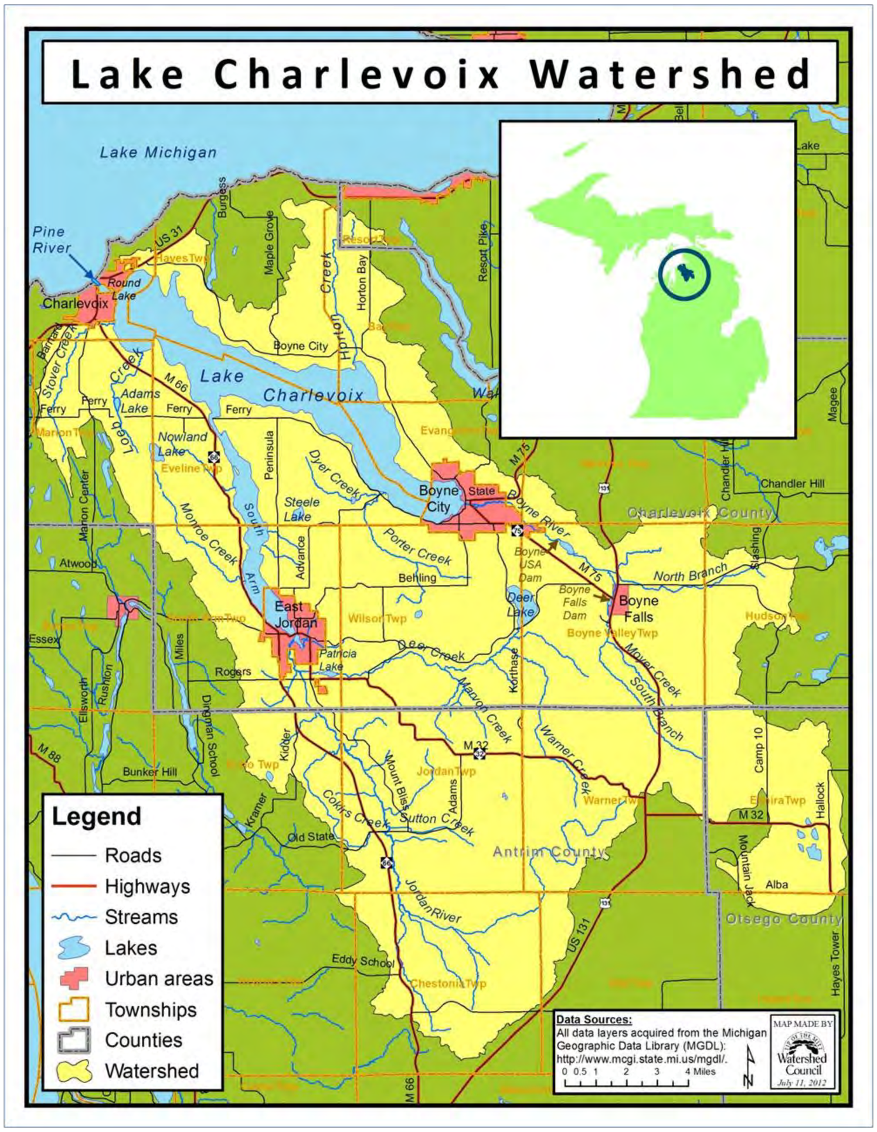
LAKE CHARLEVOIX WATERSHED
MANAGEMENT PLAN



PROTECTING WATER QUALITY FOR TODAY AND TOMORROW

JULY 2012

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ACKNOWLEDGEMENTS

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- Thank you to the Charlevoix Public Library and Boyne City for providing their facilities for the Lake Charlevoix Watershed Advisory Committee meetings.
- Thank you to Claire Rasmussen for volunteering her time and talents to the Advisory Committee and other Lake Charlevoix Watershed programs.

The Lake Charlevoix Watershed Management Plan is available online at: www.watershedcouncil.org.

The online version includes color maps and tables and, therefore, may be easier to interpret information presented in these formats.

FOREWARD

The Lake Charlevoix Watershed is home to many precious water resources; from quiet inland lakes, clear, cold rivers and streams, richly diverse wetlands, and, of course, the beautiful and beloved Lake Charlevoix. These resources are what make the Lake Charlevoix Watershed special to so many. Their value to the people who live and visit the Watershed is immeasurable. The Watershed, as a whole, must be protected.

The Lake Charlevoix Watershed Management Plan is the toolbox that houses the tools necessary to protect the Watershed. Inside you will find an assessment of the current conditions of the Watershed, potential threats to its resources, and recommended actions that must be carried out by the entities with the capacity to implement change.

We are those entities; we are the Lake Charlevoix Watershed Advisory Committee. For many years we have come together as ambassadors of the Watershed and we pledge to continue our commitment to protecting it. We will continue to educate the residents and visitors about resource stewardship; we will practice watershed best management practices (BMPs); we will work with businesses and local governments to make change; we will continue to pursue the funding necessary to implement watershed protection projects; and we will use the tools necessary to protect the watershed.

Please join us in our commitment to protecting the Lake Charlevoix Watershed.

Antrim Conservation District
Antrim County
Antrim County Road Commission
Charlevoix Conservation District
Charlevoix County Board of Commissioners
Charlevoix County Planning Commission
Charlevoix County Road Commission
City of Boyne City
City of Charlevoix
City of East Jordan
Conservation Resource Alliance
Friends of the Boyne River
Friends of the Jordan River Watershed
Grand Traverse Band of Ottawa and Chippewa Indians
Grand Traverse Regional Land Conservancy
Keep Charlevoix Beautiful
Lake Charlevoix Association
Little Traverse Bay Bands of Odawa Indians
Little Traverse Conservancy
Michigan Department of Environmental Quality
Michigan Department of Natural Resources
Michigan State University Extension
Natural Resources Conservation Service
Northwest Michigan Community Health Agency
Northwest Michigan Council of Governments
Tip of the Mitt Watershed Council
Water and Air Team Charlevoix, Inc. (WATCH) & CARE Committee

INTRODUCTION

Watershed management is a widely used and effective approach to managing water resources. The Environmental Protection Agency (EPA), the agency responsible for meeting the requirements set forth in the Clean Water Act (1973), describes the watershed approach as:

> "…a flexible framework for managing water resources quality and quantity within specified drainage areas, or watershed. This approach includes stakeholder involvement and management actions supported by sound science and appropriate technology. The watershed planning process works within this framework by using a series of cooperative, iterative steps to characterize existing conditions, identify and prioritize problems, define management objectives, develop protection or remediation strategies, and implement and adapt selected actions as necessary. The outcomes of this process are documented or referenced in a watershed plan. A watershed plan is a strategy that provides assessment and management information for a geographically defined watershed, including the analyses, action, participants, and resources related to developing and implementing the plan." *EPA's Handbook for Developing Watershed Plans to Restore and Protect Our Water (October, 2005)*

The Lake Charlevoix Watershed Management Plan (Plan) is the result of applying the "watershed approach" to managing water resources within the Lake Charlevoix Watershed (Watershed). The Plan takes into account the known sources and causes of the priority nonpoint source pollutants, the areas within the Watershed most impacted by these pollutants, and the measures necessary to protect or enhance water quality throughout the Watershed. The Plan is a tool and a guide to future management efforts based on the needs of the watershed and capacity of its stakeholders.

And why are these efforts so critical to water quality protection? Moreover, why so important in a watershed with healthy lakes, streams, and wetlands? According to the EPA, nonpoint source pollution is considered the greatest threat to water quality and is the most significant source of water quality impairment in the nation. The EPA notes that "of particular concern are high-quality waters that are threatened by changing land uses when unique and valuable aquatic resources (e.g. habitat for salmon migration, spawning and rearing) are at serious risk of irreparable harm."

Therefore, the development and implementation of watershed plans for waters that are *not* impaired by nonpoint source pollution is, perhaps, the best way to ensure they remain unimpaired. The Plan contains the actions and steps necessary to protect the water resources; implementation of these steps, however, must follow. Implementation of the Plan will be ongoing over the next ten years. At that point, the Plan will once again be updated to reflect current water quality and resource conditions, as well as accomplishments toward water quality protection. New recommended actions and steps for watershed protection will be made and the process will continue. Watershed management is an ongoing effort, but essential for protecting water quality for today and tomorrow.

CHAPTER ONE: THE LAKE CHARLEVOIX WATERSHED

Lake Charlevoix is one of Michigan's premier inland lakes. With a surface area over 17,200 acres, it is the third largest lake in Michigan. The beauty of Lake Charlevoix has attracted visitors for more than a century with its clean water, scenic shoreline, and superb fishing. Lake Charlevoix's tributaries are also a draw with their good water quality and trout fishing opportunities. The largest tributary, the Jordan River, is a state-designated natural river.

The Watershed's resources, however, have not always been valued as they are today. Impacts to Lake Charlevoix's water quality date back to the late 1800s when lumbering occurred throughout the Watershed and associated industries were built along the shores of Lake Charlevoix in Boyne City, East Jordan, and Charlevoix. Lake Charlevoix was primarily seen as a resource for water supply, navigation, and waste disposal. Lake Charlevoix's tributaries experienced a similar fate with significant logging impacts.

Although nearly 100 years have passed, water quality concerns still exist for Lake Charlevoix and its tributaries. The pollutants that threaten Lake Charlevoix's health today are not from industrial sources such as tanneries and lumber companies, but nutrients and sediments from various human activities such as dams, shoreline development, recreational pressures, streambank erosion, road/stream crossings, and agricultural activities. Fortunately, today's residents and visitors of the Watershed have a better understanding how their activities have the potential to impact water resources.

GEOGRAPHY AND HYDROGRAPHY

The Lake Charlevoix Watershed is one of Northern Michigan's larger watersheds covering approximately 332 square miles or 212,515 acres in Antrim, Charlevoix, Emmet, and Otsego Counties (Figure 1). The majority of Charlevoix County's townships are in the watershed including: Bay, Boyne Valley, Charlevoix, Eveline, Evangeline, Hayes, Hudson, Marion, Melrose, South Arm, and Wilson. Antrim County townships in the Watershed include: Chestonia, Echo, Jordan, Star, and Warner. A portion of Elmira Township in Otsego County and a part of Resort Township in Emmet County are also a part of the Watershed. The Lake Charlevoix Watershed includes the municipalities of Charlevoix, Boyne City, East Jordan, and Boyne Falls. The unincorporated villages of Alba, Bay Shore, and Elmira are also in the Watershed.

Lake Charlevoix stretches across the west side of Charlevoix County from northwest to southeast, covering portions of seven townships (Bay, Charlevoix, Evangeline, Eveline, Hayes, South Arm, and Wilson) and touching upon three municipalities (Boyne City, City of Charlevoix, and City of East Jordan).

The lake has two distinct arms separated by an expansive peninsula-like land form. The main basin of Lake Charlevoix measures nearly 14 miles from the entrance to Round Lake at the west end to Boyne City on the east end, and ranges from one to two miles in width. The South Arm extends over 8 miles from Hemingway Point on the main basin southward to East Jordan, and is narrower with widths of less than one mile. Round Lake connects Lake Charlevoix to the Pine River, is encircled by the City of Charlevoix, and measures a half mile or less in diameter. The Pine River measures slightly less than one mile in length and is approximately 110 feet wide and 18 feet deep. The Pine River is a heavily-trafficked waterway because it provides passage between Lake Charlevoix and Lake Michigan. Accordingly, the River requires periodic dredging on a 10 to 15 year cycle, although the last dredge was in 1984. Flow through the channel is interchangeable and may be attributed to seiches, or wind-driven waves, occurring on Lake Michigan; however, the River typically flows toward Lake Michigan.

The two primary inlet tributaries, the Boyne and Jordan Rivers, drain over 70% of the land in the Lake Charlevoix Watershed; 45,912 and 82,356 acres respectively. The Boyne River is Lake Charlevoix's second largest tributary and has approximately 22 miles of mainstream with a multitude of small tributaries. The South Branch of the Boyne River starts in Otsego County and flows through the northeastern corner of Antrim County, while the North Branch begins in eastern Charlevoix County. The confluence of the two branches occurs west of Boyne Falls and the main stem of the river discharges into Lake Charlevoix in Boyne City. Discharge was measured on the Boyne River at Park Street in Boyne City by LTBB from 2004 to 2007 and ranged from 75 cubic feet per second (cfs) to 161 cfs, with an average of 102 cfs.

There are three impoundments on the Boyne River. Starting at the mouth of the river, the first pond is within the Boyne City limits and is oftentimes referred to as the Boyne City Mill Pond. Although the Pond is not a result of any damming of the river, it does impact the river similarly. It collects sediments and provides a large surface area that tends to raise the water temperature during the summer months. Around the turn of the century it was heavily used by various industries located along the south bank of the river. In the 1901 Plat Book this pond is referred to as “Little Lake”.

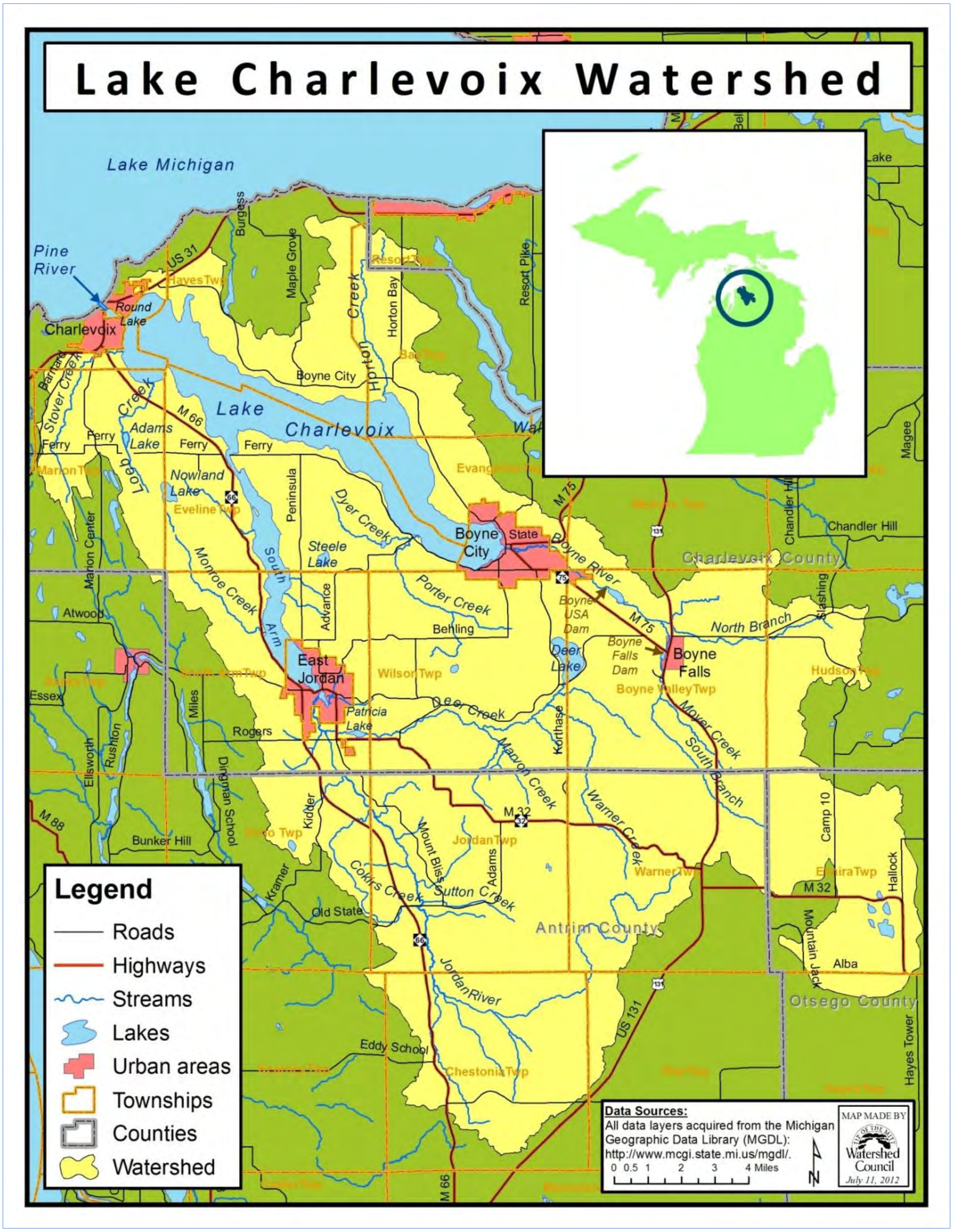


Figure 1: Lake Charlevoix Watershed

Moving upstream the largest impoundment is above the Boyne U.S.A Power Plant Dam. Just after the turn of the century, the dam and power plant were built as a public utility to provide electricity to the surrounding communities. The resulting impoundment above the dam covers about 80 acres. The lake is completely surrounded by private land and is not available for public access. However, the stretch of river from Dam Road upstream (about 0.3 miles) to the pool below the dam is one of the most popular fishing spots on the river.

The South Branch of the Boyne River has an impoundment above the dam at Boyne Falls. The dam was built prior to the turn of the century. A saw mill was located at the site of the auxiliary spillway and a grist mill was located at the opposite end of the pond to the south. There are local stories that tell of the great brown trout that flourished when the pond was new with deep water. Today the pond is filled with sediment and shallow. M-75, the main road between Boyne Falls and Boyne City, crosses over the dam. There are no impoundments on the North Branch.

Portions of the North Branch and mainstem of the Boyne River are recognized as State Designated Blue Ribbon Trout Streams. The North and South branches of the Boyne are noted for brook and brown trout fishing. These branches are not stocked; they are top quality trout streams maintained by natural reproduction of resident fish populations. Downstream of the Boyne U.S.A. Dam, the stream becomes an anadromous fishery known for steelhead and Chinook salmon populations.

The Jordan River, the State's first designated Natural River, flows from headwaters in Antrim County to discharge into the South Arm of Lake Charlevoix in East Jordan. A dense network of tributaries flow into the Jordan River, the largest being the Green River, in headwaters to the south, and Deer Creek, which drains Deer Lake and much of the land area between East Jordan and Boyne Falls. Long-term historical data (1967 to 2011) from a USGS gauge station on the Jordan River at Webster Bridge Road show a range of 166 to 205 cfs, with an average of 186 cfs. Of particular note is the Jordan River Spreads, a highly productive and diverse natural area adjacent to the City of East Jordan. The Spreads occupy several hundred acres and transitions from the open waters of Lake Charlevoix through shallow submerged aquatic plant beds; emergent vegetation such as rushes, sedges, and cattails; wetlands dominated by shrubs (willow, alder, dogwood) and trees (cedar, balsam poplar, black ash, red maple); to uplands. This area is popular for boating, fishing, and wildlife viewing. Bald eagles and ospreys have taken up residence in the area, much to the delight of local residents.

Additionally, a multitude of small inlet streams flow into Lake Charlevoix, including Horton, Loeb, Monroe, Porter, and Stover Creeks. The only outlet is the Pine River, located in the northwest end and flowing through Round Lake before discharging into Lake Michigan.

According to shoreline map files developed in GIS using digital orthophotography, the surface area of Lake Charlevoix is approximately 17,061 acres (Charlevoix County 2004). The deepest point is located near the center of the main basin and reported to be 122 feet deep (MDNR 2011). The South Arm is shallower with a maximum depth of 52 feet. The mean depth of the lake, including the main basin and the South Arm, is approximately 57 feet. The lake area corresponding to depth ranges is distributed somewhat evenly, though nearly 80% of the lake area falls within the ranges of zero to 40 feet and 70 to 100 feet; 39% and 38% respectively (Table 1). Round Lake adds another 70 acres of surface area and measures less than a half-mile in length and width, and is approximately 60 feet of depth.

Table 1: Lake Charlevoix Depth and Area

Depth Range	Acres	Percent
0-10'	1590.73	9.29
11-20'	1148.28	6.70
21-30'	2138.77	12.49
31-40'	1814.70	10.60
41-50'	1161.51	6.78
51-60'	1087.14	6.35
61-70'	1208.01	7.05
71-80'	1519.84	8.87
81-90'	1913.72	11.17
91-100'	1426.91	8.33
101-110'	1611.12	9.41
111-122'	505.13	2.95

With a 60-mile perimeter, Lake Charlevoix has the longest shoreline of any inland lake in the State of Michigan. There are nearly 1,700 properties on the Lake Charlevoix shoreline, of which 85% are developed to some degree (Tip of the Mitt Watershed Council (TOMWC) 2007). Several prominent points along the shoreline project into the main basin, including Two-mile, Loeb, Hemingway, Rocky, and Hayden Points on the south shore and Horse Point on the north shore. Holy Island, the only island found in Lake Charlevoix, is in the northern end of the South Arm and connected via bridge to the west shoreline (Figure 2).

The water levels of Lake Charlevoix fluctuate in tandem with those of Lake Michigan due to the direct hydrologic connection via Round Lake and the Pine River. The long-term average for Lake Michigan is 578.44 feet above sea level, though lake levels have declined since the mid-1980s, and are now hovering at approximately 576.80 feet (USACOE 2011). Therefore, the water levels of Lake Charlevoix and Round Lake have also dropped, exposing the lake bottom and moving the shoreline outward in many areas of the lake.

Water quality vulnerability to watershed development can be assessed using the watershed ratio; a ratio determined by comparing the watershed area to the lake surface area. The watershed ratio provides a statistic for gauging susceptibility of lake water quality to changes in watershed land cover; the higher the ratio, the more land per area of water and thus, the greater the buffer for protecting water quality. The Lake Charlevoix Watershed has a watershed ratio of 11:1, which lies toward the lower end of the range of ratios calculated for other lakes in the region (e.g., Walloon Lake has a ratio of 5:1 whereas the Huffman Lake ratio is 46:1). With an 11:1 ratio, the Lake Charlevoix watershed has a small to moderate protective buffer to safeguard water quality against small areas of development. However, the cumulative impact of extensive landscape development throughout the watershed is likely to have serious adverse impacts on the lake's water quality.

