ft. from Protected Parcel (1 Points)

Adjacent to Protected Parcel (2 Points)

Linking Protected Parcel (3 Points)

Doubling Size of Protected Parcel (4 Points)

Threatened or Endangered Species:

RI* < 3 (0 Points)

3 < RI < 4 (1 Points)

RI > 4 (2 Points)

PROB** = Moderate (3 Points)

PROB = High (4 Points)

* The biological rarity index (RI) is designed to help prioritize the known occurrence areas for conservation.

** The probability value is designed to highlight those areas with known occurrences of rare species or high quality natural communities.

Proximity to Development:

Undeveloped* (0 Points)

Developed* (1 Points)

Within 2.5 Miles of 'Urban'** Area (2 Points)

Within .75 Miles of 'Urban'** Area (3 Points)

'Urban'** Area (4 Points)

* Undeveloped land categories were drawn from the NOAA CCAP land cover data and included naturalized, forested, wetland, and etc. (This needs work, check GIS Data)
** 'Urban' Areas were considered to be within the major town/village boundaries verified by the SNRE team.

Natural Land Cover Types:

< 50% Natural Coverage (0 Points)

50 – 70% Natural Coverage (1 Points)

70 – 80% Natural Coverage (2 Points)

80 – 90% Natural Coverage (3 Points)

> 90% Natural Coverage (4 Points)

Drinking Water Protection Areas:

< 1% Wellhead Protection Area (0 Points)

1 - 20% Wellhead Protection Area (1 Points)

20 - 35% Wellhead Protection Area (2 Points)

35 - 50% Wellhead Protection Area (3 Points)

> 50% Wellhead Protection Area (4 Points)

Exceptional Resources:

Adjacent to Blue Ribbon Trout Streams (2 Points)

Adjacent to Undeveloped Lakes (2 Points)

Adjacent to Old Growth Forest (> 90 Years) (2 Points)

APPENDIX F: STAKEHOLDER ENGAGEMENT INFORMATION

Engagement	Date	Notes
Town Hall 1	August 12th, 2015	Town hall style event to present and discuss developments on a new watershed plan. Open to the public, led by SNRE team and TOMWC staff.
Town Hall 2	August 13th, 2015	Town hall style event to present and discuss developments on a new watershed plan. Open to the public, led by SNRE team and TOMWC staff.
Workshop 1	November 11th, 2015	Work session with ERCOL-WPIT members and SNRE team to review field work, threat and stressors and initial critical areas.
Workshop 2	January 29th, 2016	Work session with ERCOL-WPIT members and SNRE team to discuss goals and objective and initial thoughts on implementation tasks.

AUGUST 12TH AND 13TH, 6:30-8:00

ELK RIVER CHAIN OF LAKES WATERSHED TOWN HALLS

An open forum to discuss the Elk River Chain of Lakes

Join the Elk River Chain of Lakes Watershed Plan Implementation Team (ERCOL-WPIT) to present and discuss developments on a new watershed plan! We will be holding two town hall-style events, hosted by a team of students from the University of Michigan's School of Natural Resources and Environment. The first will be held at the Old Elk Rapids Village Hall Meeting Room, the second at the Torch Lake Township Hall. This team is working with Tip of the Mitt Watershed Council, The Watershed Center-Grand Traverse Bay, and many area lake associations conducting research to develop a new Watershed Management Plan for the Elk River Chain of Lakes.

M | SNRE The Watershed Center GRAND TRAVERSE BAY Tip of the Mitt Watershed Council

Join us in the process of protecting and restoring our freshwater resources!

Provide us with your input on components you feel should be incorporated into the plan

---

The meeting of the 12th will be held at the Elk Rapids Old Village Hall Meeting Room at:
321 Bridge Street
Elk Rapids, MI

The meeting of the 13th will be held at the Torch Lake Township Hall at:
2355 North US-31
Kewadin, MI

PRESENTED BY:

University of Michigan School of Natural Resources and Environment

The Watershed Center Grand Traverse Bay

Tip of the Mitt Watershed Council

APPENDIX G: COUNTY ROAD COMMISSION ROAD STREAM CROSSING IMPROVEMENT PROJECTS 2005 - PRESENT

Road Name/Location	Township/Section	Waterway	Date	Culvert/Work Type	Culvert Shape/ Size	Road Surface	Culvert Length
Skinkle Rd. - 2.1 m south of Old State	Echo Section 35	Seamon Creek	4/2006	N/A	Dredge S. side Rd.	20' Asphalt	N/A
Gorham Beach Rd. - N. & S. of M-88	Forest Home Sec. 1	Unnamed	2005	N/A	Dredge E. side Rd.	22' Asphalt	N/A
Gardner Rd. - S. of Six Mile Lake Rd.	Echo Section 6	Unnamed	2007	W. side of road	Ditch Stabilization	22' Gravel	N/A
Gardner Rd. - 300' +/- S. of Six Mile Lake Rd.	Echo Section 6	Unnamed	2007	W. side of road	Dredging - 360 LF	22' Gravel	N/A
Six Mile Lake Rd. - 1270' NW of Buckler	Echo Section 20	Unnamed	9/2015	CMP	Arch - 43" x 27"	20.5' Asphalt	65'
W. Old State Rd. - 0.5 m west of M-88	Central Lake Sec. 22	Unnamed	6/2015	CMP	Round - 24"	21.5' Asphalt	63'
Old State Rd. - 0.8 m west of Finkton	Echo Sect. 26	Taylor Creek	2009	N. side of road	Dredging 290'	20' Asphalt	N/A
Eckhardt Rd. - 1090' W. of M-88	Central Lake Sec. 34	Sisson Creek	2010	CMP - Lower Exist.	Round - 24"	22' Asphalt	39' (Dredge 50')
Valley St. - 1.2 m SE of Smalley St.	Helena Sect. 34	Spencer Creek	9/2005	CMP - Extension	Round - 36"	22' Asphalt	(1) 6' Extension
Wilson Rd.0.85m NW Old State Rd.	Echo Section 21	Russell Creek	2006	CMP	Arch - 60" x 46"	22' Asphalt	60'
Eddy School Rd. - 1.05 m W. of M-66	Chestonia Sec. 18	Unnamed	2011	CMP	Round - 24"	22' Asphalt	49'
Old State Rd. - near Kidder Rd.	Echo Section 22	Unnamed	2005	CMP Ext. - 6' of 30"	Relocate 360' channel	23' Asphalt	(1) 6'
Roberts Rd. - 0.25 m east of Mitchell Rd.	Central Lk. Sec. 3/10	Olgletree Creek	8/2006	CMP - Aluminum Box Culvert	Open Bottom - 19.1' x 3.9'	15' Gravel - Seasonal	48.5'
Mitchelll Rd. - 0.5 m north of Roberts Rd.	Central Lk. Sec. 3	Ogletree Creek	2006	CMP - Aluminum Box Culvert	Open Bottom - 19.1' x 4.2'	16' Gravel	40.5'
Meggison Rd. - 700' W. of N. East Torch Lk.	Central Lk. Sec. 17/20	Unnamed	2005	HDPE	Round - 15"	N/A	100'
Tyler Rd. - 300' East of Comfort Rd.	Custer Sect. 7 & 18	Cold Creek	2006	CMP	Arch - 112" x 75"	22' Gravel	54'
S.W. Torch Lake Dr. - 400' N. of Hickin Rd.	Milton Sect. 30	Unnamed	2006	CMP	Round - 24"	20' Asphalt	65'
Cedar River Rd. - 2412' N, of Doerr Rd.	Chestonia Sec. 31/32	Unnamed	2011	CMP	Arch - 42" x 29"	29' Gravel	44'
Eddy School Rd. - Just East of Batterbee Rd.	Chestonia Sect. 18	Unnamed	2012	CMP	Arch - 36" x 22"	22' Asphalt	59'

ROAD STREAM CROSSING IMPROVEMENTS KALKASKA COUNTY ROAD COMMISSION

Rapid River Crossings replaced within 10-15 years

1. Aarwood Road Bridge, Section 5, Clearwater Township
2. Wood Road Arch Culvert, Section30, Rapid River Township

Rapid River Crossings that are potential threats to the watershed

1. Kellogg Road Crossing, Section 14, Clearwater Township
2. Underhill Road Crossings, Section 14/13, Clearwater Township
3. Dundas Road Crossings, Section 24, Clearwater Township and Section 30, Rapid River Township
4. Wood Road Culvert, Section 21/28, Rapid River Township
5. Day Road Culvert, Section 14/15, Rapid River Township
6. Priest Road Culvert, Section 24, Rapid River Township and Section 19 Coldsprings Township
7. Hanson Road Culvert, Section 31, Rapid River Township
8. Seeley Road Culvert, Section 31, Rapid River Township and Section 6 Kalkaska Township
9. Old M-72 Culvert, Section 7, Kalkaska Township

Information provided by

John S Rogers - Manager

Kalkaska County Road Commission

1049 Island Lake Road

Kalkaska, MI 49646

Phone: 231-258-2242

Fax: 231-258-8205