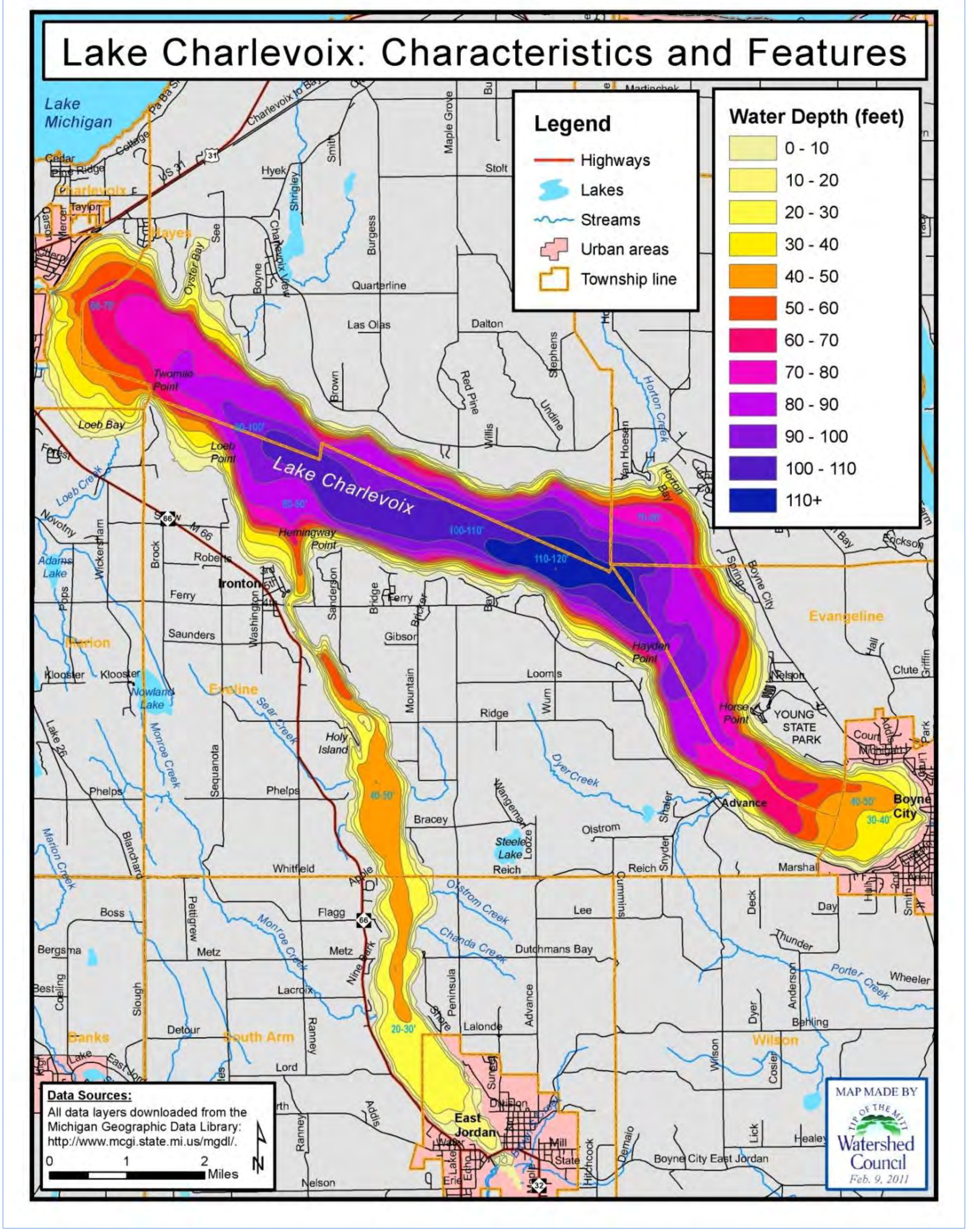


Figure 2: Lake Charlevoix depth

GROUNDWATER

Groundwater is critically important for water quality and ecosystem integrity of lakes, streams, and wetlands in the Lake Charlevoix Watershed (Figure3). Rain, melting snow, and other forms of precipitation move quickly into and through the ground throughout much of the watershed due to highly permeable (sandy) soils. Gravity causes vertical migration of groundwater through soils until it reaches a depth where the ground is filled, or saturated, with water. This saturated zone in the ground is called the water table and can vary greatly in depth. In watershed areas with steep slopes, such as the headwaters of the Jordan River, the hillside intersects the water table, resulting in groundwater expelling at the land surface. The exposed water table causes horizontal groundwater movement, which releases to create seeps and springs that then form or contribute water to streams and wetlands.

Groundwater contributions through the forces and motions described above provide considerable quantities of water to Lake Charlevoix, the Jordan River, Boyne River, other lakes and streams, and wetlands in the Lake Charlevoix Watershed. The degree of groundwater contributions to surface waters in the watershed is illustrated by the Darcy map developed by the University of Michigan and MDNR (Figure 4). The natural aquatic ecosystems formed within water bodies of the Lake Charlevoix Watershed are thereby dependent upon groundwater inputs. Due to this dependency, it is extremely important to protect and conserve groundwater resources in the watershed.

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

Groundwater protection measures should also take into account that groundwater contributions to surface waters in the Lake Charlevoix Watershed are not limited to the watershed area. Extensive areas outside the Lake Charlevoix Watershed boundary, particularly in the Mancelona Plains to the southeast, are known to contribute groundwater to the Jordan River and other stream systems. Groundwater migration from the Mancelona Plains to the Jordan River valley is very gradual, likely occurring over the course of decades if not more, however, these areas need to be considered to comprehensively address groundwater impacts.

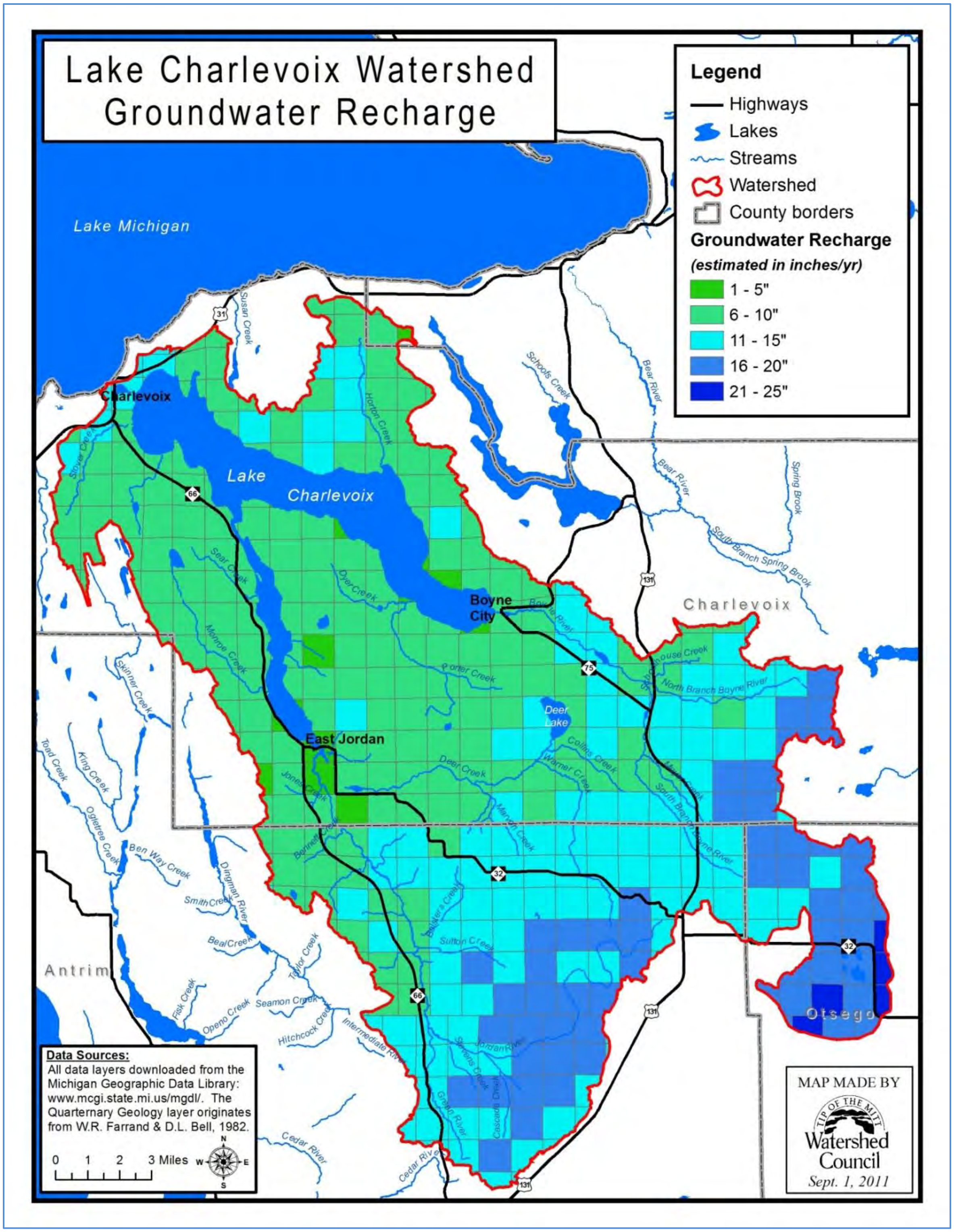


Figure 3: Lake Charlevoix Watershed groundwater recharge

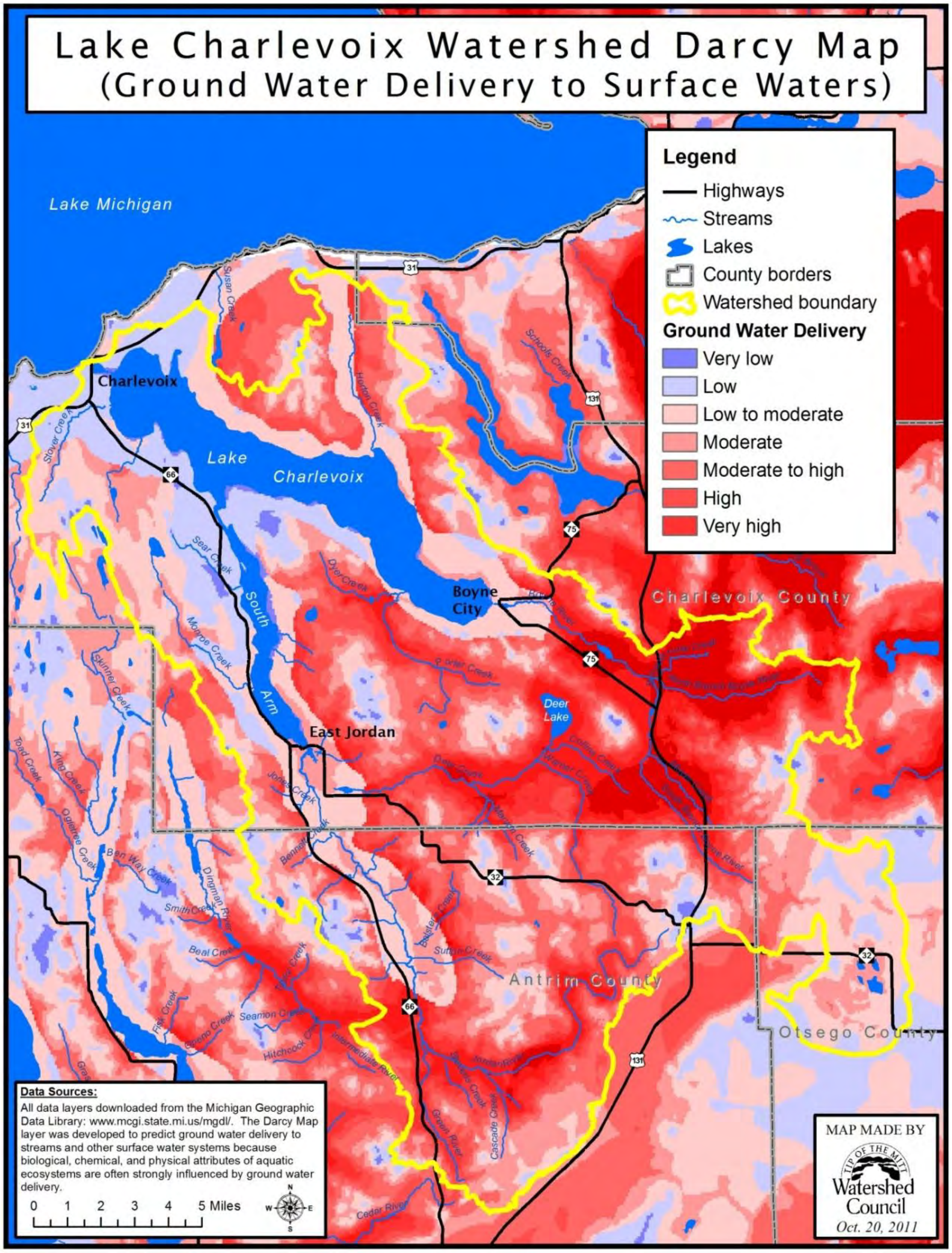


Figure 4: Lake Charlevoix Watershed Darcy Map

GEOLOGY & SOILS

The Lake Charlevoix Watershed contains a mix of gently rolling hills, productive farmland, excellent swimming areas, large expanses of forest and wetlands, steeply sloped hills, and relatively flat lake plains. The present-day topography, hydrology, and surficial geology of the Lake Charlevoix Watershed are a result of a series of glaciers up to 10,000 feet thick that advanced and retreated through the region, the last retreat beginning more than 14,000 years ago (Farrand 1998). In their wake, the glaciers left behind a large scoured area that formed Lake Charlevoix; large ice chunks that melted to form kettle lakes like Nowland and Steele Lakes; precipitous slopes on high moraines in the Boyne and Jordan River Valleys; smaller elongated hills called drumlins, and much more.

Glacially-formed moraines and drumlins run roughly parallel to Lake Charlevoix and the pattern of the ice movement can be identified when looking at topographic maps or aerial photos (Figure 5). In some areas near the lake, moraines rise to 300 feet above the lake's surface, while in the upper Boyne and Jordan River Watersheds, moraines reach more than 1300 feet of altitude (700 feet above the lake's water level). The Lake Charlevoix Watershed is one of the few areas in Michigan where drumlins are found and, in fact, a virtual field of drumlins is found to the west of Lake Charlevoix. The drumlins and moraines run roughly parallel to the lake and the pattern of the ice movement can be identified when looking at topographic maps or aerial photos. The soil type most common in many of the drumlins and moraines is the Emmet-Onaway association, a more loamy soil found in nearly level to very steep areas.

Other landscape features show evidence of rising and falling Great Lake levels that occurred as the glaciers gradually receded (Figure 6). During the time of Lake Algonquin, a phase in post-glacial Great Lakes history that lasted from approximately 11,600 year ago to 10,000 years ago, Great Lakes' water levels in nearby Petoskey were as high as 120 feet above current levels (Spur and Zumberge 1956). In another age of high water from 6,000 to 4,000 years ago called the Nipissing Great Lakes era, water levels were 30 feet higher than today. Both of these historical high Great Lakes' water levels are evident in beach ridges and flat lake plains around the edges of Lake Charlevoix.

The soils in the Lake Charlevoix Watershed vary greatly from steep sandy soils to wet mucky soils (Figure 7). In general, soils in the headwaters of the Boyne River

Subwatershed are in the Kalkaska-Leelanau Association, the steepest association in the watershed. These soils formed in sand and loamy sand till, are well-drained, and mainly sloping to steep on the hilly moraines. The predominant soil type found along the streambanks is the Carbondale-Lupton-Tawas Association. These are very poorly drained, level to gently sloping organic soils in depressional areas on till plains, outwash plains, and lake plains. These soils are indicative of the commonly found shoreline wetlands. Along the lakeshore the predominant soils found are the Kalkaska-Mancelona Association, which are well-drained to moderately well-drained sandy soils that are nearly level and common in lake plains. The soils that fill in the areas between the tributaries and the lakeshore are dominated by the Emmet-Leelanau Association which includes well-drained, sandy soils on moraines with varying steepness from gently rolling to very steep. Similar to the Boyne River, soils throughout much of the Jordan River Subwatershed are in the Kalkaska-Leelanau-Emmet Association, which were formed in sand and loamy sand till. These soils are characteristically well-drained, level to very steep, and on moraines, drumlins, lake plains, and till plains. In flatter valley areas extending from the river channel, particularly in the area between Pinney Bridge and Webster Bridge, soils belong to the Roscommon and Tawas series, which are poorly drained and nearly level to gently sloping.

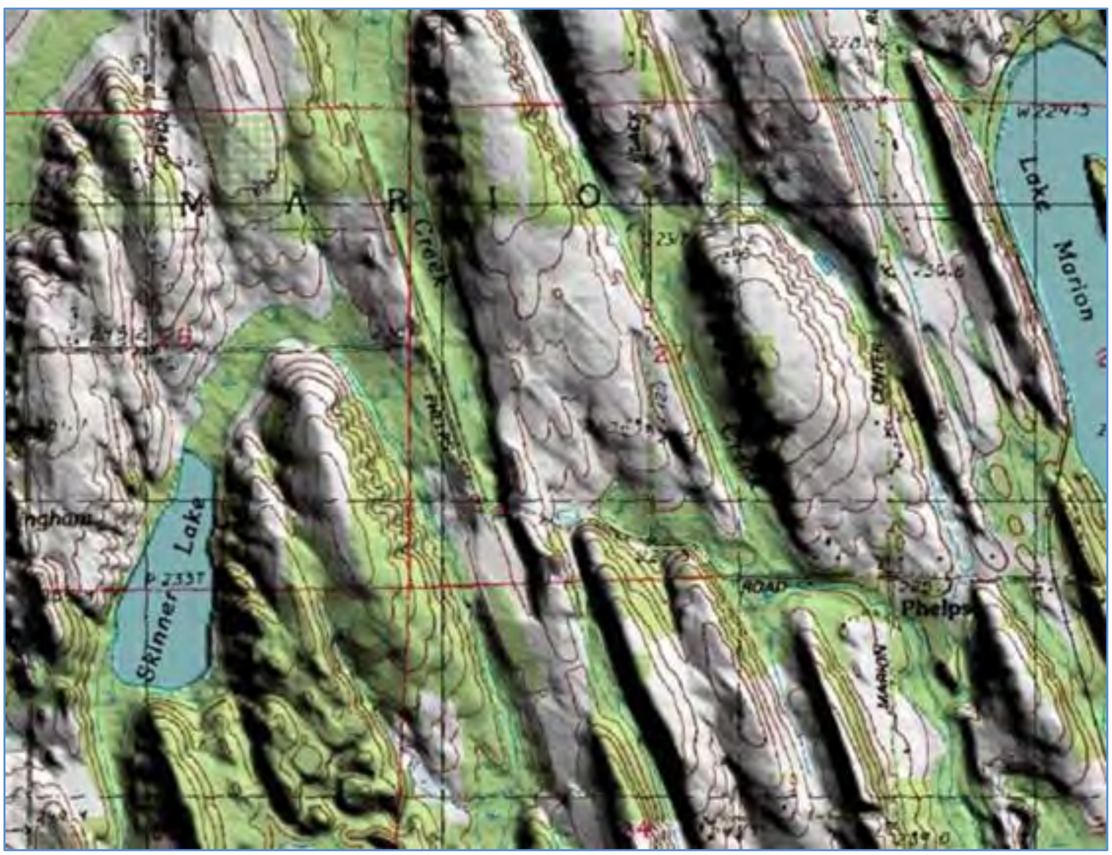


Figure 5: Drumlins in Marion Township, Charlevoix County

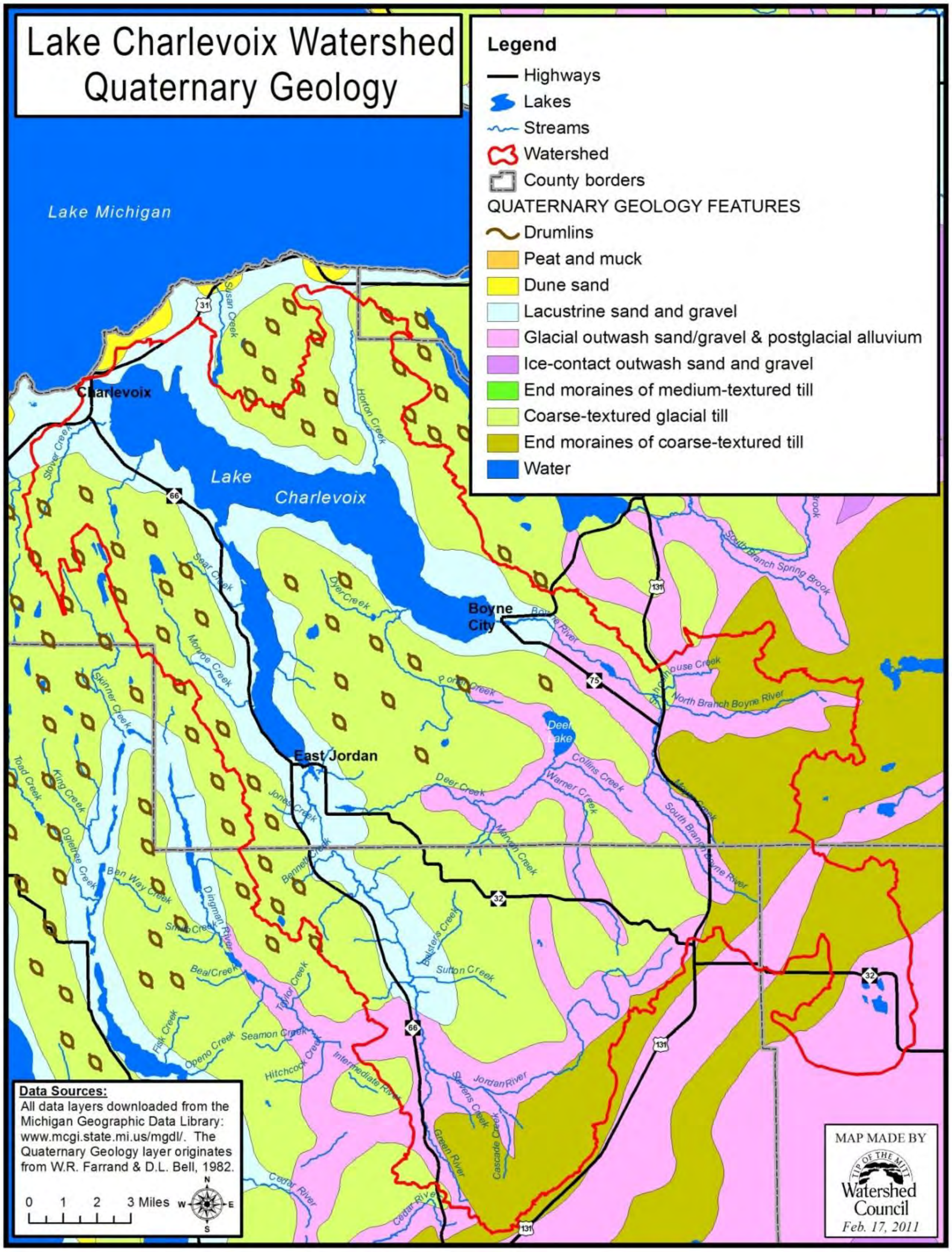


Figure 6: Lake Charlevoix Watershed quaternary geology

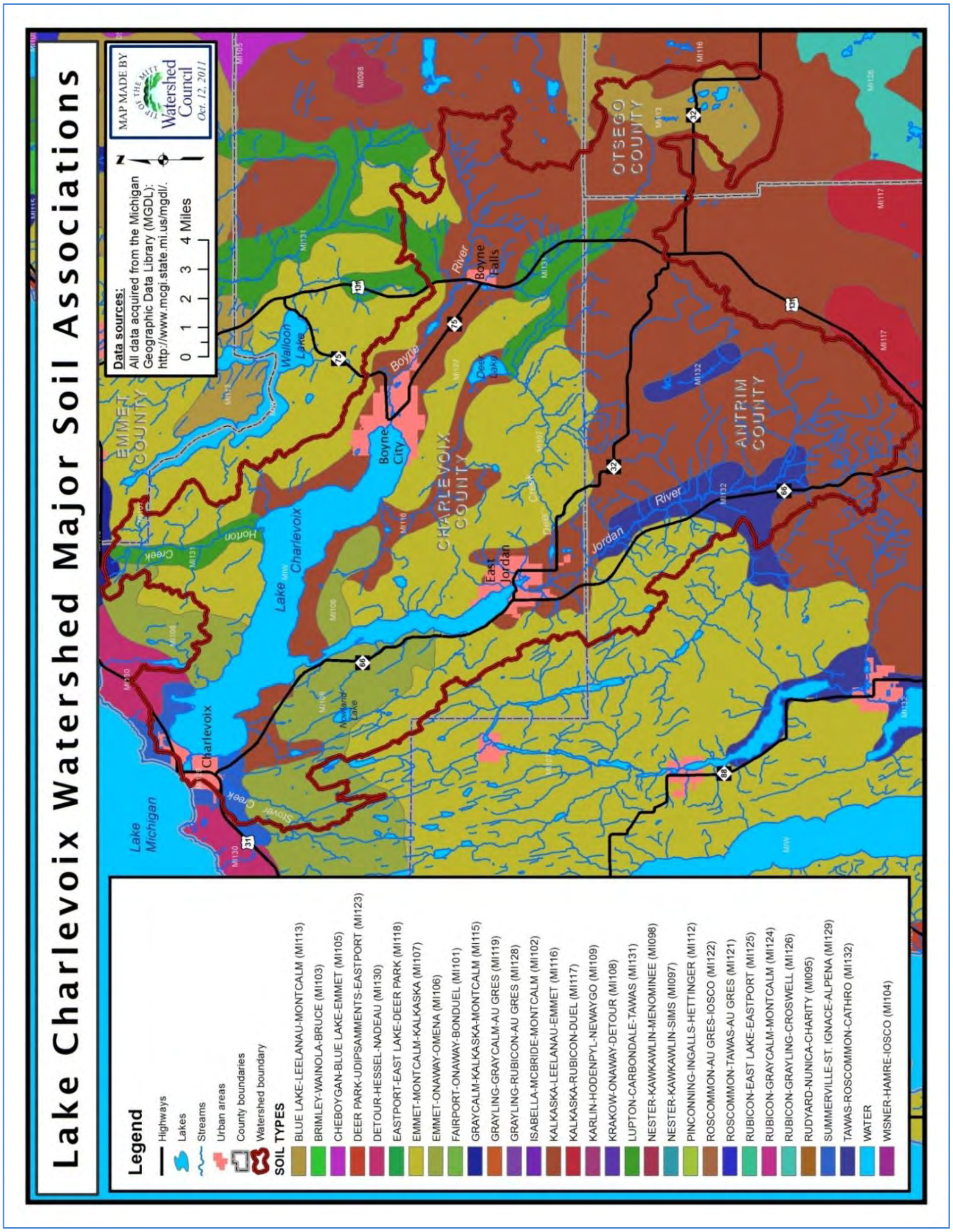


Figure 7: Lake Charlevoix Watershed major soil associations

LOCAL CLIMATE

The local climate for the Lake Charlevoix Watershed is typical of Northern Michigan: mild summers and cold, snowy winters. Table 2 includes data for the City of Charlevoix, which is representative of the greater Watershed climate.

Table 2: Local Climate for the Lake Charlevoix Area

Average annual rainfall (inches)	31
Average annual snowfall (inches)	96
Growing season (days)	113
Days above 90°F/32°C	7
Days below 0°F/-18°C	18
Average minimum/maximum temperature for January	13°F (-11°C/28°F (-2°C)
Average minimum/maximum temperature for July	55°F (13°C)/80°F (27°C)
The average warmest month	July
The highest recorded temperature	99°F in 1955
The average coolest month	February
The lowest recorded temperature	-41°F in 1979
The maximum average precipitation	October

Table 3: Locally Observed Ice In/Ice Out Dates (Lake Charlevoix resident)

Year	Ice In	Ice Out
2000	January 17	March 10
2001	December 28 (2000)	April 12
2002	February 27	April 17
2003	January 15	April 16
2004	January 11	April 7
2005	January 11	April 11
2006	February 9	April 2
2007	January 27	March 28
2008	January 23	April 15
2009	January 3 Froze over 12-23-08, thawed, re-froze 1-3-09	April 18
2010	January 11	March 31

Full-time residents on Lake Charlevoix often note the dates of "ice in" and "ice out." One resident provided their records (Table 3) from 2000-2010. Dates for "ice in" and "ice out" appear, for the most part, remarkably consistent. The visual determination for "ice in" was made when the resident could no longer see, with the aid of binoculars, any open water from his residence, which lies about a mile west of Boyne City and overlooks the east end of the main body. The visual determination for “ice out" was made when all ice was completely gone from view.

DEMOGRAPHICS

Compared to the State of Michigan, with an average of 174 persons per square mile, Antrim and Charlevoix Counties have much lower population densities, with 62.3 and 49.4 persons, respectively.

The Watershed includes both permanent and seasonal residents. According to a 10-county area study of seasonal populations (Charlevoix County Recreation Plan 2009-2013), seasonal visitors raise the population of Charlevoix County from a low of 8% during the month of April to a high of 35% in the summer months of July and August.

Although the population of the Lake Charlevoix Watershed decreased between 2000 and 2010, population levels are expected to increase in the future (Table 4).

Table 4: Population Change between 2000 and 2010 for the Major Municipalities

County	*Municipality*	*2000 population*	*2010 population*	*% Change*
Antrim		23,110	23,580	2.0
	Bellaire	1,166	1,086	-6.9
	Central Lake	990	952	-3.8
	Elk Rapids	1,700	1,642	-3.4
	Ellsworth	483	349	-27.7
	Mancelona	1,408	1,390	-1.3
Charlevoix		26,090	25,949	-0.5
	Boyne City	3,525	3,735	6.0
	Boyne Falls	370	294	-20.5
	Charlevoix	2,994	2,513	-16.1

THREATENED AND ENDANGERED SPECIES

The Lake Charlevoix Watershed is ecological and biologically diverse with thousands of plant and animals species inhabiting the Watershed's high-quality wetlands, rivers and streams, upland forests, and inland lakes. The collective efforts made by natural resource agencies, universities and other institutions, such as the Michigan Natural Features Inventory (MNFI), to identify and protect rare, threatened, and endangered species (Table 5) are critical. Implementing the recommendations of the Lake Charlevoix Watershed Management Plan will support their efforts to protect species through habitat and water quality protection.

Table 5: Lake Charlevoix Watershed Protected Species (source: MNFI)

Species/Habitat		Federal	State	Global	Heritage
Great Blue Heron Rookery	Great Blue Heron Rookery			G5	SU
Planogyra asteriscus	Eastern flat-whorl		SC	G4	S3
Microtus pinetorum	Woodland vole		SC	G5	S3S4
Appalachina sayanus	Spike-lip crater		SC	G5	SU
Accipiter gentilis	Northern goshawk		SC	G5	S3
Buteo lineatus	Red-shouldered hawk		T	G5	S3S4
Gavia immer	Common loon		T	G5	S3S4
Sistrurus catenatus catenatus	Eastern massasauga	C	SC	G3G4T3T4Q	S3S4
Pandion haliaetus	Osprey		SC	G5	S4
Drosera anglica	English sundew		SC	G5	S3
Coregonus artedi	Lake herring or Cisco		T	G5	S3
Haliaeetus leucocephalus	Bald eagle		SC	G5	S4
Ammodramus savannarum	Grasshopper sparrow		SC	G5	S3S4

Federal Protection Status Code Definitions:
C: Species being considered for Federal status

State Protection Status Code Definitions:
SC: Special Concern
T: Threatened

Global Heritage Status Rank Definitions:

The priority assigned by NatureServe's national office for data collection and protection based upon the element's status throughout its entire world-wide range. Criteria not based only on number of occurrences; other critical factors also apply. Note that ranks are frequently combined.

G3: Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g. a single western state, a physiographic region in the East) or because of other factor(s) making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100.

G4: Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.

G5: Demonstrably secure globally, may be quite rare in parts of its range, especially at the periphery.

Q: Taxonomy uncertain

T: Subspecies

Heritage Status Rank Definitions:

The priority assigned by the Michigan Natural Features Inventory for data collection and protection based upon the element's status within the state. Criteria not based only on number of occurrences; other critical factors also apply. Note that ranks are frequently combined.

SU: Possibly in peril in state, but status uncertain; need more information.

S3: Rare or uncommon in state (on the order of 21 to 100 occurrences).

S4: Apparently secure in state, with many occurrences.

LAKE CHARLEVOIX FISHERIES

The Lake Charlevoix Fishery is dependent upon good water quality. Currently, the water quality of Lake Charlevoix supports many different species, including popular sport fish. It is important to note, increases in the lake's water temperature has the potential to impact its fishery. Heather Hettinger, Fisheries Biologist for the Michigan Department of Natural Resources (MDNR) prepared the following summary of the fisheries history of Lake Charlevoix.

Stocking History

Lake Charlevoix has a long and diverse stocking history (Appendix C). Numerous fish species have been stocked in the lake since the early 1900s, including rainbow trout, lake trout, brown trout, and walleye. Rainbow trout were stocked intermittently from 1933-1981. The rainbow trout stocking program was discontinued due to limited return to creel. However, Fisheries Division annually stocks 8,000 yearling steelhead into the Jordan River and 8,000 yearling steelhead into the Boyne River, which provides a fishery in Lake Charlevoix as they migrate to and from Lake Michigan.

Lake trout were stocked intermittently into Lake Charlevoix from 1907-2008. The lake trout stocking program was discontinued after 2008 due to poor population levels and poor returns to creel (Hanchin 2010). It is suspected that many of the lake trout stocked into Lake Charlevoix were migrating to Lake Michigan.

Brown trout were stocked intermittently into Lake Charlevoix from 1937-2004, and walleye have been stocked intermittently into Lake Charlevoix since 1905. The brown trout stocking program was discontinued after 2004 because it was not maintaining a significant fishery, and return to creel was very limited. In addition, Fisheries Division began stocking Lake Charlevoix with walleye in 2001. Stocking brown trout in conjunction with walleye is not a biologically sound management option, because walleye can prey heavily on stocked brown trout and compete for food resources.

Survey History

Lake Charlevoix has a long and diverse history of fisheries surveys. Since 1947 the MDNR Fisheries Division has been conducting various types of surveys in the waters of Lake Charlevoix (Appendix C).

The most recent Fisheries Division survey of Lake Charlevoix occurred on September 21, 2009. The survey consisted of an electrofishing effort targeting young walleye using the Serns survey protocol (Serns 1982, 1983). A total of 56 walleye from 5.0-11.6 inches in length were caught. Of those, 36 were age-0 (2009 year class), ranging from 5.0 to 7.5 inches in length. The remaining 20 walleye caught in the survey were age-1, ranging from 8.6 to 11.6 inches in length. The age-0 and 1 walleye from the 2009 fisheries survey had growth rates that were slightly below the state average. The 2009 walleye year class was estimated at 35,550 fish, or 2.1/surface acre, while the 2008 year class was estimated at 16,374 fish, or 0.95/surface acre. Catch rates for age-0 walleye were 8.8/acre, and for age-1 were 4.89/acre. Although the 2009 Serns fall walleye sampling efforts all resulted in a "poor" year class according to Ziegler and Schneider (2000), it is possible that the index doesn't exactly fit Lake Charlevoix. A poor year class according to Ziegler and Schneider (2000) may actually be a good year class on Lake Charlevoix.

The 2006 survey consisted of three different efforts conducted at different times of the year (April, June, and October) as part of the Large Lake Survey Program (Hanchin 2010). A total of 1,947 walleye, 319 northern pike, and 345 smallmouth bass were tagged (Hanchin 2010). That survey also included creel census conducted during the summer of 2006 and the winter of 2007. A total of 20,090 angler trips were estimated, resulting in an estimated 57,126 angler hours of effort.

ZONING ASSESSMENT

Water quality reflects land uses in a watershed. Water bodies in wilderness areas generally have little pollution other than air borne contaminants. Urban rivers or lakes that are surrounded by intense commercial and industrial uses generally have the most contaminants. How communities manage land use has a direct impact on their water resources. Master plans, zoning, and stand-alone ordinances are a few of the more commonly used land management tools.

The primary tool used to regulate land use in the Lake Charlevoix Watershed is zoning. Charlevoix County does not have county zoning in place. However, it has an established tradition of localized zoning, and every township within Charlevoix County has its own zoning ordinance, as do the three cities. The Introduction to the Charlevoix County Future Land Use Plan notes the following: "The Charlevoix County Future Land Use Plan is not intended to replace or supersede any local plan in the County. It has not been developed for, nor is it intended as the basis for developing a County Zoning Ordinance to replace township and city zoning ordinances." The Village of Boyne Falls is the only community in Charlevoix County that does not currently have a zoning ordinance in effect.

No Antrim County township within the Lake Charlevoix Watershed has a zoning ordinance, and Antrim does not have zoning at the county level, either. The portion of the Jordan River and its tributaries that are south of Rogers Road in Charlevoix County and into Antrim County are all subject to the Jordan River Natural River Zoning Ordinance. That ordinance, while only covering the land directly adjacent to the rivers and streams, does provide some degree of protection which otherwise does not exist in the Antrim County sections of this watershed. Resort Township in Emmet County has its own zoning, and Elmira Township in Otsego County is covered by the county zoning ordinance.

LOCAL ORDINANCE GAPS ANALYSIS

In 2011, the Charlevoix County Local Ordinance Gaps Analysis and the Antrim County Local Ordinance Gaps Analysis were published by Tip of the Mitt Watershed Council. These guides provide the crucial Zoning Assessment needed for the Lake Charlevoix Watershed. The Watershed Council conducted an extensive review of all the water-related ordinances within both counties. The purpose was to evaluate them against what should be in place to best protect water resources, and offer recommendations and suggested actions to help local government officials understand and strengthen any areas that need improved. It covers ordinances at not only the county level, but also for cities, townships, and villages in the county.

Because the Lake Charlevoix Watershed covers both Antrim and Charlevoix Counties, both guides are valuable to managing water resources within the Watershed. Both are also included on the Tip of the Mitt Watershed Council website, at the Publications link: www.watershedcouncil.org.

The Gaps Analysis was conducted with the underlying assumption that specific Critical Elements are considered vital to address, if a local government wants to create strong protections for local water resources. These Critical Elements are:

- 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

The rationale for creating this particular list was detailed in the Gaps Analysis in a formal academic Literature Review, documenting the current relevant research literature for each of these items. It explains why the Critical Elements were considered important enough to include in this work.

An Evaluation Checklist was created to focus on the Critical Elements listed above, in accordance with the Literature Review. The checklist was compared to each jurisdiction's Master Plan and all ordinances in place. The checklist question was asked; the answer was found and noted. If the answer was "yes", the question earned 3 points. If the answer was "yes, partially" the question earned 2 points. If the answer was "yes, minimally" the question earned 1 point. If the answer was no, the question earned 0 points and that item is considered to be missing. The score for each question was assigned and then the next question was asked, until the entire checklist was complete.

It is important to note that the scoring system used with the Evaluation Checklist does not penalize a jurisdiction for missing ordinances that are not appropriate for their area, because of geographic or other circumstances. Upon completion of a checklist section, the points were totaled and the section was ranked. Table 6 summarizes the ranking of the 16 jurisdictions within the Lake Charlevoix Watershed.

Table 6: Gaps Analysis Ranking Results for Lake Charlevoix Watershed Jurisdictions

Elements	Master Plan Components	Basic Zoning Components	Shorelines	Impervious Surfaces	Stormwater Management	Soil Erosion and Sediment Control	Sewer/Septic	Wetlands	Groundwater and Wellhead Protection	Other: Floodplains, Steep Slopes, and Critical Dunes
Strong	5	10	2	1	2	2	0	0	3	0
Adequate	10	4	6	2	6	3	13	0	8	15
Weak	0	1	6	9	8	10	3	12	3	0
Missing	1	1	2	4	0	1	0	4	2	1
TOTAL	16	16	16	16	16	16	16	16	16	16

The summary of the Ranking System is as follows:

STRONG: The section of the ordinance being reviewed can be identified as more protective or better than most ordinances in the state, for reasons that can be clearly articulated. For example, the section replicates a model ordinance on the same topic, or minimum standards are exceeded.

ADEQUATE: The section of the ordinance being reviewed is on par with other ordinances in the state; it is at least as protective as ordinances for areas with similar water resource features.

WEAK: The section of the ordinance being reviewed is deemed weaker than similar ordinances in the state, for a specific reason that can be clearly articulated. For example, a model ordinance is changed to delete some protection that should have remained intact.

MISSING: The topic is not included in the jurisdiction's ordinance.

An analysis of the results was done when each checklist was finished, including Recommendations and Suggested Actions. Those are covered in the Gaps Analysis guides, with a Chapter devoted to each jurisdiction. Additionally, connections to Watershed Management Plan implementation steps are also noted in the guides, where appropriate.

A series of three workshops were conducted in Boyne City, East Jordan, and Charlevoix Township to unveil the Gaps Analysis to representatives of the municipalities in the watershed. Copies were provided for every member of the County Planning Commission and Board of Commissioners; all township Supervisors, Trustees, and Planning Commissioners; city Mayors, Councils, and Planning Commissioners; and copies were also made available to Zoning Administrators and staff. The workshops stepped participants through the guides, explaining the purpose and how to use the information included in them. Follow up work is currently underway to do presentations to any jurisdiction that missed the workshops, or any that want other kinds of help with implementation. For access to both the Antrim and Charlevoix Counties Gaps Analysis: www.watershedcouncil.org

NEW CHARLEVOIX COUNTY STORM WATER CONTROL (SWC) ORDINANCE

In 2006, the Grand Traverse County Prosecutor queried the State Attorney General (AG) Office about stormwater management. In response, a letter from the AG stated that counties cannot regulate stormwater runoff beyond what is needed for soil erosion and sediment control, and said that only townships, cities and villages have authority to control flooding.

There are several reasons the transfer of authority is not in the best interest of watersheds, including the burden placed on townships due to limited resources and expertise at that level. Also, the potential to create a checkerboard effect that would cause more confusion for the regulated community. After much discussion and consideration, Charlevoix County officials decided to address this situation in a manner similar to what was done in Grand Traverse County. A draft has been prepared for a new Storm Water Control (SWC) Ordinance that would need to be passed by individual municipalities, giving the county authority to administer and enforce the ordinance. To make this work effectively and efficiently, all participating municipalities would have to pass identical language and participate in an Intergovernmental Agreement. The Lake Charlevoix Watershed Advisory Committee (refer to Chapter 5 for more information regarding the Committee) supports this approach for two reasons: the draft ordinance is strong, and this approach is being successfully used in Grand Traverse County. For more information regarding the status of the ordinance:

(http://www.charlevoixcounty.org/downloads/landuse_section1of3.pdf, p.1.1)

LAND USE/COVER TYPE INVENTORY

Over the last few hundred years, the Lake Charlevoix Watershed landscape has undergone considerable change. Prior to European settlement, landcover in the Lake Charlevoix Watershed is presumed to have been nearly all forested. A statewide database for Michigan based on original surveyors' descriptions of the vegetation and land in the early 1800s indicates that landcover consisted primarily of beech/sugar maple/hemlock forest, cedar swamp, and lakes and river (Table 7). Presumably, during this early time period, all lakes and streams throughout the Lake Charlevoix Watershed were pristine; with exceptionally healthy ecosystems and excellent water quality.

Table 7: Pre-settlement Landcover in the Lake Charlevoix Watershed (MDNR, 1978)

Land-cover Type	Acres	Percent
Beech/Sugar Maple/Hemlock Forest	165910	78.07
Black Ash Swamp	222	0.10
Cedar Swamp	24142	11.36
Hemlock/White Pine Forest	6	0.00
Lake/River	19458	9.16
Mixed Conifer Swamp	1582	0.74
Mixed Hardwood Swamp	511	0.24
Shrub Swamp/Emergent Marsh	685	0.32
TOTAL	212516	100.00

The current landcover status of the Lake Charlevoix Watershed can be accurately assessed through remote sensing using satellite imagery. Data gathered as part of the National Oceanic and Atmospheric Administration's Coastal Change Analyses Program (CCAP) show that nearly a quarter of the watershed area has been altered by humans for agricultural, residential, and commercial use (Table 8 and Figure 8).

Table 8: Recent Landcover Statistics for Lake Charlevoix Watershed (NOAA, 2006)

Landcover Type	2000 – Acres	2000 - Percent	2006 - Acres	2006 - Percent
Agriculture	33159	15.59	34840.2	16.38
Barren	734	0.35	486.1	0.23
Forested	100032	47.04	101762.3	47.85
Grassland	24029	11.30	15053.8	7.08
Scrub/shrub	4883	2.30	5584.6	2.63
Urban	6097	2.87	9542.5	4.49
Water	18676	8.78	18499.7	8.70
Wetlands	25042	11.78	26895.0	12.65
TOTAL	212652	100.00	212664.2	100.00

According to the Agricultural Census (USDA, 2007), the top crops produced in Antrim and Charlevoix Counties is forage crops (land used for all hay and haylage, grass silage, and greenchop) tart cherries, and corn.

Human population increases in the watershed and the consequent conversion of natural landcover types to agricultural and urban invariably impact water resources. Sediments that wash in from agricultural and urban areas clog gills of fish and invertebrates, smother spawning beds, reduce habitat by filling interstitial spaces, increase water temperatures through particle absorption of sunlight, and reduce dissolved oxygen levels. Nutrient pollution from fertilizers, animal waste, and sewage can cause cultural eutrophication of adjacent water bodies resulting in excessive algae and macrophyte growth that can affect water quality.

Other contaminants found in stormwater runoff from agricultural and urban areas, including herbicides, pesticides, oil, grease, lead, arsenic, cadmium, chromium, mercury, and zinc, affect the flora and fauna of nearby lakes, streams, and wetlands. Stormwater runoff from urban areas also causes thermal pollution, wherein waters heated by pavement and other impervious surfaces wash into lakes and streams, elevating water temperatures and lowering dissolved oxygen levels. Furthermore, impervious surfaces in urban areas prevent precipitation from infiltrating into the ground, which instead accumulates and is delivered to rivers and streams. This unnaturally high volume of water alters natural flow regimes, scouring and eroding stream channels, as well as dislodging and harming aquatic plants and animals.

The effects of agricultural and urban landuse on surface waters are well documented. Degradation of aquatic ecosystems has been shown to be directly related to increased landscape development and urbanization (Klein 1979, Jones and Clark 1987, Steedman 1988). Cold water streams, which are common in the Lake Charlevoix Watershed, are particularly susceptible to thermal pollution caused by watershed urbanization (Wang and Kanehl 2003). A recent nation-wide USGS study of pesticides, found that pesticides were present in streams 97% of the year in agricultural, urban or mixed-land-use watersheds (USGS 2006). The same study found that more than 50 percent of wells in shallow groundwater beneath agricultural and urban areas contained one or more pesticide compounds.

Based on the CCAP data, the area with wetland landcover increased by nearly 2,000 acres between 2000 and 2006. Although an increase is possible through wetland restoration or natural succession of one landcover type to another, such a large increase is probably the result of changes to the process used for landcover classification. Based on National Wetlands Inventory (NWI) data, the vast majority of wetlands in the Lake Charlevoix Watershed are forested wetlands, followed by scrub-shrub wetlands, and emergent wetlands (Table 9).

Table 9: Wetland Types in the Lake Charlevoix Watershed

Wetland Type	Acres	Percent
Emergent	1309.47	5.33
Scrub-Shrub	2338.60	9.52
Forested	20527.15	83.55
Open Water/Unknown Bottom	392.16	1.60
Unconsolidated Bottom	2.10	0.01
TOTAL	24569.47	100.00

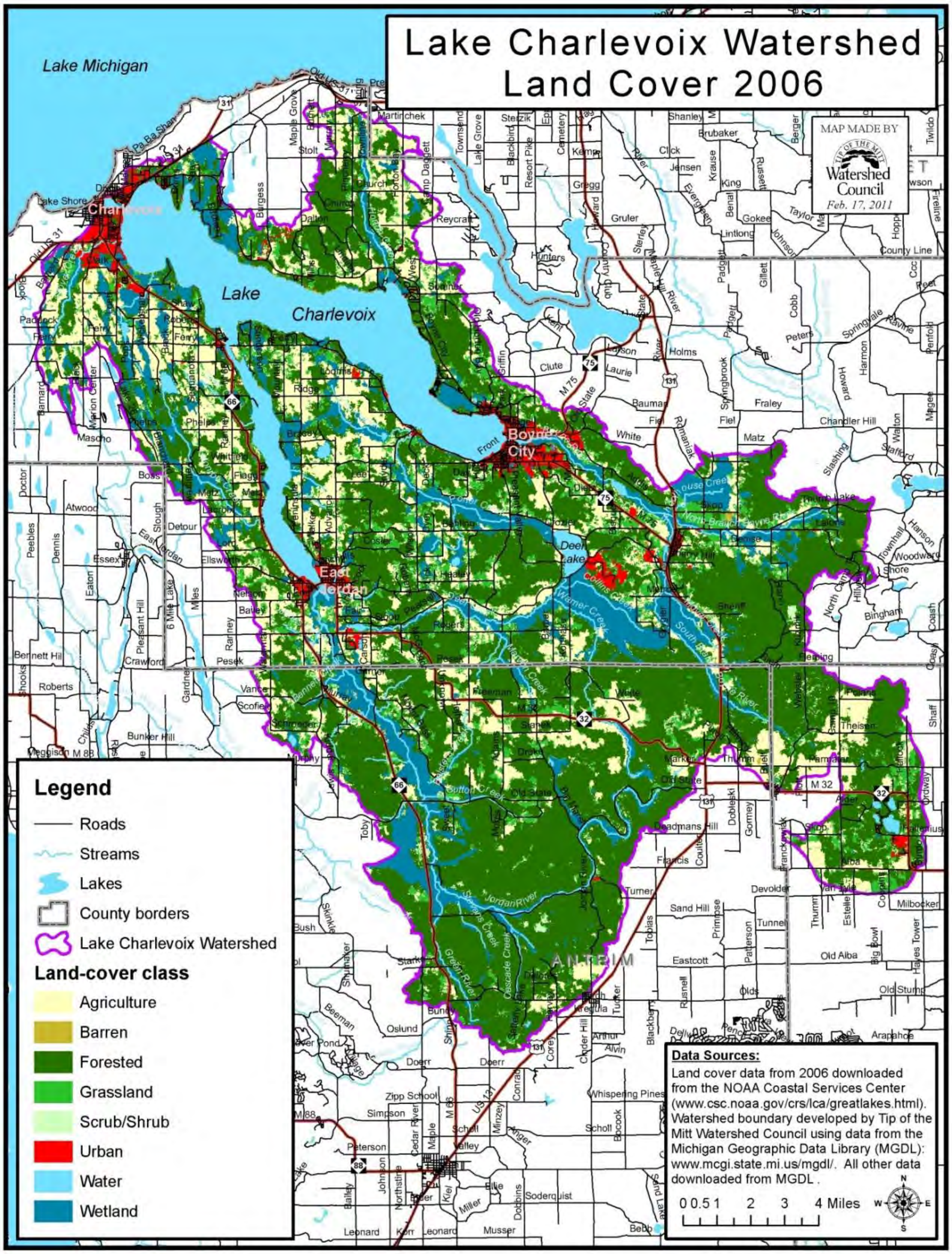


Figure 8: Lake Charlevoix Watershed land cover 2006

CHAPTER TWO: WATER QUALITY OF THE LAKE CHARLEVOIX WATERSHED

A considerable amount of water quality data have been collected from surface waters of the Lake Charlevoix Watershed over the last several decades and is available from the Michigan Department of Environmental Quality (MDEQ), United States Geological Survey (USGS), Tip of the Mitt Watershed Council (TOMWC), Little Traverse Bay Bands of Odawa Indians (LTBB), and the Health Department of Northwest Michigan (HDNWM) (Figure 9). Water quality data obtained from MDEQ includes "Legacy" data, which is historical data (prior to year 2000) from the United States Environmental Protection Agency STORET database. Physical, chemical, and biological water quality monitoring has been carried out on three lakes and eight stream drainage systems in the Watershed. Water quality data have been collected from the main basin and South Arm of Lake Charlevoix, as well as in Deer, Nowland, and Adams Lakes. Multiple sites have been monitored over time in the Boyne River drainage system, the Jordan River drainage system, Porter Creek, Horton Creek, Stover Creek, Loeb Creek, and Monroe Creek.

Over 40 physical and chemical parameters have been monitored in the lakes and streams of the Lake Charlevoix Watershed (see Appendix G for full list of parameters). Physical water quality data have been collected at most sites on both lakes and streams, including commonly monitored parameters such as water temperature, pH, conductivity, and dissolved oxygen. A large variety of chemical data have been collected from lakes and streams in the Watershed, including many different forms of nutrients, a variety of metals, alkalinity, hardness, chloride, and more. Organochlorine compounds, such as dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyls (PCBs), have been monitored in the open waters of Lake Charlevoix. In addition, discharge data (volume of water per unit of time) exists for many of the rivers and streams that drain into Lake Charlevoix.

Biological and bacteriological monitoring has been performed in lakes and streams throughout the Watershed. The majority of biological monitoring has occurred on streams and consisted of assessments of the aquatic macroinvertebrate communities. There are also some data for the aquatic macroinvertebrate communities of Lake Charlevoix. Although most bacteriological monitoring has been carried out in Lake Charlevoix, there are bacteria data for sites on streams in the Watershed as well.

MDEQ and Legacy water quality data span five decades, stretching back to 1960 at some sites and collected at approximately 70 locations in the Watershed. The USGS monitored five sites on the Jordan River from 1966 to 1971 and two sites on Lake Charlevoix and one on Deer Lake in 2002 and 2003. Watershed Council staff and volunteers have monitored the water quality of Lake Charlevoix at two sites since 1986 and for a lesser time period at 16 additional locations on other lakes and streams in the Watershed. Staff from the LTBB began monitoring water quality in the Watershed in 2001 and now monitor seven sites on Lake Charlevoix and three on the Boyne River. The Health Department performs regular bacteriological monitoring during summer months at 12 public beaches on Lake Charlevoix; data going back to 2001 at some locations.

WATER QUALITY OF LAKE CHARLEVOIX

The water quality of Lake Charlevoix has been monitored for over 40 years and, though there have been some changes, data show that water quality has consistently been high. This is not surprising. Lake Charlevoix is one of the largest (~17,250 acres) and deepest (~122 feet) inland lakes in Michigan, which equates to a high volume of water that essentially serves as a buffer to absorb and diminish any impacts from human activities. Human activity in the Watershed is still minor relative to more populated areas of the state, which is evident in the most recent landcover data (2006) showing that agricultural and urban landcover comprise small percentages of total landcover in the watershed (19% and 4% respectively). Furthermore, the majority of water flowing into the lake comes from two of the highest quality trout streams in the State: the Boyne and Jordan Rivers. All of these factors contribute to the exceptionally and consistently high quality water of Lake Charlevoix evidenced in the extensive water quality dataset.

ALKALINITY, HARDNESS, AND PH

Typical for lakes in the Northern Lower Peninsula, Lake Charlevoix contains relatively high amounts of calcium carbonate, which classify it as a moderately alkaline lake with a high buffering (i.e., acid neutralizing) capacity, and with hard water. Data from MDEQ for the main basin and South Arm of Lake Charlevoix show that alkalinity has ranged from a low of 101 to a high of 176 PPM $CaCO_3$, with an average value of 137 PPM, while hardness has ranged from 109 to 180 PPM $CaCO_3$, with an average of 156 PPM (Table 10). The MDEQ, LTBB, and TOMWC have pH data from sites on both the main basin and South Arm; values ranging from 7.2 to 9.4, with an average of 8.2.

Table 10: Alkalinity, hardness, and pH data for Lake Charlevoix

Parameter	Low * (value)	Low (year)	Low (site)	High* (value)	High (year)	High (site)	Average Value*
Alkalinity	101	1985	Main basin	176	1970	South Arm	137
Hardness	109	1985	Main basin	180	1977	South Arm	156
pH	7.2	1987	Main basin	9.4	1973	Main basin	8.2

*units: milligrams per liter or parts per million.

DISSOLVED OXYGEN

Dissolved oxygen is one of the most important parameters monitored for assessing the lake's water quality. Oxygen is required by almost all organisms, including those that live in the water. Oxygen dissolves into the water from the atmosphere and through photosynthesis of aquatic plants and algae. State law requires that a minimum of five to seven parts per million (PPM) be maintained depending on the lake type. Due to Lake Charlevoix's designation as a cold-water fishery, the minimum is seven PPM.

The MDEQ and LTBB water quality datasets are the most appropriate for assessing dissolved oxygen conditions in Lake Charlevoix because the data were collected throughout summer months and span many years. Of the 172 dissolved oxygen records found in the MDEQ dataset, concentrations below seven PPM were found on 33 occasions and below five PPM on eight occasions. The LTBB data include 326 dissolved oxygen records collected during the last 10 years, of which only six records were below seven PPM. Documented low dissolved oxygen levels in Lake Charlevoix always occurred late in the summer (August and September) and in deeper waters.

Oxygen depletion in the deep waters of lakes in late summer is not uncommon, though it can be an indicator of water quality impairment depending upon the extent and duration. Considering the time of year when low dissolved oxygen levels were recorded and that low levels were found in deeper waters, oxygen depletion does not appear to be a serious water quality concern in Lake Charlevoix. Furthermore, the most current and complete dataset (LTBB data) show that dissolved oxygen concentrations have rarely dipped below seven PPM and only in the South Arm, which indicates that dissolved oxygen has continually been abundant throughout the water column in recent years.

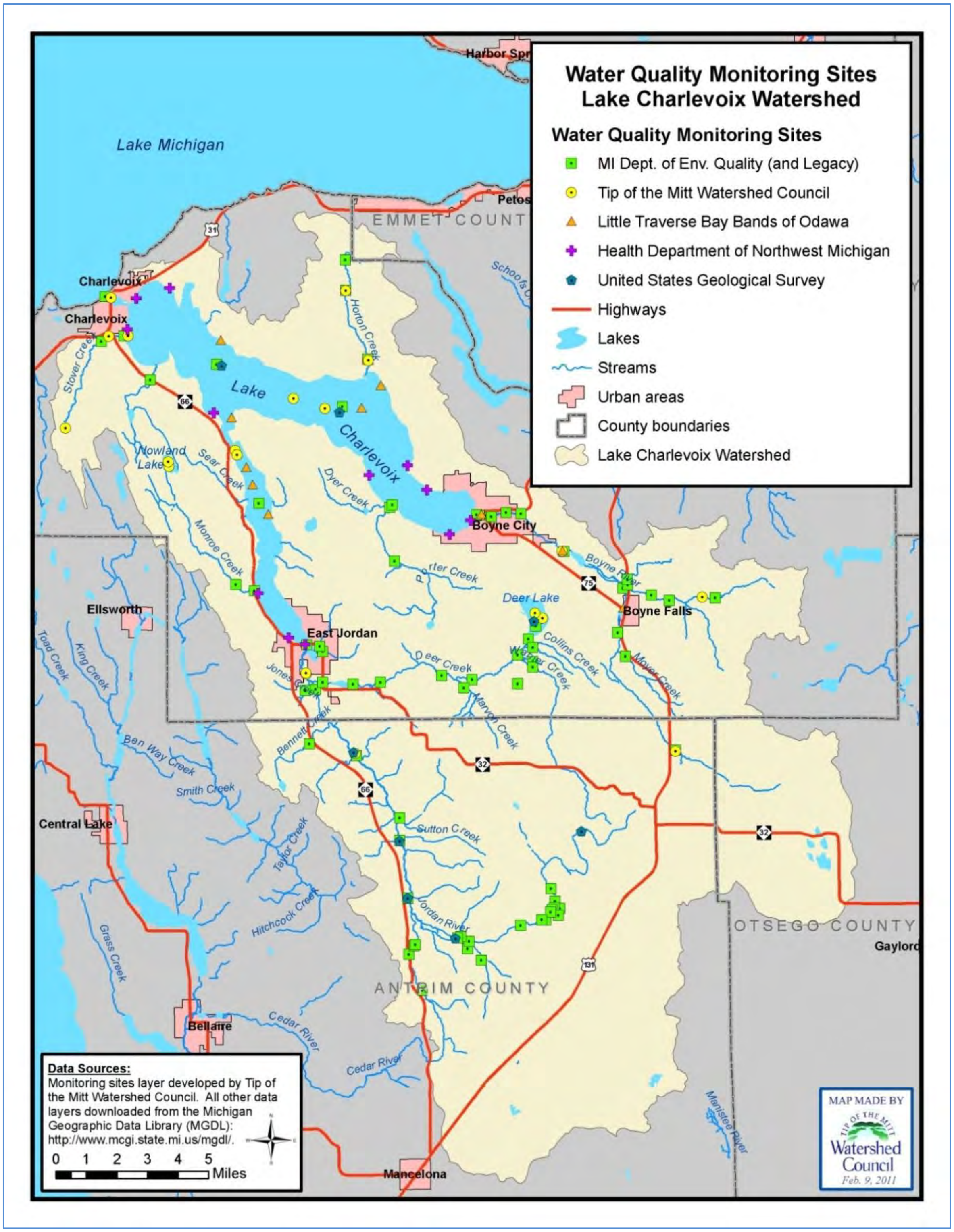


Figure 9: Water quality monitoring sites for the Lake Charlevoix Watershed

CONDUCTIVITY AND CHLORIDE

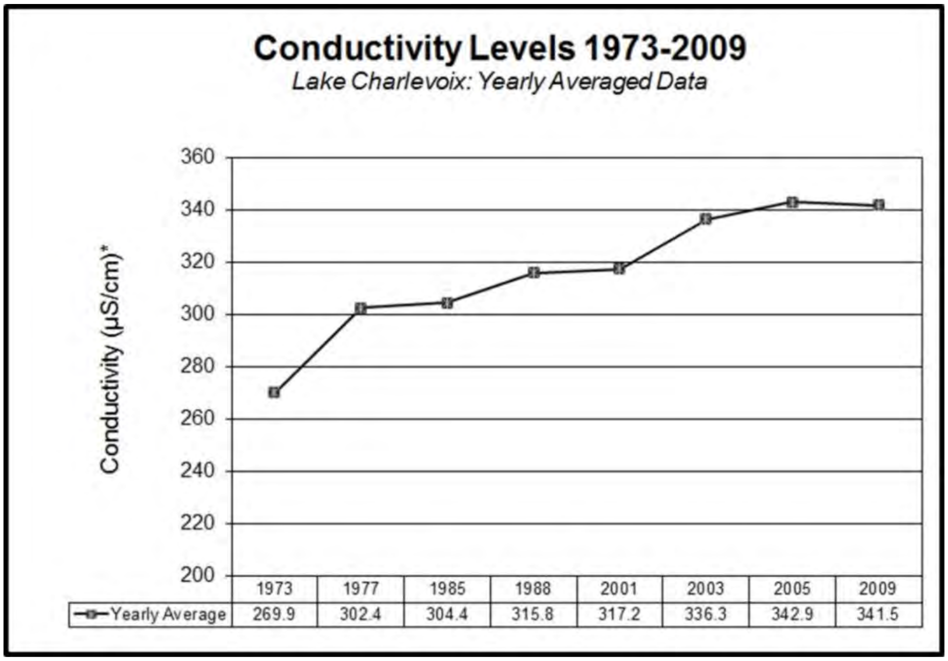
Conductivity is a measure of the ability of water to conduct an electric current, which is dependent upon the concentration of charged particles (ions) dissolved in the water. Chloride, a component of salt, is a negatively charged particle that contributes to the conductivity of water. Chloride is a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

Water quality data collected by all governmental agencies and the Watershed Council show that conductivity levels in Lake Charlevoix, measured in equivalent units of micromhos or microSiemens, have ranged from 182 (MDEQ, 1973) to 370 (LTBB, 2009). Averaged yearly data, for years when data were collected at multiple points throughout the year, show a gradual increase in conductivity levels from 1973 to 2009 (Figure 10).

Chloride concentrations in Lake Charlevoix have ranged from 3.7 PPM (MDEQ, 1985) to 13.5 PPM (LTBB, 2007). Based on averaged yearly data collected by all agencies and organizations, chloride concentrations steadily increased between 1973 and 2010 (Figure 11).

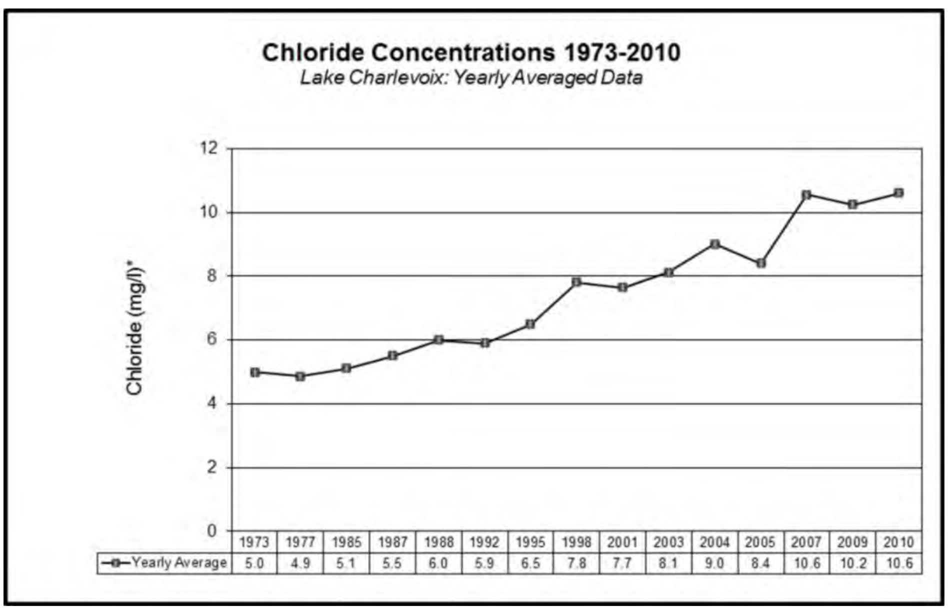
Water quality data show a clear pattern of increasing conductivity and chloride levels in Lake Charlevoix, which corresponds with US Census data that show a steady population increase in counties in the Watershed between 1970 and 2000. Nonpoint source pollution from urban areas in the Watershed, particularly those located directly on Lake Charlevoix (i.e., Charlevoix, Boyne City, and East Jordan), is likely responsible for the documented increases in conductivity and chloride. In spite of increases, conductivity levels remain within the range of 150-500 µS/cm, which studies in inland freshwater streams have found to support good mixed fisheries (USEPA, 1997). Averaged chloride concentrations have doubled, but are still well below levels that affect aquatic organisms. Studies show that chloride levels do not affect aquatic insects until well over 1,000 PPM (Crowther and Hynes 1977, Blasius and Merritt 2002). However, increases in conductivity and chloride can be indicative of more harmful pollutants that are associated with human activity, but not regularly monitored, contaminating the

Watershed's surface waters (e.g., automotive fluids and metals from roads, nutrients and bacteria from septic systems).



*µS/cm = microSiemens/centimeter.

Figure 10: Conductivity levels in Lake Charlevoix from 1973 to 2009



*mg/l = milligrams/liter = parts per million.

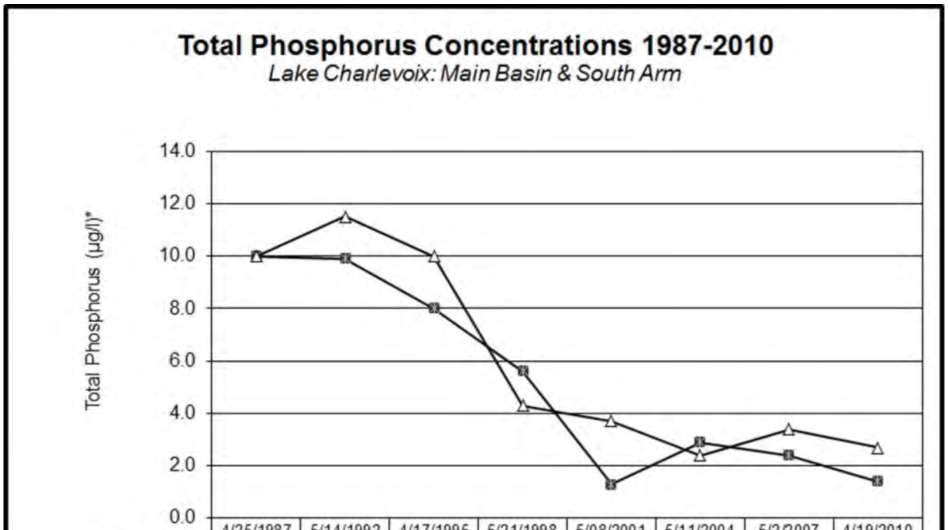
Figure 11: Chloride concentrations in Lake Charlevoix from 1973 to 2010

NUTRIENTS

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

Phosphorus is the most important nutrient for plant productivity in Northern Michigan lakes because it is usually in shortest supply relative to nitrogen and carbon. A water body is considered phosphorus limited if the ratio of nitrogen to phosphorus is greater than 15:1. Based on data collected by Tip of the Mitt Watershed Council, most lakes monitored in the Northern Lower Peninsula, including Lake Charlevoix, are found to be phosphorus limited (TOWMC, 2010). It has been estimated that one pound of phosphorus could stimulate 500 or more pounds of algae growth. Therefore, heavy phosphorus inputs into Lake Charlevoix could result in nuisance algae and plant growth, which could, in turn, degrade water quality and alter the natural lake ecosystem. Because of the negative impacts that phosphorus can have on surface waters, legislation was first passed in Michigan to ban phosphorus in soaps and detergents and more recently, phosphorus use in fertilizers has been regulated. The State of Michigan uses a narrative water quality standard for nutrients, so a numeric water quality standard for phosphorus in surface waters does not exist; however, total phosphorus concentrations are usually less than 10 PPB in the high quality lakes of Northern Michigan.

An accurate assessment of a lake's phosphorus levels can be difficult because of variability in concentrations resulting from phosphorus uptake by aquatic plants and algae. TOMWC water quality data are ideal for examining trends in Lake Charlevoix's phosphorus levels because samples are collected during the spring turnover when conditions are homogenous throughout the water column and when there is relatively little aquatic plant and algae growth. Data collected by TOMWC show a considerable decline in total phosphorus concentrations during the last few decades with a high of 11.5 parts per billion (PPB) in 1992 to a low of 1.3 PPB in 2001 (Mid-depth only) (Figure 12). This decline could be the result of decreased phosphorus inputs due to improved regulation, as well as extensive outreach, and education. However, it is likely that changes brought on by the introduction of invasive zebra and quagga mussels have altered the lake's nutrient cycling and contributed to the documented phosphorus reductions.



	4/25/1987	5/14/1992	4/17/1995	5/21/1998	5/08/2001	5/11/2004	5/2/2007	4/19/2010
Main Basin	10.0	9.9	8.0	5.6	1.3	2.9	2.4	1.4
South Arm	10.0	11.5	10.0	4.3	3.7	2.4	3.4	2.7

*ug/l = micrograms/liter = parts per billion. Mid-depth data only.

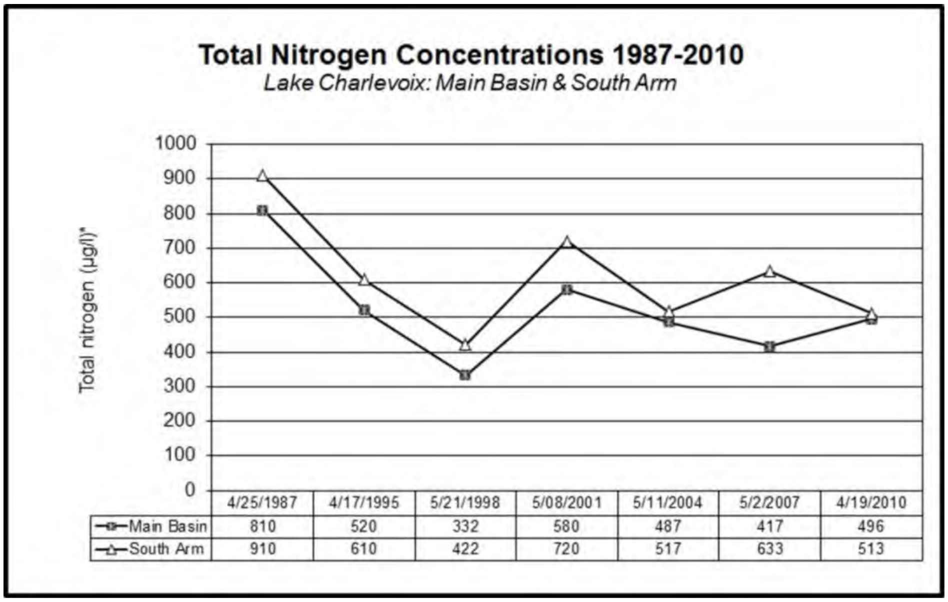
Figure 12: Total phosphorus in Lake Charlevoix from 1987 to 2010

Nitrogen is a very abundant element throughout the earth's surface and is a major component of all plant and animal matter. Nitrogen is also generally abundant in our lakes and streams and needed for plant and algae growth. Interestingly, algae have adapted to a wide variety of nitrogen situations in the aquatic environment, some fixating nitrogen directly from the atmosphere to compete in low-nitrogen environments (blue-green algae), while others thrive in nitrogen-rich environments (certain diatoms).

Many different forms of nitrogen have been monitored in Lake Charlevoix, of which two are here presented: total nitrogen and nitrate-nitrogen. Total nitrogen includes all organic and inorganic forms and is important in determining whether a lake is nitrogen limited in relation to phosphorus. Nitrate-nitrogen is soluble in water and readily available for uptake by aquatic plants and algae.

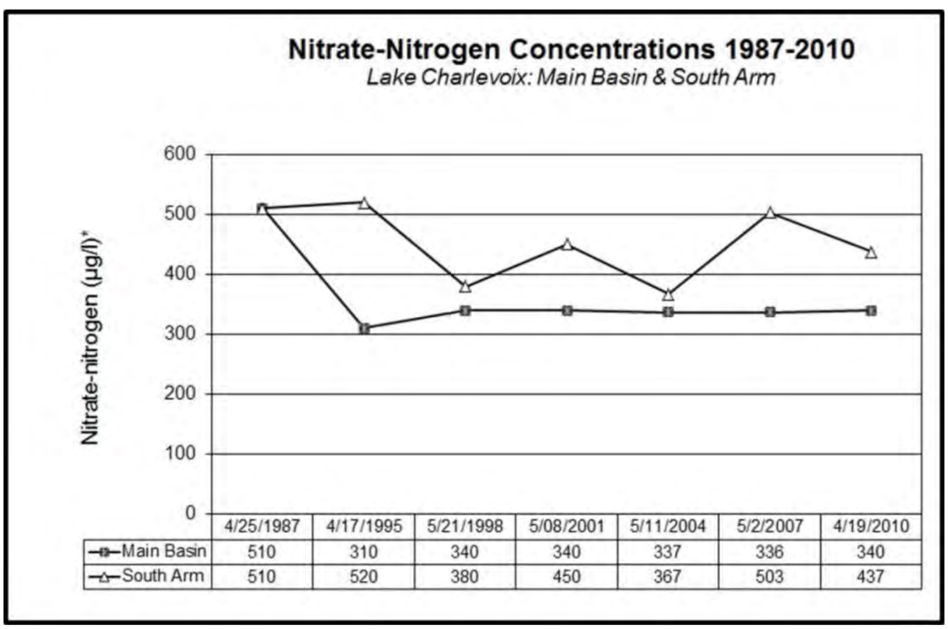
The State of Michigan uses a narrative water quality standard for nutrients, as it does with phosphorus; a numeric water quality standard for nitrogen in surface waters does not exist. However, Michigan drinking water standards require that nitrate-nitrogen concentrations be less than 10 PPM.

For the same reasons previously mentioned for phosphorus, TOWMC water quality data were used for assessing nitrogen levels in Lake Charlevoix. During 23 years of monitoring total nitrogen levels in Lake Charlevoix have ranged from a low of 332 PPB (1998) to a high of 910 PPB (1987) (Mid-depth only) (Figure 13), while nitrate-nitrogen ranged from a low of 310 PPB (1995) to a high of 520 PPB (1995) (Mid-depth only) (Figure 14). All data were within typical ranges for lakes of Northern Michigan. While there were no clear patterns in the data, the data do make clear the relative abundance of nitrogen as compared to phosphorus.



*ug/l = micrograms/liter = parts per billion. Mid-depth data only.

Figure 13: Total nitrogen in Lake Charlevoix from 1987 to 2010



*ug/l = micrograms/liter = parts per billion. Mid-depth data only.

Figure 14: Nitrate-nitrogen in Lake Charlevoix from 1987 to 2010

WATER CLARITY AND TROPHIC CONDITIONS

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

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

Oligotrophic lakes are characteristically deep, clear, nutrient poor, and with abundant oxygen. On the other end of the spectrum, eutrophic lakes are shallow, nutrient rich, and full of productivity. A highly productive eutrophic lake could have problems with oxygen depletion whereas the low-productivity oligotrophic lake may have a lackluster fishery. Mesotrophic lakes lie somewhere in between and are moderately productive.

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

Water clarity and other data used to determine the trophic status of lakes have been collected by most agencies and organizations that monitor water quality in the Lake Charlevoix Watershed. However, the longest-term and most comprehensive water quality data available for these parameters are from the TOMWC Volunteer Lake

Monitoring Program. Volunteers in this program have collected water quality data at two locations on Lake Charlevoix since 1986. During summer months, volunteers measure water clarity with a Secchi disc on a weekly basis and a sample is collected to measure chlorophyll-a concentration every other week.

Results from the TOMWC Volunteer Lake Monitoring Program show that changes have occurred in the biological productivity of Lake Charlevoix during the last two decades. Water clarity has increased dramatically with averaged Secchi disc depths increasing from an approximate range of 6-12 feet in the late 1980s and early 1990s to 17-23 feet in recent years (Figure 15). At the same time, chlorophyll-a concentrations have dropped from roughly 1-4 micrograms per liter (µg/l) to consistently less than one µg/l (Figure 16). The TSI values, which were calculated using Secchi depth data, show a marked drop in the lake's biological productivity. In the late 1980s and early 1990s, TSI values for both basins generally fell into the mesotrophic category, and then gradually shifted into the oligotrophic category where they have remained for the last 5-10 years (Figure 17).

The changes observed in trophic state data are similar to other lakes in the region that are monitored as part of the Tip of the Mitt Watershed Council's Volunteer Lake Monitoring program and where zebra and/or quagga mussels have been introduced. Zebra and quagga mussels, both now inhabiting Lake Charlevoix, are prodigious filter-feeders that feed upon phytoplankton (algae) and essentially clear the water column. Their feeding habits offer one explanation for the observed increase in water clarity and decrease in chlorophyll-a concentrations in Lake Charlevoix. An examination of long-term water clarity trends in Michigan Lakes found that water clarity in the majority of lakes studied over a 26-year time period stayed the same or, similar to Lake Charlevoix, increased (Bruhn, 2005). The authors analyzed data to determine impacts from the zebra mussels and found that the invasive mussels alone could not explain state-wide patterns.

Thus, prior to the introduction of zebra and quagga mussels, Lake Charlevoix was a mesotrophic lake that bordered on oligotrophy. As evidenced in the water clarity, chlorophyll-a, and nutrient data, the lake is now less biologically productive and now consistently falls in the oligotrophic category. Although the invasive mussels altered the trophic state of Lake Charlevoix, it was and remains a large, deep lake, nutrient-poor, but oxygen-rich.

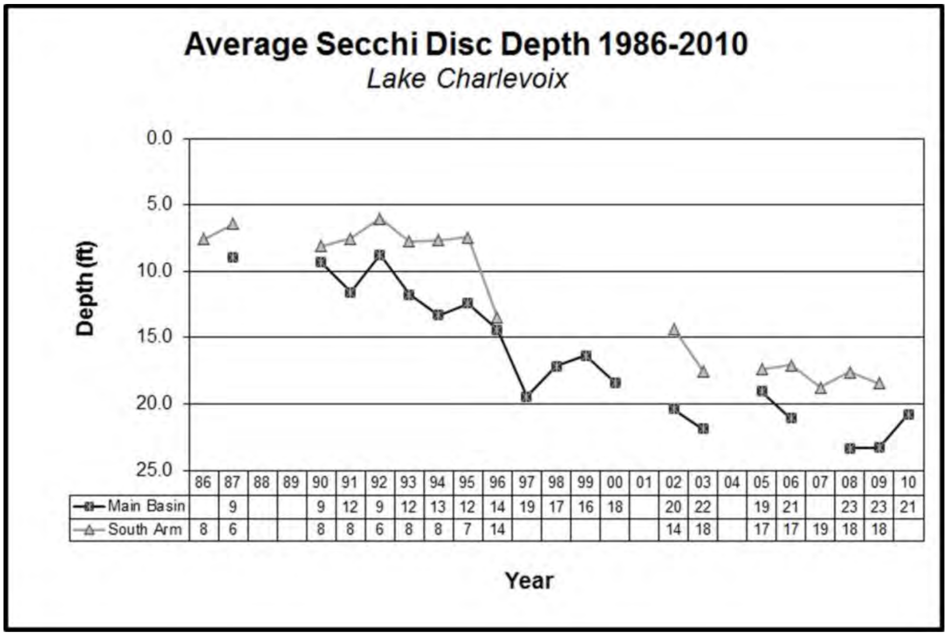
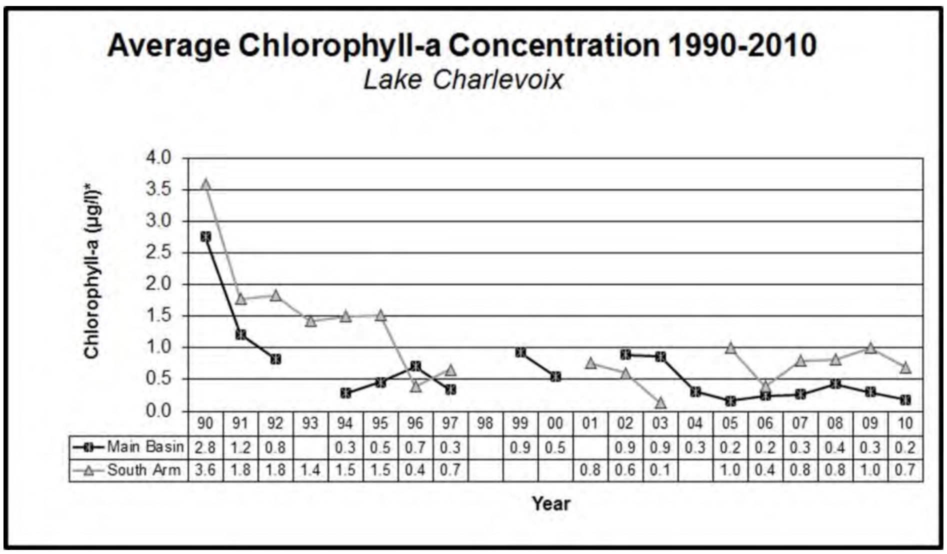
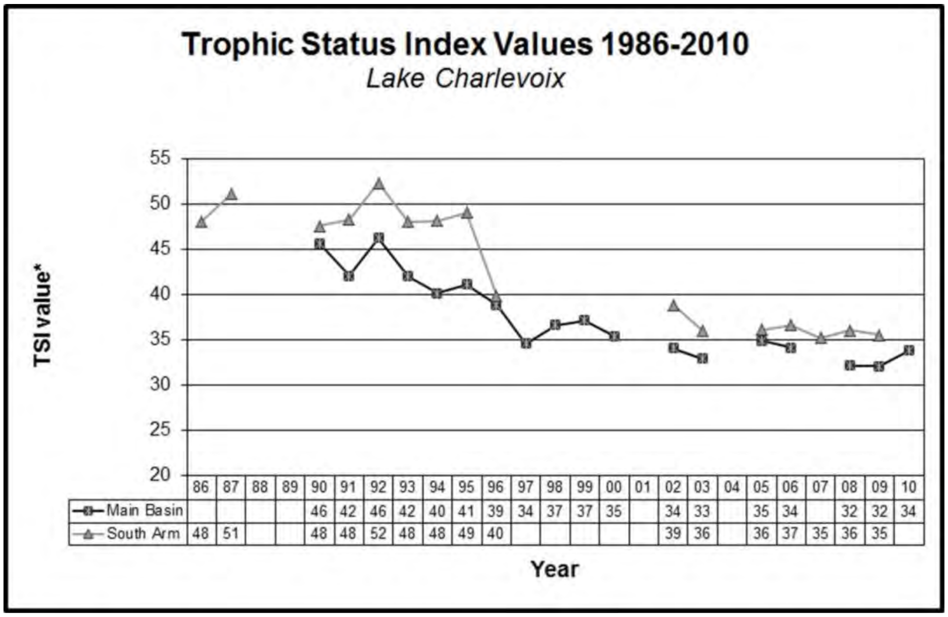


Figure 15: Secchi disc depths in Lake Charlevoix from 1986 to 2010



*ug/l = micrograms/liter = parts per billion.

Figure 16: Chlorophyll-a concentrations in Lake Charlevoix from 1990 to 2010



	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Main Basin					46	42	46	42	40	41	39	34	37	37	35		34	33		35	34		32	32	34
South Arm	48	51			48	48	52	48	48	49	40						39	36		36	37	35	36	35	

*TSI values range are based on secchi disc data and range from 0 to 100. Lower values (0-38) indicate an oligotrophic or low productive system, medium values (39-49) indicate a mesotrophic or moderately productive system, and higher values (50+) indicate a eutrophic or highly productive system.

Figure 17: Trophic Status Index (TSI) values in Lake Charlevoix from 1986 to 2010

HEAVY METALS AND ORGANOCHLORINES

Heavy metals are a loosely defined group of elements that have some metallic properties. Some of these metals, such as copper and zinc, are required in trace amounts by humans and other organisms, but can be harmful if excessive. Other heavy metals, such as lead and mercury, are not needed by organisms, but rather accumulate in the bodies of and potentially harm fish, humans, and other animals. Another group of metals, including cadmium, are normally toxic, but do provide some benefit to certain organisms. Heavy metals occur naturally in the earth's crust and are used by humans in many applications. Degradation of products containing metals (e.g., cars), wastes from processing (e.g., factories), and by-products of industry (e.g., coal-burning energy plants) invariably cause some degree of environmental pollution, particularly in heavily populated areas.

Organochlorines are organic compounds that have at least one covalently bonded chlorine atom. They have been used in a broad range of applications, some of which are controversial due to effects that the compounds have on the environment. A number of organchlorines are of particular concern in the aquatic environment, such as DDT and PCBs, which are both classified as persistent organic pollutants. DDT is a synthetic pesticide that was used in the United States to control mosquitoes, but was banned because it accumulated in aquatic food chains, interfered with metabolism in birds, and led to large declines in some bird species populations. PCBs were commonly used as electrical insulators and heat transfer agents, but banned in the United States in 1979 due to health concerns.

Heavy metals and organochlorines are included in Michigan's water quality standards to address environmental problems and human health issues. Standards have been established for surface waters to protect wildlife and for drinking water to protect human health. Very limited data are available for heavy metals and organochlorines in Lake Charlevoix. Only legacy data from the MDEQ water quality dataset include records for these contaminants, which date primarily from the 1970s. Except for a few metals, data from most parameters were collected from sediments and therefore, cannot be compared with standards that were established for water. The heavy metals for which there are usable data include manganese and zinc, which were both at levels far under the limits.

BACTERIOLOGICAL MONITORING

The Health Department of Northwest Michigan has performed bacteriological monitoring on Lake Charlevoix since 2001. Samples are usually collected on a weekly basis throughout summer months at 11 locations on Lake Charlevoix. The monitoring sites include the most heavily-used public access sites on the lake. Water samples are analyzed in the Health Department's laboratory in Gaylord to determine the number of *Escherichia coli* (*E. coli*) bacteria per 100 milliliters. *E. coli* bacteria usually do not pose a direct danger, but are rather indicators of the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that originate in human and animal digestive systems. Thus, their presence in surface waters indicates that pathogenic *microorganisms* might also be found and that there may be health risks associated with full body contact.

Between 2001 and 2010, the Health Department has collected and analyzed 895 water samples from sites on Lake Charlevoix. Results have ranged from less than one to 1009 *E. coli* bacteria per 100 milliliters. Rule 62 (R 323.1062) of DEQ Part 4 Water Quality Standards does have a provision for *E. coli* concentrations in surface water: "All waters of the state protected for total body contact recreation shall not contain more than 130 Escherichia coli (*E. coli*) per 100 milliliters, as a 30-day geometric mean." Rule 62 also states: "At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 milliliters." The maximum of 300 was exceeded 16 times; five times at the East Jordan Tourist Park, three times at Peninsula Beach, three times at Young State Park (which resulted in a one-day beach closing due to two consecutive exceedances), and once at the following locations: Elm Point, Ferry Beach, Hayes Township Park, and Whiting Park (Table 11).

Table 11: Bacteriological Monitoring Results Exceeding Standards

Location	Sample Date	Sample Type	Result Value*
EJ Tourist Park	7/31/2001	Daily Mean	308.47
EJ Tourist Park	8/3/2001	Daily Mean	320.83
EJ Tourist Park	8/10/2001	Daily Mean	338.80
EJ Tourist Park	8/31/2001	Daily Mean	435.55
EJ Tourist Park	8/30/2005	Daily Mean	468.36
Elm Point	8/28/2007	Daily Mean	1008.60
Ferry Beach	8/2/2006	Daily Mean	649.47
Hayes Township Park	7/27/2009	Daily Mean	318.50
Peninsula Beach	8/2/2006	Daily Mean	535.38
Peninsula Beach	6/12/2012	Daily Mean	463.60
Peninsula Beach	6/19/2012	Daily Mean	968.90
Tannery Beach	7/18/2011	Daily Mean	842.20
Whiting Park	8/31/2001	Daily Mean	302.27
Young State Park	6/26/2003	Daily Mean	416.66
Young State Park	7/18/2011	Daily Mean	314.80
Young State Park	7/19/2011	Daily Mean	317.90

*Results reported in the number of *E. coli* bacteria per 100 milliliters.

Based on results of the Health Departments comprehensive bacteriological monitoring dataset, it appears there are occasional bacteria-related health concerns in the water at public beaches and access points on Lake Charlevoix; however, most samples not meeting State water quality standards were isolated, occurring at the monitoring site on just one occasion. There were several samples that were higher than the allowable limit of 300 *E. coli*/100ml at East Jordan Tourist Park in 2001, but only one sample at the Tourist Park (2005) has not met the State standards since.

The Health Department follows a 2-stage protocol for bacteriological monitoring. If a collected sample exceeds the state minimum water quality standards for E. coli then an advisory is immediately posted and a second sample is collected and analyzed. If the second sample also exceeds the state standards, then a beach closing is issued until subsequent tests meet the standards. The Health Department currently has funding to conduct bacteriological monitoring at beaches through a Great Lakes Restoration Initiative grant; however, future funding is uncertain and without funds to support the program, monitoring might not continue.

WATER QUALITY OF RIVERS OF THE LAKE CHARLEVOIX WATERSHED

Water quality has been monitored in many of the rivers and streams in the Lake Charlevoix Watershed. Tributaries that have been monitored include Bennett Creek, Birney Creek, the Boyne River, Brown Creek, Cascade Creek, Collins Creek, Deer Creek, Eaton Creek, Five-tile Creek, the Green River, Hog Creek, Horton Creek, the Jordan River, Landslide Creek, Loeb Creek, Marvon Creek, Mill Creek, Monroe Creek, Moyer Creek, Porter Creek, Schoolhouse Creek, Six-tile Creek, Stover Creek, and Warner Creek (Figure 9). Most of these streams are part of the larger Boyne and Jordan River systems.

Several organizations and agencies have monitored stream water quality in the Lake Charlevoix Watershed, including the USEPA, MDEQ, TOMWC, LTBB, and USGS. The majority of data are available from the MDEQ, which has water quality data for 68 sites on 25 streams in the Watershed. TOMWC has data for 12 sites on five streams, LTBB has data for three sites on one stream, and USGS has data for five sites on one stream. The earliest data, Legacy data from the USEPA STORET database, date from 1967.

Water quality data types for streams include physical, chemical, biological, channel, and discharge (Table 12). Physical data include parameters such as dissolved oxygen and pH; chemical include parameters such as nutrients and metals; biological documents the aquatic macroinvertebrate community; channel includes parameters such as width, depth, and riparian vegetation; and discharge is a measurement of volume per unit time (e.g., cubic feet per second). The types and amount of water quality data available vary from stream to stream; in general, there is more data available for large rivers and creeks and less data available for the smaller creeks in the Watershed.

Table 12: Water Quality Data Availability for Lake Charlevoix Tributaries

Tributary Name	River/Creek System	Water Quality Data Availability:*				Water Quality Data Types Available: †				
		MDEQ	TOMWC	LTBB	USGS	Physical	Chemical	Biological	Channel	Discharge
Bennett Creek	Jordan River	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Birney Creek	Jordan River	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Boyne River	Boyne River	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Brown Creek	Jordan River	Yes	No	No	No	Yes	Yes	No	No	Yes
Cascade Creek	Jordan River	Yes	No	No	No	No	Yes	No	No	No
Collins Creek	Deer Creek (Jordan)	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Deer Creek	Jordan River	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Eaton Creek	Deer Creek (Jordan)	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Five-tile Creek	Jordan River	Yes	No	No	No	Yes	Yes	No	No	No
Green River	Jordan River	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Hog Creek	Deer Creek (Jordan)	Yes	No	No	No	No	Yes	No	No	No
Horton Creek	Horton Creek	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Jordan River	Jordan River	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Landslide Creek	Jordan River	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Loeb Creek	Loeb Creek	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Marvon Creek	Deer Creek (Jordan)	Yes	No	No	No	No	Yes	No	No	No
Mill Creek	Jordan River	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Monroe Creek	Monroe Creek	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Moyer Creek	Boyne River	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Porter Creek	Porter Creek	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Schoolhouse Creek	Boyne River	Yes	No	No	No	No	Yes	No	Yes	Yes
Six-tile Creek	Jordan River	Yes	No	No	No	Yes	Yes	No	No	No
Stover Creek	Stover Creek	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Unnamed Creek	Jordan River	Yes	No	No	No	No	Yes	No	No	No
Warner Creek	Deer Creek (Jordan)	Yes	No	No	No	No	No	Yes	Yes	Yes

***** MDEQ=Michigan Department of Natural Resources and Environment, TOMWC=Tip of the Mitt Watershed Council, LTBB=Little Traverse Bay Bands of Odawa, USGS=United States Geological Survey

† Examples: physical: dissolved oxygen and pH; chemical: nutrients and metals; biological: macroinvertebrates; channel: width, depth, and riparian vegetation; discharge: cubic feet per second

THE BOYNE RIVER

Water quality data available from MDEQ, TOMWC, and LTBB for the Boyne River and its tributaries indicate that stream ecosystems are healthy. The MDEQ dataset includes water quality monitoring data from 15 locations in the Boyne River Watershed (Figure 18); data spanning more than 40 years from 1967 to 2008. Volunteers and staff from TOMWC have monitored water quality from 2004 to present at four locations on the Boyne River. LTBB has monitored 3 locations on the river since 2004. Data collected show that all sites monitored in the Boyne River Watershed consistently meet State of Michigan water quality standards.

PHYSICAL-CHEMICAL MONITORING RESULTS

DISSOLVED OXYGEN

The Boyne River consistently had an abundance of dissolved oxygen based on water quality data from six locations. Dissolved oxygen has been monitored at two locations on the North Branch: Thumb Lake Road and US131, one location on the South Branch: M75, and three locations on the main stem: Dam Road, Boyne City Park, and Lake Street. Data at some sites go back to 1967 and the most recent data are from 2010. All readings were above the State water quality standard of 7 PPM, attesting to the high water quality of the Boyne River (Table 13).

Table 13: Dissolved Oxygen Data for the Boyne River

River section	Location	Data sources	Low*	High*	Time Period
North Branch	Thumb Lake Road	MDEQ†	11.8	11.8	1967
North Branch	US131, Boyne Falls	MDEQ†	8.4	11.8	1967-1970
South Branch	M75, Boyne Falls	LTBB	7.6	14.9	2004-2010
Main stem	Dam Road	MDEQ†, LTBB	7.7	14.7	1977-2010
Main stem	Boyne City Park	MDEQ†, LTBB, TOMWC	7.8	14.0	1977-2010
Main stem	Lake Street, mouth	MDEQ†	7.8	13.7	1968-1975

*units: milligrams per liter or parts per million.
†MDEQ data include legacy data from USEPA

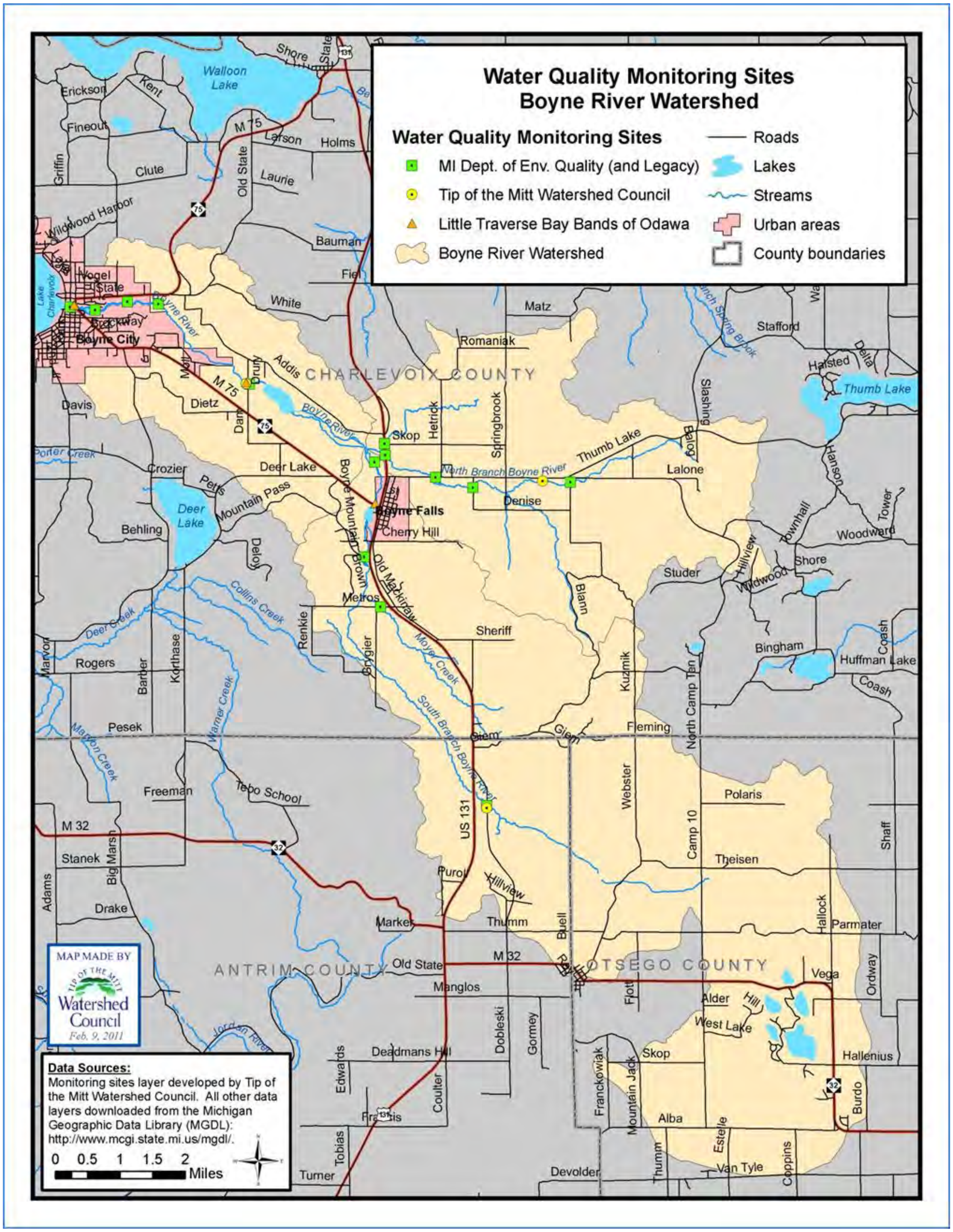


Figure 18: Water quality monitoring sites for Boyne River Watershed

ALKALINITY, HARDNESS, AND PH

Alkalinity, hardness, and pH data indicate that water of the Boyne River contains relatively high amounts of calcium carbonate ($CaCO_3$), which classify it as a moderately alkaline stream with a high buffering (i.e., acid neutralizing) capacity, and with very hard water. Alkalinity data from the MDEQ for seven locations in the Boyne River Watershed had an average value of 188 PPM $CaCO_3$ Hardness data from MDEQ for three sites in the watershed averaged 202 PPM $CaCO_3$. The MDEQ, LTBB, and TOMWC have pH data for five sites on the river and the average value was 8.1 (Table 14).

Table 14: Alkalinity, Hardness, and pH Data for the Boyne River

Parameter	Low * (value)	Low (year)	Low (site)	High* (value)	High (year)	High (site)	Average Value*
Alkalinity	125	1973	Lake St, mouth	215	1974	Lake St, mouth	188
Hardness	170	1974	Lake St, mouth	220	1973	Lake St, mouth	202
pH	7.2	1974	Lake St, mouth	8.8	2010	M75, Boyne Falls	8.1

*alkalinity and hardness measured in milligrams per liter $CaCO_3$ or parts per million.

CONDUCTIVITY AND CHLORIDE

Conductivity data have been collected from the Boyne River by MDEQ, LTBB, and TOMWC while chloride monitoring has only been performed by MDEQ and TOMWC. Conductivity levels in Boyne River, measured in microSiemens (µS), have ranged from 305 µS (LTBB, Dam Rd, 2006) to 442 µS (LTBB, Boyne City Park, 2005). LTBB has the most extensive conductivity dataset, though limited to the years 2004 through 2010. Averaged data from LTBB show a slight increase in conductivity levels from upstream to downstream monitoring locations. From upstream to downstream averaged data were 393 µS at Boyne Falls, 392 µS at Dam Rd, and 404 µS at the Boyne City Park. Legacy data from MDEQ for the lower section of the river (near the river mouth on Lake St.) show lower conductivity levels in the 1970s as compared with recent data collected by LTBB at the Boyne City Park (the average conductivity of all data collected in the 1970s was 377µS). However, there were only 16 records from 1973 to 1975 versus 50 records collected by LTBB in the last 7 years.

Chloride has been monitored in the Boyne River by MDEQ and TOMWC; data limited to only 31 records. These data show that chloride concentrations have ranged from 0.0 PPM (State Legacy data, 1967) to 11.4 PPM (TOMWC, 2010). Based on data collected at locations near the mouth of the river, chloride concentrations have increased from an average of 2.9 PPM during the 1970s to 9.0 PPM during recent years (2004 to 2010).

PHOSPHORUS

Phosphorus is one of several nutrients that have been monitored on the Boyne River by MDEQ and TOMWC, and is perhaps the most important in terms of water quality because it is usually in short supply relative to other nutrients. Total phosphorus concentrations have ranged from a high of 110.0 PPB in 1973 to a low of 3.0 PPB in 1978. The averaged total phosphorus concentration from monitoring data collected between 1993 and 2010 is much lower than the average value of data collected between 1968 and 1978; 7.0 PPB versus 18.4 PPB, respectively. Similar to the trend observed in Lake Charlevoix, the decline in the Boyne River could be explained by decreased phosphorus inputs due to improved regulation, as well as extensive outreach and education. Changes to the river ecosystem brought on by invasive zebra and quagga mussels may also play a role in the observed phosphorus declines (zebra mussels have been documented at the Dam Road site by Tip of the Mitt Watershed Council volunteer stream monitors).

NITROGEN

Nitrogen is an essential nutrient that has been monitored throughout the Lake Charlevoix Watershed, though generally not as important as phosphorus for water quality. Nitrogen data from the TOMWC CWQM program show that concentrations in the Boyne River are higher than average in relation to other rivers monitored, excluding the Jordan River. Of the 11 rivers monitored in the TOMWC CWQM program, nitrogen concentrations have been highest in the Jordan River, followed by the Boyne River. Excluding the Jordan and Boyne, the average total nitrogen concentration for these rivers is 333 PPB and average for nitrate-nitrogen is 151. Averages for the Boyne River are 528 PPB for total nitrogen and 372 PPB for nitrate-nitrogen. Although levels are not as high as those found in the Jordan River, elevated nitrogen concentrations in the Boyne could be linked to the same suspected source of nutrient pollution: agricultural activity in the Mancelona Plains. Potato farming in the Mancelona Plains primarily occurs outside the Boyne's topographical watershed boundary, but nutrient pollution may occur via groundwater as, similar to the Jordan, the Boyne River groundwater watershed probably extends into the Plains.

HEAVY METALS AND OTHER TOXIC SUBSTANCES

MDEQ datasets (including legacy data) contain records for several heavy metals and other substances of concern from the Boyne River, including antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, cyanide, lead, lithium, manganese, mercury, molybdenum, nickel, thallium, vanadium, and zinc. The levels of more than 50% of test results were non-detectable. Those tests that resulted in detectable levels were compared with MDEQ Water Quality Standards and found to all be well below maximum limits, with the exception of mercury. Mercury was found at 0.2 PPB in the Boyne River on three occasions from 1973 to 1993, which exceeds the standard wildlife value of 0.0013 PPB. However, methodologies for collecting and analyzing water samples for mercury have changed since the mercury samples exceeding standards were collected. The concentration of 0.2 PPB probably represents the lowest detectable value based on available methods at the times of analyses.

BIOLOGICAL MONITORING

Biological monitoring has been performed by MDEQ and TOMWC at 12 sites on the Boyne River; three on the North Branch, four on the South Branch, and five on the main stem. MDEQ biologists have monitored 11 sites in watershed. Volunteers, trained by TOMWC staff, monitor four sites as part of the Tip of the Mitt Volunteer Stream Monitoring program. MDEQ data are limited to one or two sampling events, whereas TOMWC data include six to ten sampling events. MDEQ biologists perform taxonomic identification to the family level in the field. Specimens collected by TOMWC volunteers are preserved in ethanol and identified to the family level by experienced aquatic macroinvertebrate taxonomist at a later date.

Examination of the biological data and comparisons are made using three metrics: 1) total taxa = the total number of macroinvertebrate families found at a site; 2) EPT taxa = the number of families belonging to three insect orders that are largely intolerant of pollution (mayflies, stoneflies, and caddisflies); and 3) sensitive taxa = the number of macroinvertebrate families that are the most intolerant of pollution (those that rate 0,1, or 2 in PhD William Hilsenhoff's family-level sensitivity classification system). At sites monitored by both MDEQ and TOMWC, MDEQ staff found a higher number of total and

EPT taxa, which is likely due to the fact that MDEQ field biologists have more experience than TOMWC volunteers. However, numbers for sensitive taxa were quite similar among MDEQ and TOMWC data, indicating that this metric is not as heavily influenced by collector(s) experience and therefore, the most reliable for making comparisons.

Because the MDEQ was performed by experienced professionals, descriptive statistics are presented using MDEQ data only. Biological data show strong diversity in the aquatic macroinvertebrate communities throughout the entire Boyne River. The number of total taxa per site ranged from 19 to 36 with an average of 27.1 (Table 15). EPT taxa diversity ranged from nine to 17 taxa, with an average of 12.9. The number of sensitive taxa ranged from five to nine, averaging 5.8 among all sites. In general, the main stem of the river, from Dam Road to Park Street, had higher total taxa diversity (Figure 19). EPT diversity was also higher in the main river on average, though not markedly different between upstream and downstream sections. Sensitive taxa numbers were similar throughout the river system.

The relatively high number of sensitive taxa found throughout the Boyne River is testimony to the river's high water quality and healthy ecosystem. Averaged sensitive taxa data for all sites monitored in the TOMWC program range from 0.1 to 7.3; the Boyne River is among the highest with averaged values ranging from 4.6 to 5.6. Compared with other streams monitored (by averaging sensitive taxa data for all sites in a stream system), the Boyne River was among the top three (Table 16).

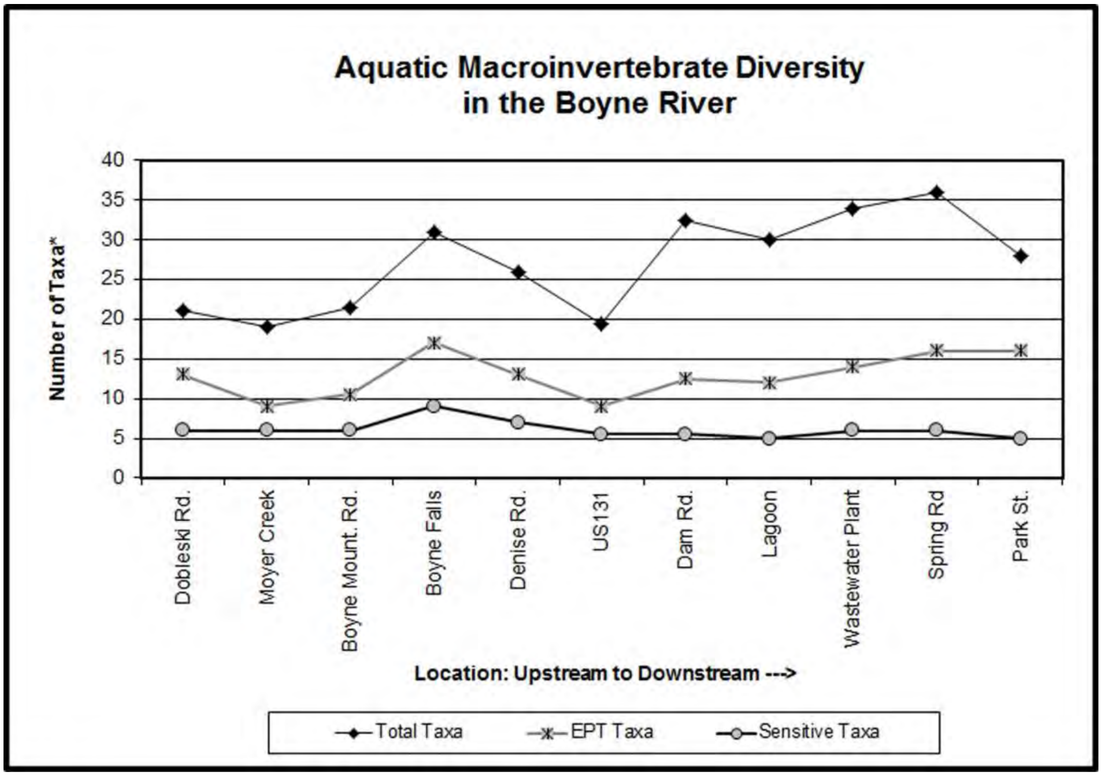
The high quality waters of the Boyne River are even more evident when compared to data from stream monitoring programs in Southern Michigan. Biological data from sites monitored by volunteers from the Huron River Watershed Council show that no sensitive taxa are found in a number of highly urbanized streams (P. Steen, Huron River Watershed Council, personal communication). On average, approximately 2 sensitive families are found per site throughout the entire Huron River Watershed and the highest average sensitive taxa count for any site on the Huron is 5.2.

There are localized conditions that may be contributing to the marginally lower sensitive taxa scores at Park Street on the lower section of the Boyne River. Urbanization in this lower section (Boyne City) probably affects the Boyne River due to stormwater runoff inputs laden with sediments, nutrients, metals and other pollutants commonly found in urban areas. Thermal pollution as a result of stormwater runoff flowing across pavement and other impervious surfaces may also have negative impacts on the water quality and aquatic macroinvertebrate populations in the Boyne City area.

Table 15: Biological Monitoring Results for the Boyne River

Location	River Section	Entity	Time Period	Num. of samples	Total Taxa*	EPT Taxa**	Sensitive Taxa***
Dobleski Rd.	S. Branch	MDEQ	2003	1	21.0	13.0	6.0
Dobleski Rd.	S. Branch	TOMWC	2005-2010	10	15.5	9.7	5.6
Moyer Creek	S. Branch	MDEQ	2003	1	19.0	9.0	6.0
Boyne Mount. Rd	S. Branch	MDEQ	1998-2003	2	21.5	10.5	6.0
Boyne Falls	S. Branch	MDEQ	2008	1	31.0	17.0	9.0
LTC NB Preserve	N. Branch	TOMWC	2007-2010	6	17.8	10.5	5.3
Denise Rd.	N. Branch	MDEQ	2003	1	26.0	13.0	7.0
US131	N. Branch	MDEQ	1998-2003	2	19.5	9.0	5.5
Dam Rd.	Main	MDEQ	2003-2004	2	32.5	12.5	5.5
Dam Rd.	Main	TOMWC	2007-2010	7	17.6	9.3	5.0
Lagoon	Main	MDEQ	2004	1	30.0	12.0	5.0
Wastewater Plant	Main	MDEQ	2004	1	34.0	14.0	6.0
Spring Rd.	Main	MDEQ	2004	1	36.0	16.0	6.0
Park St.	Main	MDEQ	2008	1	28.0	16.0	5.0
Park St.	Main	TOMWC	2005-2010	10	15.3	8.5	4.6

*Total taxa: the total number of macroinvertebrate families found at a site **EPT taxa: the number of families in three insect orders known to be intolerant of pollution (mayflies, stoneflies, and caddisflies).***sensitive taxa: the number of macroinvertebrate families that are the most intolerant of pollution.



*Total taxa = the total number of macroinvertebrate families found at a site; EPT taxa = the number of families in three insect orders known to be intolerant of pollution (mayflies, stoneflies, and caddisflies); and sensitive taxa = the number of macroinvertebrate families that are the most intolerant of pollution.

Figure 19: Macroinvertebrate diversity in the Boyne River

Table 16: Sensitive Taxa from the TOMWC Volunteer Stream Monitoring Program

River/Stream Name	Sensitive Taxa Low*	Sensitive Taxa High*	Sensitive Taxa Average*
Bear River	1.7	4.0	3.0
Boyne River	4.6	5.6	5.1
Eastport Creek	2.0	5.0	3.5
Horton Creek	0.9	6.5	3.7
Jordan River	5.6	7.3	6.4
Kimberly Creek	3.5	4.3	3.9
Milligan Creek	5.3	5.7	5.5
Mullett Creek	0.8	4.9	2.9
Russian Creek	1.8	1.8	1.8
Spencer Creek	4.6	5.0	4.8
Stover Creek	0.1	3.4	1.8
Tannery Creek	1.0	3.3	2.2

*Sensitive taxa low and high values are averages for individual sites on stream systems. The averaged value is for data from all sites on the river system.

THE JORDAN RIVER

Water quality data available from the MDEQ, USGS, and TOMWC for the Jordan River and its tributaries indicate that stream ecosystems are healthy. The MDEQ dataset (including legacy data from USEPA) includes water quality monitoring data from 39 locations in the Jordan River Watershed; data spanning more than 40 years from 1967 to 2008. The USGS monitored water quality on the Jordan River from 1966 to 1971 at five sites. Volunteers and staff from TOMWC have monitored water quality from 2004 to present at two locations on the Jordan River (Figure 20). Data collected show that almost all sites monitored in the Jordan River Watershed maintain excellent water quality and that nearly all test results meet State of Michigan water quality standards.

PHYSICAL-CHEMICAL MONITORING RESULTS

DISSOLVED OXYGEN

Based on water quality data collected at ten locations in the Jordan River system, dissolved oxygen stores are generally abundant (Table 17). Dissolved oxygen was monitored at five locations in the upper watershed (from Pinney Bridge upstream) and five locations in the lower watershed. There are 198 dissolved oxygen records available from MDEQ and TOMWC that were collected between 1967 and 2010. The average value of all dissolved oxygen readings was 10.7 PPM. Only two readings were below the State water quality cold-water fishery standard of 7 PPM; 6.1 PPM at the discharge from the Jordan River National Fish Hatchery in 1977 and 6.9 PPM at the river mouth at Bridge Street in 1977. The aerobic digestion by bacteria of organic compounds from the hatchery discharge and from the marshy area upstream of Bridge Street probably contributed to the lower readings at these sites. Regardless, the lower readings were limited to two occasions over 30 years ago and were just below the cold-water fishery standard of 7.0 PPM.

Table 17: Dissolved Oxygen for the Jordan River

River section	Location	Data sources	Low*	High*	Time Period
Upstream	Jordan River Road	MDEQ†	8.4	13.2	1977-1978
Upstream	Five-tile Creek	MDEQ†	8.5	11.2	1977-1978
Usptream	Hatchery, discharge	MDEQ†	6.1	11.7	1977-1978
Usptream	Six-tile Creek	MDEQ†	9.9	10.8	1977-1978
Usptream	Pinney Bridge	MDEQ†	7.8	14.1	1968-1978
Downstream	Old State Rd	MDEQ†	8.4	13.8	1967-1975
Downstream	Rogers Rd	MDEQ†	8.2	14.0	1967-1978
Downstream	Deer Creek, M32	MDEQ†	8.3	13.8	1968-1978
Downstream	Fair Rd	TOMWC	10.0	11.1	2004-2010
Downstream	Bridge St, mouth	MDEQ†	6.9	13.1	1968-1978

*dissolved oxygen units: milligrams per liter or parts per million.
†MDEQ data includes legacy data from USEPA.

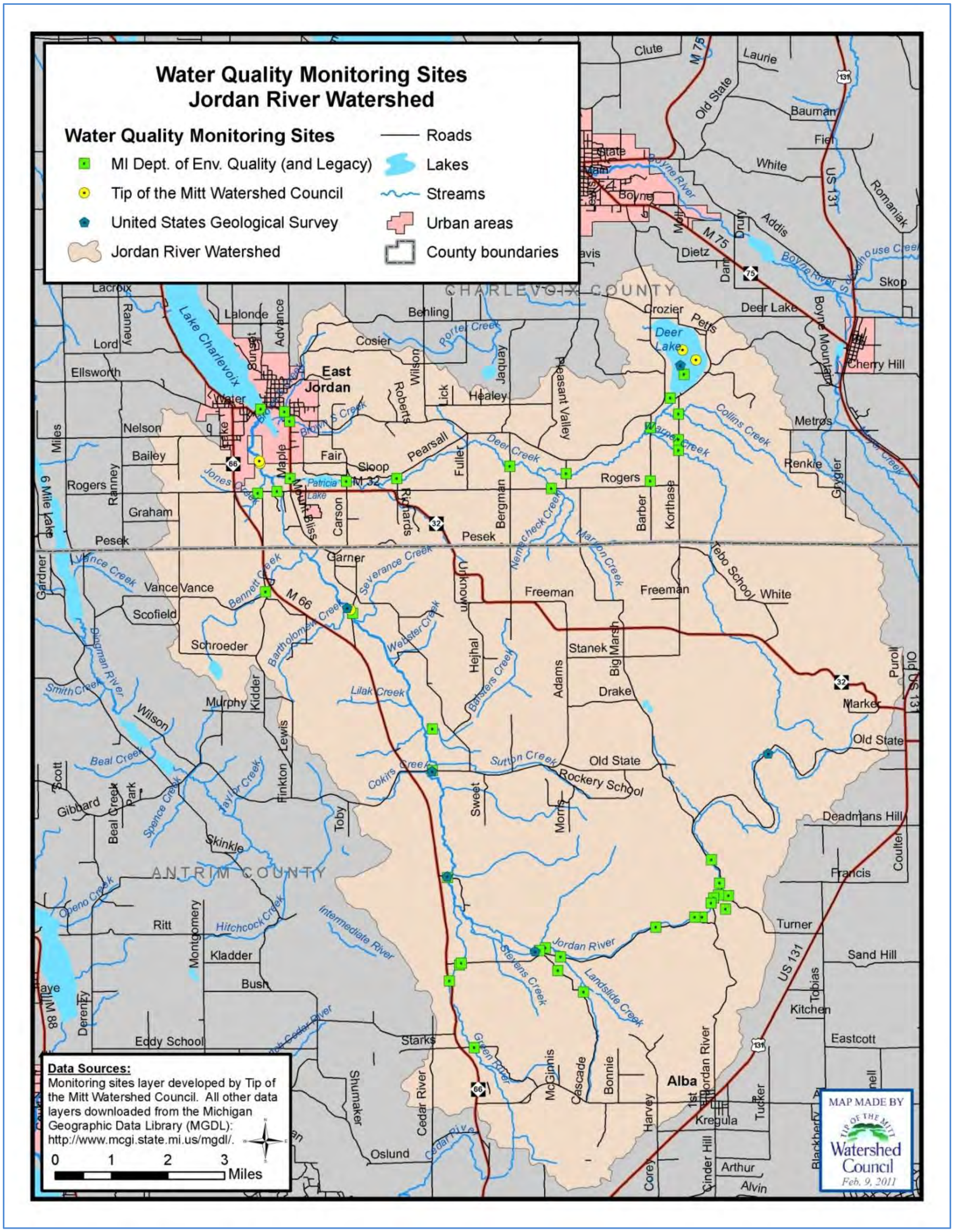


Figure 20: Water quality monitoring sites for the Jordan River Watershed

ALKALINITY, HARDNESS, AND PH

The MDEQ and USGS datasets contain 88 alkalinity records for the Jordan River system, collected between 1966 and 2003 at 17 different locations. Alkalinity values have ranged from a low of 110 PPM $CaCO_3$ to a high of 223 PPM $CaCO_3$, with an average value of 166 PPM $CaCO_3$ (Table 18). Hardness data include 94 records from the MDEQ and USGS, collected between 1966 and 2003 at 17 different locations. Hardness values have ranged from a low of 130 PPM $CaCO_3$to a high of 253 PPM $CaCO_3$, with an average value of 177 PPM $CaCO_3$. The MDEQ, USGS, and TOMWC have pH data for 11 sites on the river; with a total of 131 records from 1966 to 2010. The pH values range from a low of 7.0 to a high of 8.7, with an average value of 8.1. Alkalinity, hardness, and pH data indicate that water of the Jordan River contains relatively high amounts of calcium carbonate, which classify it as a moderately alkaline stream with a high buffering (i.e., acid neutralizing) capacity, and with very hard water.

Table 18: Alkalinity, Hardness, and pH Data for the Jordan River

Parameter	Low * (value)	Low (year)	Low (site)	High* (value)	High (year)	High (site)	Average Value*
Alkalinity	110	1973	Old State Rd	223	2003	Birney Creek	166
Hardness	130	1966	Webster Rd	253	2003	Birney Creek	177
pH	7.0	1968	Rogers Rd	8.7	1977	Hatchery discharge	8.1

*units: milligrams per liter or parts per million.

CONDUCTIVITY AND CHLORIDE

Conductivity and chloride data for the Jordan River are available from MDEQ (including Legacy data), USGS, and TOMWC for 14 sites in the watershed. Conductivity was measured on 105 occasions and chloride tested 72 times between 1966 and 2010.

Conductivity levels in the Jordan River have been within the range of 150-500 µS/cm, which studies in inland freshwater streams have found to support good mixed fisheries (USEPA, 1997). Conductivity levels in the river have ranged from 162 µS (USGS, Webster Rd, 1970) to 483 µS (MDEQ, Birney Creek, 2003), with an average of 333 µS. There were no discernible trends in the conductivity data. The relatively high conductivity value measured at Birney Creek in 2003 indicates that there may be water quality problems associated with nonpoint source pollution, particularly considering that chloride levels were also found to be high in Birney Creek.

The data show that chloride concentrations have ranged from 0.0 PPM (MDEQ Legacy, Old State Rd, 1967) to 10.0 PPM (MDEQ, Birney Creek, 2003), with an average of 2.8 PPM. Chloride concentrations have increased from an average of 2.0 PPM during the 1960s and 1970s to 4.0 PPM in the 1990s to 6.9 PPM during recent years (2003 to 2010). The trend toward increasing chloride levels is common in lakes monitored by TOMWC; they are indicative of increased development and activity in the watershed. However, chloride concentrations from the most recent monitoring results from the Jordan River are still far below levels that negatively impact aquatic life.

PHOSPHORUS

Phosphorus is one of several nutrients that have been monitored on the Jordan River by MDEQ, USGS, and TOMWC, and is perhaps the most important in terms of water quality because it is usually in short supply relative to other nutrients. Over 190 phosphorus records are available for the Jordan River system, covering a time period from 1967 to 2010. Total phosphorus concentrations have ranged from a low of 0.0 PPB (MDEQ Legacy, Old State Rd, 1967) to a high of 550.0 PPB (MDEQ Legacy, Hatchery discharge, 1977). Averaged total phosphorus concentrations from the 1968 to 1978 time period were much higher than those collected between 1993 and 2010; 26.8 PPB versus 12.0 PPB respectively. Similar to trends observed in Lake Charlevoix and the Boyne River, the decline in the Jordan River could be explained by decreased phosphorus inputs due to improved regulation, as well as extensive outreach and education. Invasive zebra and quagga mussels can also play a role in phosphorus declines, but neither of these mussels appears in biological monitoring data from the Jordan River.

NITROGEN

Nitrogen is another nutrient that has been monitored throughout the Lake Charlevoix Watershed and, even though phosphorus is generally the limiting and thus, most important nutrient in the lakes and streams of Northern Michigan, nitrogen in the Jordan River merits discussion due to abnormally high levels. Of the 11 rivers monitored in the TOMWC CWQM program, nitrogen concentrations have been highest in the Jordan River. Excluding the Jordan, the average total nitrogen concentration for these rivers is 352 PPB and average for nitrate-nitrogen is 173. Averages for the Jordan River are 1155 PPB for total nitrogen and 962 PPB for nitrate-nitrogen. Current research by MSU hydrologists suggest that the elevated nitrogen levels in the Jordan River may be the result of fertilizer application in agricultural operations (potato farming) in the Mancelona Plains. Although little potato farming occurs within the topographical

Jordan River watershed boundary, extensive areas farmed in the Mancelona Plains are within the groundwater watershed of the Jordan River and potentially cause the elevated nitrogen levels observed in the data.

HEAVY METALS AND OTHER TOXIC SUBSTANCES

MDEQ datasets (including legacy data) contain records for several heavy metals and other substances of concern from the Jordan River, including antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, cyanide, lead, lithium, manganese, mercury, molybdenum, nickel, thallium, vanadium, and zinc. Nearly half of test results were non-detectable. Those tests that resulted in detectable levels were compared with MDEQ Water Quality Standards and found to all be well below maximum limits, with the exception of mercury. Mercury was found at 0.2 PPB in the Jordan River on 11 occasions from 1970 to 1993, which exceeds the standard wildlife value of 0.0013 PPB. However, methodologies for collecting and analyzing water samples for mercury have changed since the mercury samples exceeding standards were collected. The concentration of 0.2 PPB probably represents the lowest detectable value based on available methods at the times of analyses.

BIOLOGICAL MONITORING

Biological monitoring has been performed by MDEQ and TOMWC at 22 sites in the Jordan River Watershed; seven on the main stem of the river and 15 on tributaries that flow into the river. MDEQ biologists have monitored 21 sites while TOMWC volunteers monitor two sites as part of the Tip of the Mitt Volunteer Stream Monitoring program. MDEQ data are generally limited to one or two sampling events, whereas TOMWC data include eight sampling events. MDEQ biologists perform taxonomic identification to the family level in the field. Specimens collected by TOMWC volunteers are preserved in ethanol and identified to the family level by experienced aquatic macroinvertebrate taxonomist at a later date.

Examination of the biological data and comparisons are made using three metrics: 1) total taxa = the total number of macroinvertebrate families found at a site; 2) EPT taxa = the number of families in the most sensitive insect orders (mayflies, stoneflies, and caddisflies); and 3) sensitive taxa = the number of families that are very sensitive to non-point source pollution (those that rate 0, 1, or 2 in PhD William Hilsenhoff's family-level sensitivity classification system). At the site monitored by both MDEQ and TOMWC (Webster Rd), MDEQ staff found a higher number of total and EPT taxa, which is likely due to the fact that MDEQ field biologists have more experience than TOMWC volunteers. However, the number of sensitive taxa collected by MDEQ and TOMWC at Webster Road was approximately the same, indicating that this metric is not as heavily influenced by collector(s) experience and therefore, the most reliable for making comparisons.

Biological data show strong diversity in the aquatic macroinvertebrate communities throughout most of the Jordan River Watershed. The number of total taxa per site ranged from 10 to 43 with an average of 25.1 (Table 19). EPT taxa diversity ranged from three to 19.6 taxa, with an average of 12.2. The number of sensitive taxa ranged from two to 11, averaging 6.5 among all sites. There were no clear patterns in the biological data between upstream and downstream sample sites (Figure 21). The Jordan River Road site in the uppermost headwaters of the main stem and the site on Warner Creek in the Deer Creek Watershed displayed remarkable macroinvertebrate diversity. Conversely, macroinvertebrate diversity was quite poor at the Birney Creek site in the lower watershed; providing further evidence of water quality problems in this creek.

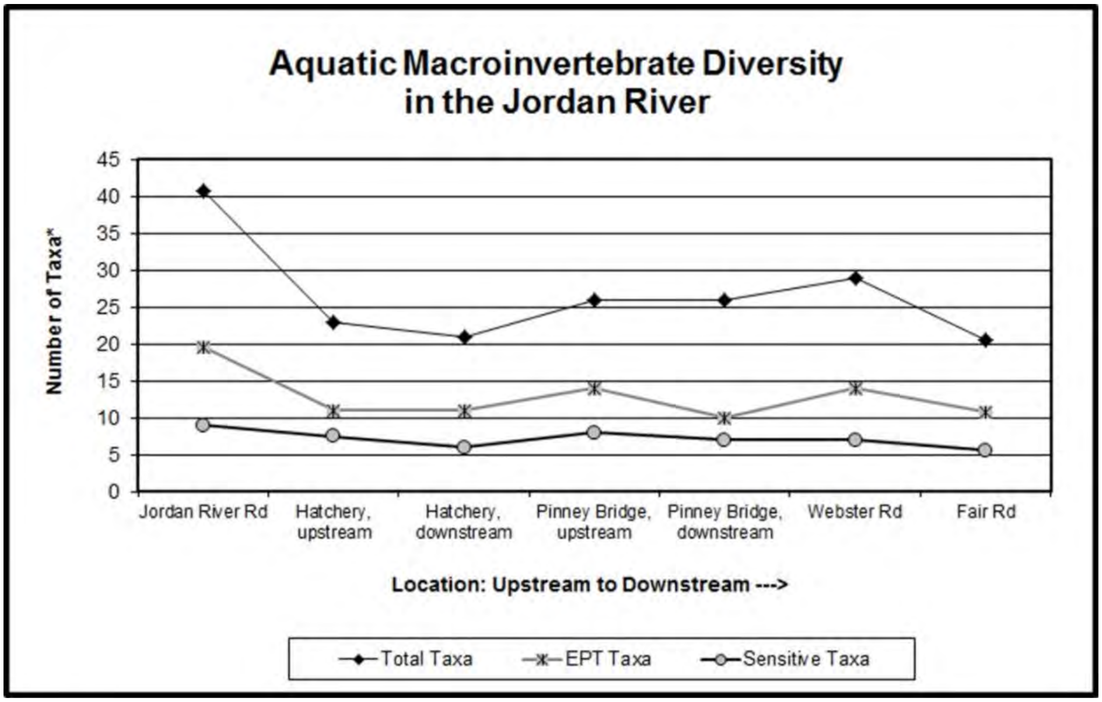
The relatively high number of sensitive taxa found throughout the Jordan River is testimony to the river's high water quality and healthy ecosystem. Averaged sensitive taxa data for sites monitored on all streams in the TOMWC program ranged from 0.1 to 7.3. The Jordan River had the highest average (by averaging sensitive taxa data for all sites in a stream system) with a score of 6.4 (Table 16). Similar to the Boyne River, the high quality waters of the Jordan River are even more evident when compared to biological monitoring data from streams in southern Michigan.

The lower taxa scores in Birney Creek likely reflect impacts from the relatively high percentage of agricultural landuse in the creek's watershed. Birney Creek Watershed 2006 land-cover statistics (NOAA, 2006) show that nearly 40% of watershed landcover is agricultural, with an additional 5% urban landcover (Table 20). In comparison, agricultural landcover in the Jordan River Watershed was approximately 19% in 2006 and urban less than 3%. Agricultural and urban landuse negatively impact water quality as a result of stormwater runoff inputs laden with sediments, nutrients, pesticides, herbicides, and other pollutants.

Table 19: Biological Monitoring Results for the Jordan River

Location	River Section	Entity	Time Period	# of samples	Total Taxa*	EPT Taxa*	Sensitive Taxa*
Jordan River Rd	Upstrm	MDEQ	2008	5	40.8	19.6	9.0
Hatchery, upstream	Upstrm	MDEQ	1993-2003	2	23.0	11.0	7.5
Hatchery, dwnstrm	Upstrm	MDEQ	1993	1	21.0	11.0	6.0
Landslide Creek	Trib	MDEQ	2003	1	21.0	11.0	5.0
Green River, Green River Rd	Trib	MDEQ	2008	1	31.0	17.0	8.0
Green River, M66	Trib	MDEQ	2008	1	23.0	12.0	7.0
Green River, upstream of Pinney	Trib	MDEQ	2008	1	20.0	11.0	7.0
Green River, Pinney Bridge Rd	Trib	MDEQ	1992-2003	3	22.7	12.0	6.7
Pinney Bridge, upstream	Upstrm	MDEQ	2003	1	26.0	14.0	8.0
Pinney Bridge, downstream	Upstrm	MDEQ	1992	2	26.0	10.0	7.0
Mill Creek	Trib	MDEQ	2003	1	20.0	11.0	6.0
Webster Rd	Dwnstrm	MDEQ	2003	1	29.0	14.0	7.0
Webster Rd	Dwnstrm	TOMWC	2007-2010	8	20.3	11.8	7.3
Collin Crk, Deer Crk	Trib	MDEQ	1990	1	26.0	9.0	3.0
Deer Creek, Barber Rd	Trib	MDEQ	1990	1	26.0	14.0	6.0
Warner Crk, Deer Crk	Trib	MDEQ	2008	1	43.0	19.0	11.0
Eaton Creek, Deer Creek	Trib	MDEQ	1990	1	15.0	6.0	4.0
Deer Creek, Marvon Rd	Trib	MDEQ	1990	1	21.0	7.0	2.0
Deer Creek, Pearsall Rd	Trib	MDEQ	1990	1	33.0	17.0	10.0
Deer Creek, Carson Rd	Trib	MDEQ	2008	5	37.4	19.4	9.2
Bennet Creek	Trib	MDEQ	2003	1	21.0	10.0	5.0
Birney Creek	Trib	MDEQ	2003	1	10.0	3.0	2.0
Fair Rd	Dwnstrm	TOMWC	2007-2010	8	20.6	10.8	5.6

*Total taxa = the total number of macroinvertebrate families found at a site; EPT taxa = the number of families in three insect orders known to be sensitive to pollution (mayflies, stoneflies, and caddisflies); and sensitive taxa = the number of macroinvertebrate families that are the most sensitive to non-point source pollution.



*Total taxa = the total number of macroinvertebrate families found at a site; EPT taxa = the number of families in three insect orders known to be sensitive to pollution (mayflies, stoneflies, and caddisflies); and sensitive taxa = the number of macroinvertebrate families that are the most sensitive to non-point source pollution.

Figure 21: Macroinvertebrate diversity in the Jordan River

Table 20: Land-cover Data for Birney Creek and Jordan River Watersheds

Land-use Type	Birney Creek Acres*	Birney Creek Percent*	Jordan River Acres*	Jordan River Percent*
Agriculture	676.37	39.22	22250.54	18.88
Barren	0.77	0.04	222.82	0.19
Forested	572.67	33.21	66483.83	56.42
Grassland	241.49	14.00	9112.66	7.73
Scrub/Shrub	70.44	4.08	3970.40	3.37
Urban	83.35	4.83	3171.93	2.69
Wetland	79.37	4.60	12627.37	10.72
TOTAL	1,724.46	100.00	117839.54	100.00

*Land-cover statistics derived from NOAA Coastal Change Analysis Program, 2006

WATER QUALITY OF SMALL LAKES AND STREAMS

Other streams and lakes that have been monitored in the Lake Charlevoix Watershed include Brown Creek, Deer Lake, Horton Creek, Loeb Creek, Monroe Creek, Nowland Lake, Porter Creek, and Stover Creek. The water quality of most of these smaller lakes and streams is comparable to that of Lake Charlevoix and the Boyne and Jordan Rivers; i.e., high water quality and healthy aquatic ecosystems. Thorough examination of water quality data from the smaller water bodies in the watershed did reveal a few instances where test results did not meet State standards or were indicative of potential water quality problems, but most of these were found to be isolated incidences or due to natural phenomena.

One dissolved oxygen reading on Deer Lake was just below the required minimum of 7 PPM, but all other readings were above the standard and thus, oxygen depletion does not appear to be a problem in the lake. Chloride levels were relatively high at the site monitored by MDEQ on Loeb Creek (14 PPM in 2003), but other physico-chemical data, as well as biological data, did not indicate that there were water quality problems in the creek. The high chloride reading was probably caused by salt in stormwater runoff from the adjacent highway (M-66). Data from upstream sites on Horton Creek show low aquatic macroinvertebrate diversity, but this lack of diversity is likely due to natural conditions. The upstream section of Horton Creek is low-gradient with sluggish flow through wetland areas where great amounts of silt and muck are deposited on the stream bottom. The resultant lack of habitat diversity and lower dissolved oxygen levels due to slower waters at the upstream sites do not support sensitive aquatic macroinvertebrate populations.

Stover Creek is the only small stream in the Lake Charlevoix Watershed where there appears to be water quality problems. Biological data from TOMWC show poor aquatic macroinvertebrate diversity in the lower section of the creek. Total taxa and EPT taxa numbers are, on average, much lower at the site near the mouth of the stream than at the next monitoring site less than a mile upstream. Furthermore, not one sensitive macroinvertebrate family has been encountered at the mouth (adjacent to Irish Boat Shop) during seven years of monitoring. The low biological diversity at the mouth of Stover Creek is thought to be the result of urbanization. The lower section of the creek flows through Charlevoix, an urban area where stormwater runoff from roads, roofs, and other impervious surfaces washes pollutants and unnaturally warm water into the creek.

CHAPTER THREE: REVIEW OF NONPOINT SOURCE POLLUTION INVENTORIES

Numerous inventories were conducted to assess and document the current level of nonpoint source pollution in the Watershed. Valuable information was collected for determining causes and potential sources of pollution. The following section includes summaries and results for all inventories conducted in the Watershed.

STORMWATER INVENTORY

Stormwater runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not infiltrate into the ground. As the runoff flows over the land or impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates debris, chemicals, sediment or other pollutants that could adversely affect water quality if the runoff is discharged untreated. In urban areas, stormwater is the primary source of nonpoint source pollution.

Lake Charlevoix has three relatively large urban areas on its shorelines-- Boyne City, East Jordan, and Charlevoix. A portion of all these cities have paved streets with curbs, gutters, and subsurface drainage pipes called storm sewers. The main purpose of these storm sewers (some of which were installed many decades ago) is to prevent flooding and water damage. Although the storm sewer systems protect infrastructure, they can also contribute nonpoint source pollutants, including bacteria from pet and animal wastes, fertilizer, oil and grease, sediment, heavy metals, salt, etc., to the receiving water body. Pollutants are washed off streets, sidewalks, and parking lots into storm drains and inlets via stormwater. Stormwater travels through the storm sewers and is discharged, oftentimes untreated, into Lake Charlevoix or its tributaries.

In 2000, as part of the Lake Charlevoix Watershed Project, Watershed Council staff conducted an inventory and assessment of the storm sewer systems for each of the three cities (Figures 22, 23, and 24). This consisted of identifying the land uses (e.g. commercial) within the city boundaries, reviewing maps of storm sewers provided by each city, delineating different drainage areas, identifying locations of stormwater inlets and outlets, and estimating pollutant loading using models developed during nationwide studies. No stormwater monitoring was conducted at that time; however, baseline monitoring began in 2011 as part of another grant (see Chapter Four).

Table 21 summarizes the stormwater characteristics of each municipality and results of the storm sewer survey. Estimated pollution contributions from storm sewers were calculated using a simple, empirical method developed by the Metropolitan Washington Council of Governments (MWCOG, 1987). It is explained in further detail in Appendix A.

Table 21: Storm Sewer Survey Summary

Lake Charlevoix Watershed Storm Sewer Survey	Boyne City	Charlevoix	East Jordan
Total land area (acres) of city	2,377	1,280	1,714
Total area (acres) draining into	4,833	1,666	3,425
Percent of Watershed	2.25	0.78	1.6
Land use in cities (% of acreage)			
Undeveloped	49.6	29.8	55.5
Commercial/Industrial	12.5	16.4	11.8
Residential	36.2	48.4	29.8
Water	1.7	5.4	2.9
Overall Impervious Cover	24.0	31.0	22.0
Number of storm sewer outfalls	15	13	5
Area (acres) of city draining to lake or river via storm sewers	936	490	360
Percent of city draining to lake or river via storm sewers	39	39	21
Estimated pollution contributions from storm sewers annually (lbs) Phosphorus Sediment	 714 201,685	 435 122,976	 253 71,591
Comparative Pollutant Export annually Aquatic Plant Growth (lbs) Soil (Dump truck loads)	 356,850 8.5	 217,620 5	 126,630 3

The results indicate that the storm sewers are contributing a significant amount of pollution to Lake Charlevoix. All of the municipalities have expressed interest in participating in efforts to reduce impacts.

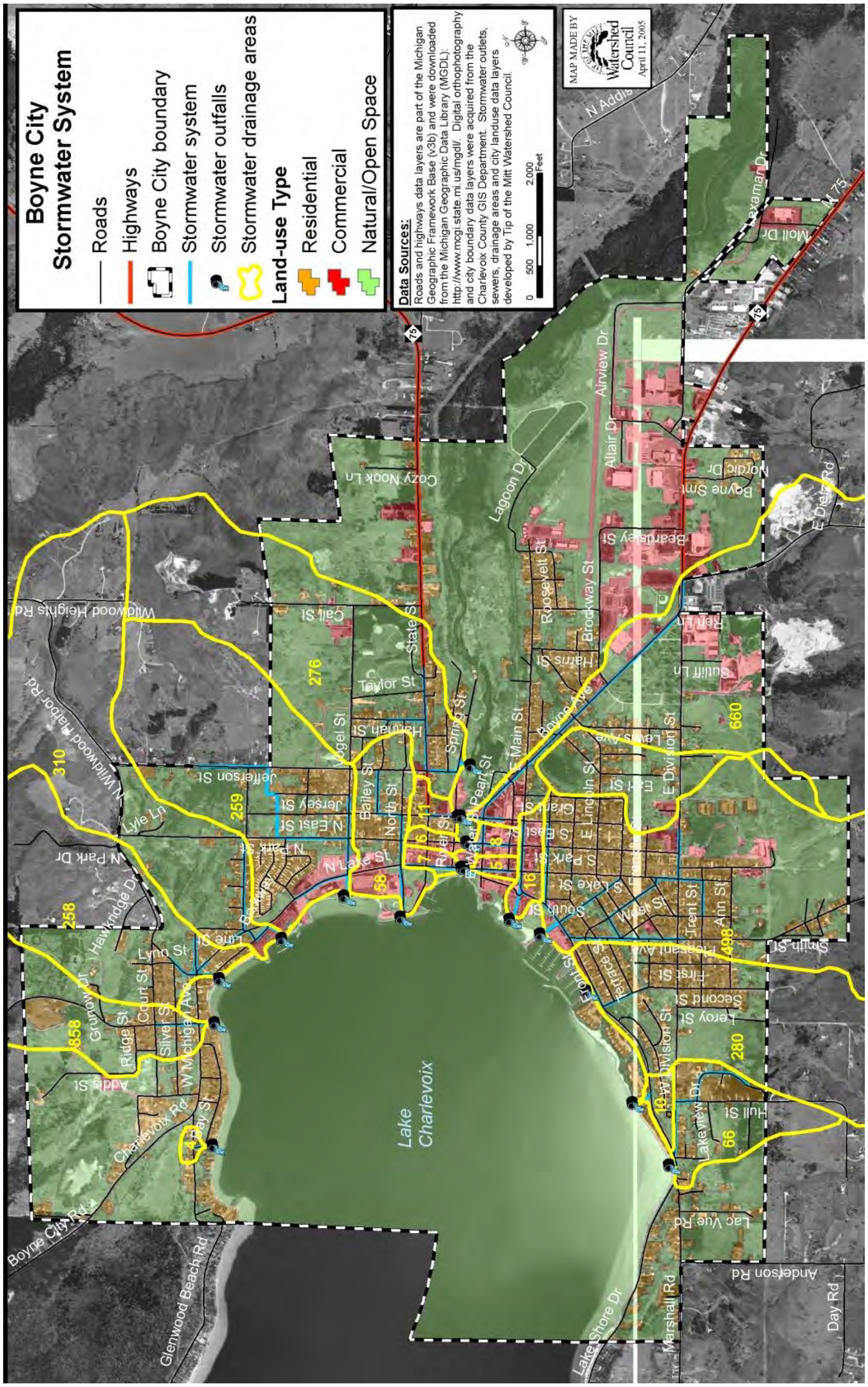


Figure 22: City of Boyne City stormwater system

Figure 23: City of Charlevoix stormwater system

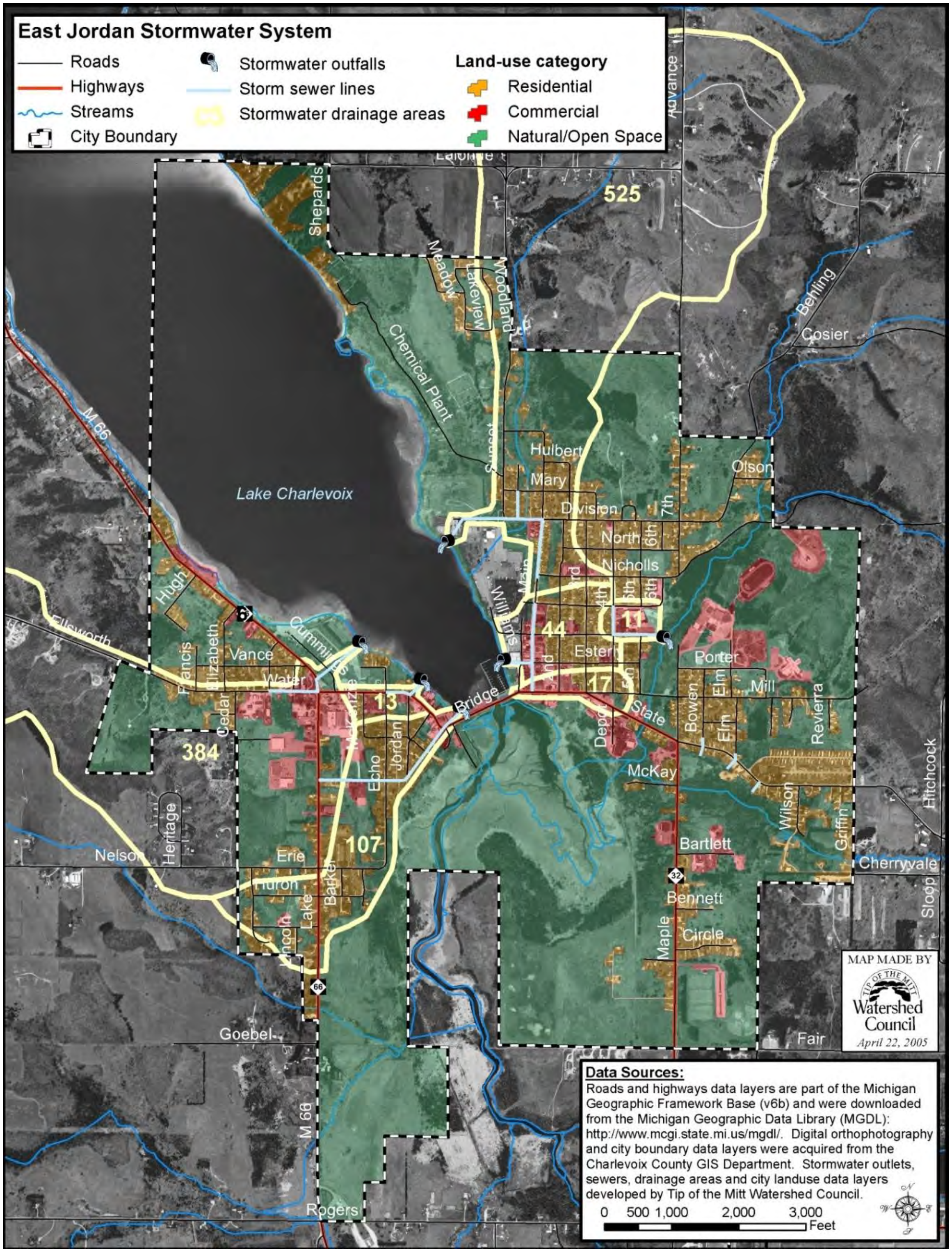


Figure 24: City of East Jordan stormwater system

LAKE CHARLEVOIX SHORELINE SURVEY

A shoreline survey to identify locations of nutrient pollution (using an algae called *Cladophora* as an indicator), bottom sediment type, and shoreline development characteristics was performed by the Tip of the Mitt Watershed Council during the summer of 2007.

Cladophora is a branched, filamentous, green algae that occurs naturally in small amounts in Northern Michigan lakes, mostly on rocky shorelines. The nutrient requirements for *Cladophora* to achieve large, dense growths are greater than the nutrient availability in lakes with high water quality, such as Lake Charlevoix. Therefore, the presence of *Cladophora* can indicate locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake. Sources of these nutrients can be due to natural conditions, however, the majority of *Cladophora* growths can be traced to cultural sources (such as lawn fertilization, malfunctioning septic systems, poor agricultural practices, soil erosion, and wetland destruction). These nutrients can contribute to an overall decline in lake water quality. Additionally, malfunctioning septic systems pose a potential health risk due to bacterial and viral contamination.

According to Tip of the Mitt Watershed Council records, this was the third comprehensive data set documenting shoreline nutrient pollution on Lake Charlevoix. Regularly conducting shoreline algal surveys is important for identifying chronic problem sites as well as recent occurrences. They are also valuable for determining long-term trends of nearshore nutrient inputs associated with land use changes, and for assessing the success of remedial actions.

This survey documented shoreline conditions at 1,694 land parcels on Lake Charlevoix. Some portion of the shoreline was developed at 85% (1,442) of the parcels. Habitat generally considered suitable for *Cladophora* growth was noted at 79% (1,336) of the parcels. Noticeable growths of *Cladophora* or other filamentous green algae were found along 17% (288) parcels.

In the field *Cladophora* growth densities were noted in seven different categories, but subsequently reduced to three categories to facilitate data examination. At properties where *Cladophora* growth was observed, there were an equal number of light and moderate growths (Table22). Over 20% of observed growths were in the heavy category, of which nearly half were very heavy. Most of the *Cladophora* growths were associated with developed shoreline properties (~93%).

Table 22: Cladophora Growth Density Statistics for Shoreline Properties

Cladophora Growth Density Statistics for Shoreline Properties		
Density Category	Number of Properties	Percent of Properties
Light	114	39
Moderate	114	39
Heavy	60	22

Maps displaying field survey data for shoreline parcels on Lake Charlevoix were reviewed to determine patterns in the occurrence of *Cladophora* growth (Figures 25, 26, and 27). In the main basin the greatest concentration of parcels with *Cladophora* growth occurred at the following locations: along the east side of Twomile Point (Evergreen Point Drive), between Spring Road to Sho Sho Nie Beach Road to the southeast of Horton Bay, on Lakeshore Drive and Cedar Street to the west of Advance, along Glenwood Beach Road to the northwest of Boyne City, and throughout much of the shoreline in the Boyne City area. In the South Arm, *Cladophora* growths were grouped in these locations: at the narrows on the north end along both shores, just south of the narrows on the east side along Sanderson Road, Holy Island, the east side between Gaunt and Bracey Roads, on the east side along Lalonde Road, on the west side between Metz and Lacroix Roads, on the west side from Lord Road south to the East Jordan city limit, and in East Jordan in the embayment just north of the M32 bridge. Of these grouped occurrences of *Cladophora,* the heaviest and therefore, most alarming growths occurred in the main basin to the west of Advance and in the Boyne City area and in the South Arm from Lord Road south to the East Jordan city limit.

Based on statistics from past surveys, there has been an increase in the occurrence of *Cladophora* along the Lake Charlevoix shoreline (Table 23). *Cladophora* was documented at 175 of 1625 parcels (~11%) in 1996 and 259 of 1619 parcels (16%) in 2000. Although the total number of parcels varied over time due to changes in technology (e.g., GPS and GIS), there was a noticeable increase (~6%) in the percentage of parcels with *Cladophora* over time. *Cladophora* densities for the 1996 and 2000 surveys were not recorded in the database and therefore, cannot be compared between time periods.

Table 23: Lake Charlevoix Shoreline Survey Summary

Lake Charlevoix Shoreline Survey Summary			
	1996	2000	2007
Shoreline Property Parcels	1,625	1,619	1,694
Developed Properties	1,245	1,338	1,442
Cladophora Growths	175	259	288

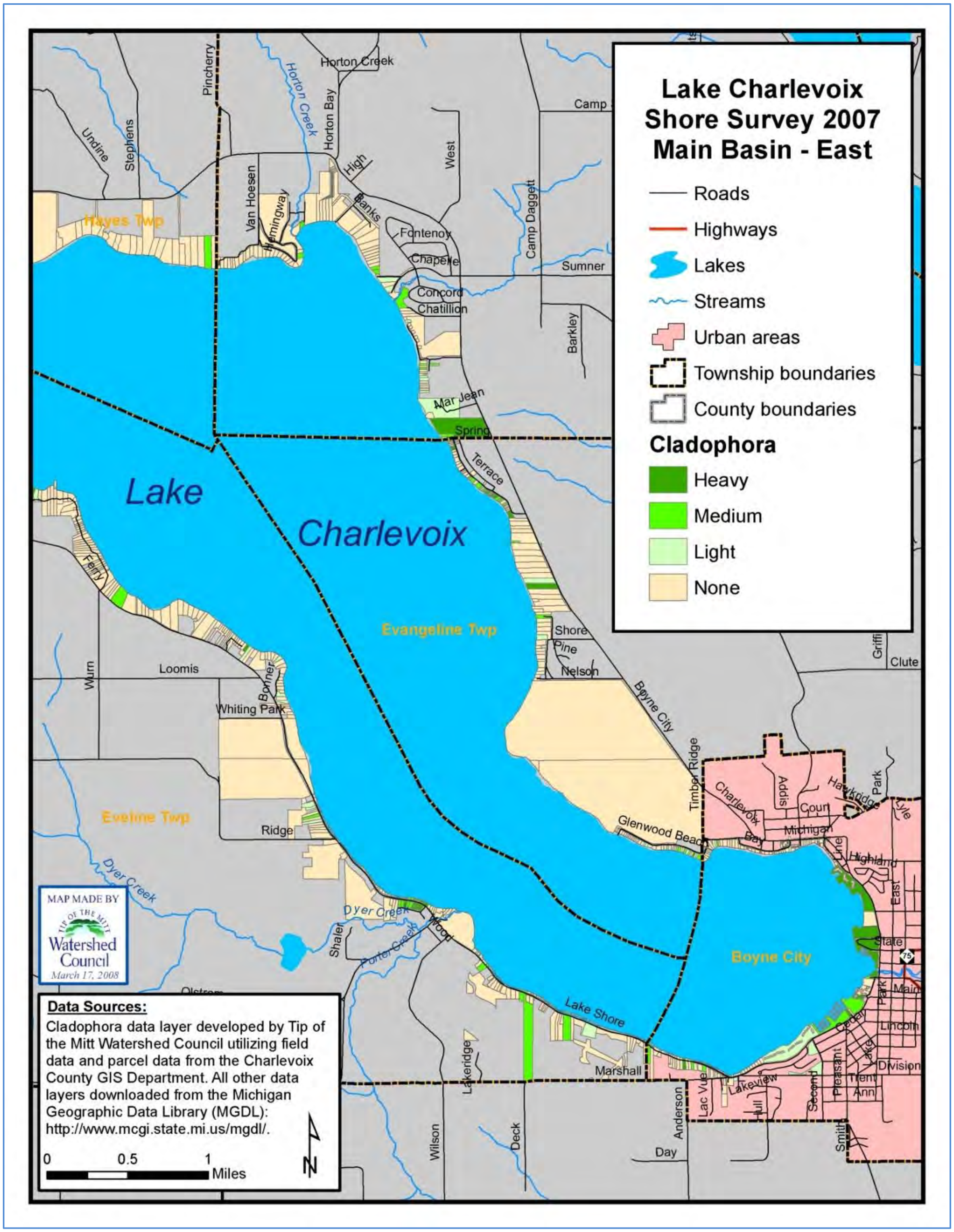


Figure 25: Lake Charlevoix shore survey 2007- *Cladophora* (Main Basin-East)

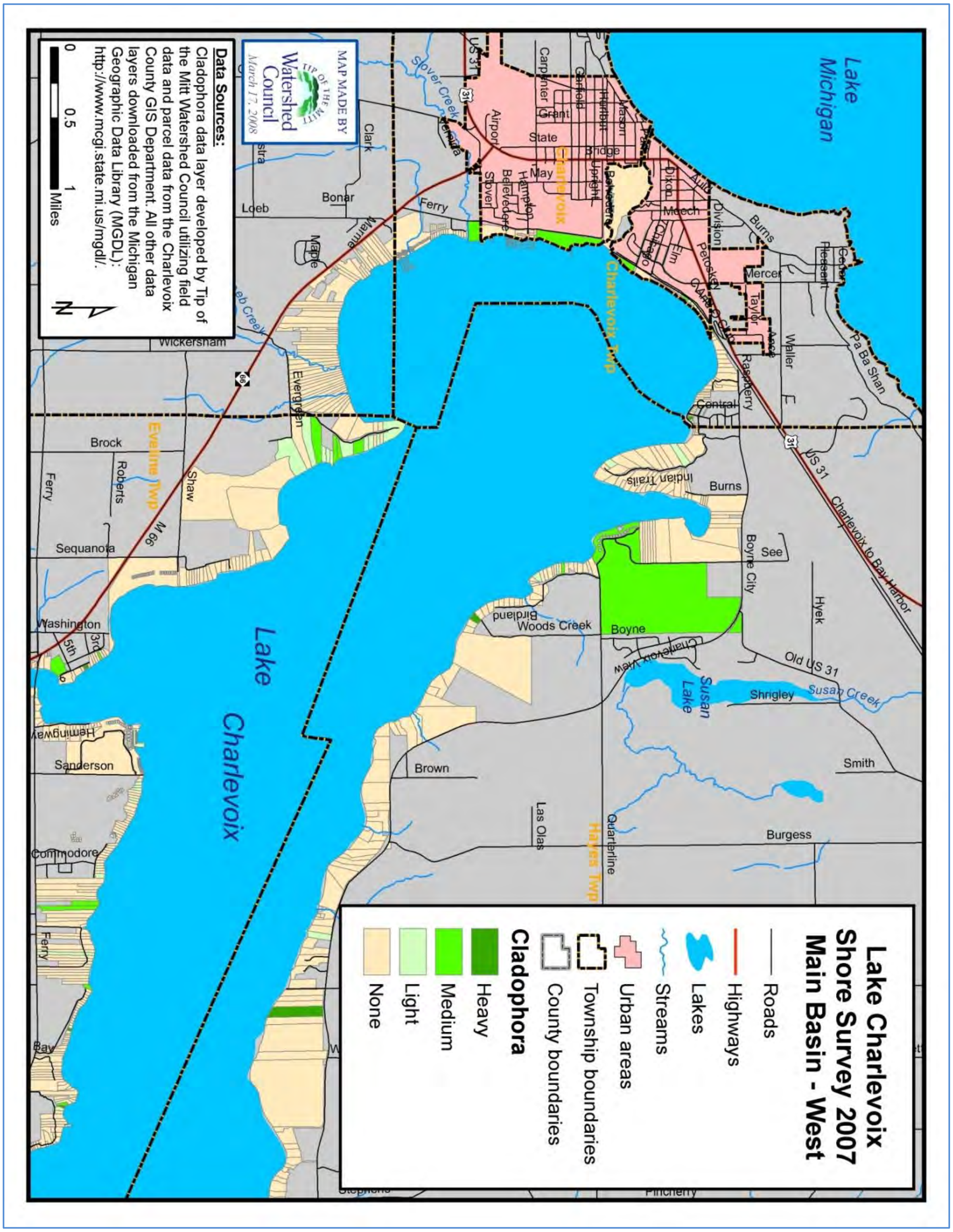


Figure 26**: Lake Charlevoix shore survey 2007-** *Cladophora* **(Main Basin-West)**

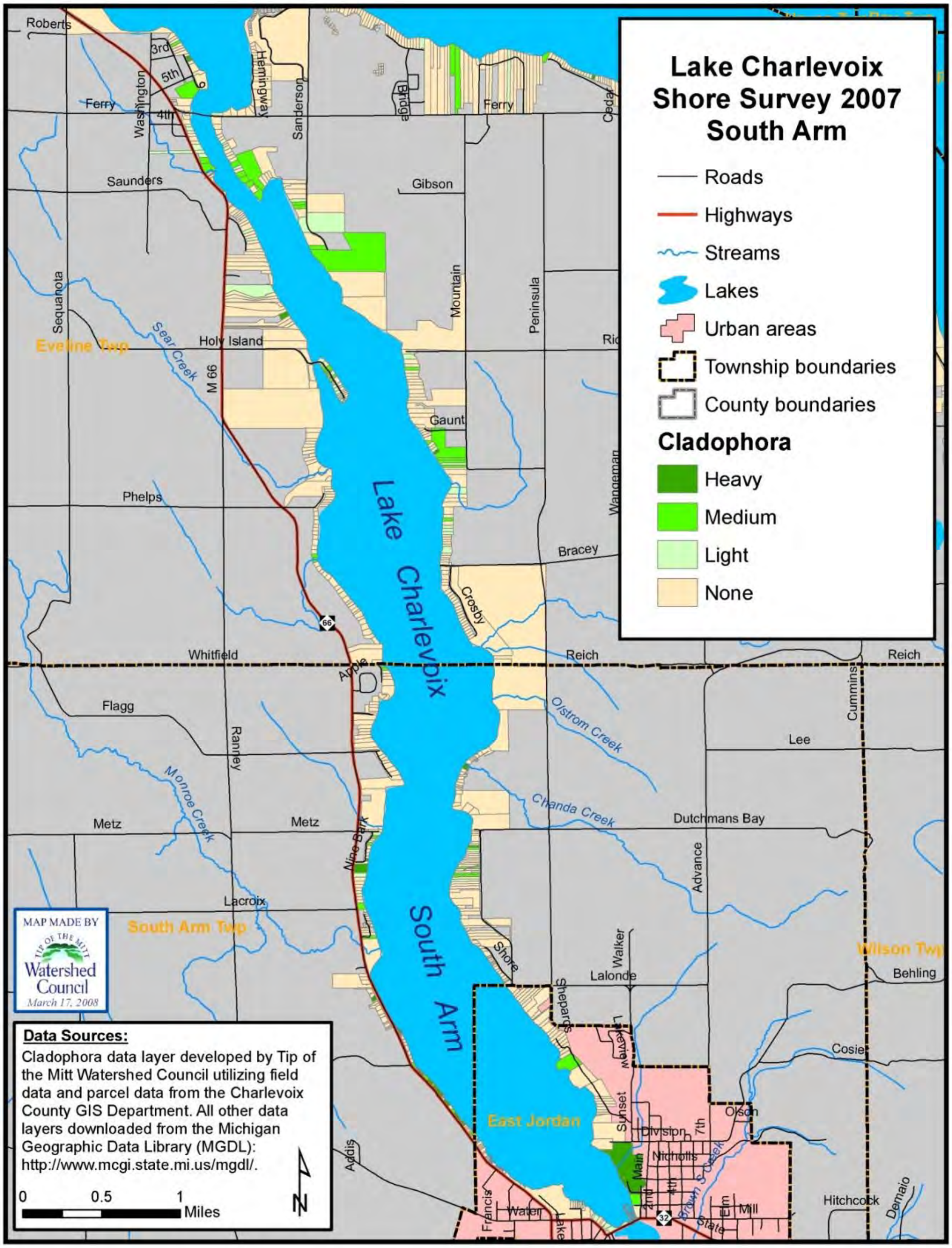


Figure 27: Lake Charlevoix shore survey 2007- Cladophora (South Arm)

Greenbelts and bottomland vegetation observed and rated during the Lake Charlevoix shoreline survey were found to be in good shape, though there is room for improvement (Table 24). Nearly 50% of all shoreline parcels had greenbelts along over 75% of their shorelines. Of the 1,254 parcels with exposed bottomlands, over 50% maintained vegetation over 75% of the shoreline length. Greenbelt depths were, on average, greater than 10 feet on over 60% of the shoreline parcels. The percent of parcels with an average depth of greater than 10 feet was less for bottomland vegetation, but still approaching 50%. Over 20% of parcels had no greenbelts and approximately 25% of parcels with exposed bottomlands had removed the vegetation. Figures 28, 29, and 30 show the results of the greenbelt rating.

Table 24: Greenbelt Statistics for Lake Charlevoix Shoreline Properties

Greenbelt Statistics for Lake Charlevoix Shoreline Properties								
Rating**	GB* Length Count	GB* Length Percent	GB* Depth Count	GB* Depth Percent	BV* Length Count	BV* Length Percent	BV* Depth Count	BV* Depth Percent
0	388	22.90	388	22.90	326	26.00	324	25.84
1	172	10.15	273	16.12	68	5.42	331	26.40
2	197	11.63	387	22.85	109	8.69	289	23.05
3	185	10.92	646	38.13	119	9.49	310	24.72
4	752	44.39			632	50.40		
NA					440	-------	440	-------

*GB = greenbelt, BV = bottomland vegetation.
**Rating descriptions: Greenbelt Length: 0=none, 1 = less than 10% of shoreline, 2 = 10 to 25%, 3 = 25 to 75% and 4 = over 75%. Greenbelt Depth: 1= less than 10 feet, 2 = 10 to 40 feet, 3 = greater than 40 feet. NA = not applicable due to lack of bottomlands.

Some form of shoreline alteration was noted at 1,101 (65%) of properties surveyed (Table 25), with most altered properties including only one type of alteration.

Table 25: Shoreline Alteration Statistics for Lake Charlevoix Shoreline Properties

Shoreline Alteration Statistics for Lake Charlevoix Shoreline Properties	
Alteration Type	Percent
Seawall (steel, concrete, and wood)	13
Riprap (big boulder)	12
Riprap (medium to small)	37
Beach sand (fill or eroded)	6
Other types	9
None	23
Total	100

Sand was the most common nearshore substrate type on the Lake Charlevoix shoreline, followed by rock and gravel, respectively (Table 26). The least common substrate types were wood and “other”, which primarily consisted of clay. A total of 358 parcels (21%) did not have substrates suitable for *Cladophora* growth as they consisted of only sand and/or muck. This 21% of parcels without hard substrate require other field methods for detecting nutrient pollution.

Table 26: Substrate Types for Lake Charlevoix Shoreline Properties

Substrate Types for Lake Charlevoix Shoreline Properties		
Substrate type	Number of parcels	Percent
Sand	1391	82
Gravel	925	55
Rock	1047	62
Boulder	241	14
Muck	337	20
Wood	37	2
Other	8	0.5

A total of 41 tributary streams were noted during the survey or identified using maps and aerial photographs. The largest include the Boyne and Jordan Rivers as inlet tributaries and the Pine River as the only outlet. Other sizable streams include Sear, Monroe, Chanda and Ostrum Creeks in the South Arm and Stover, Loeb, Porter, and Horton Creeks in the main basin. According to maps, there were a few more inlet tributaries, but these were not observed during the survey or visible on aerial photographs.

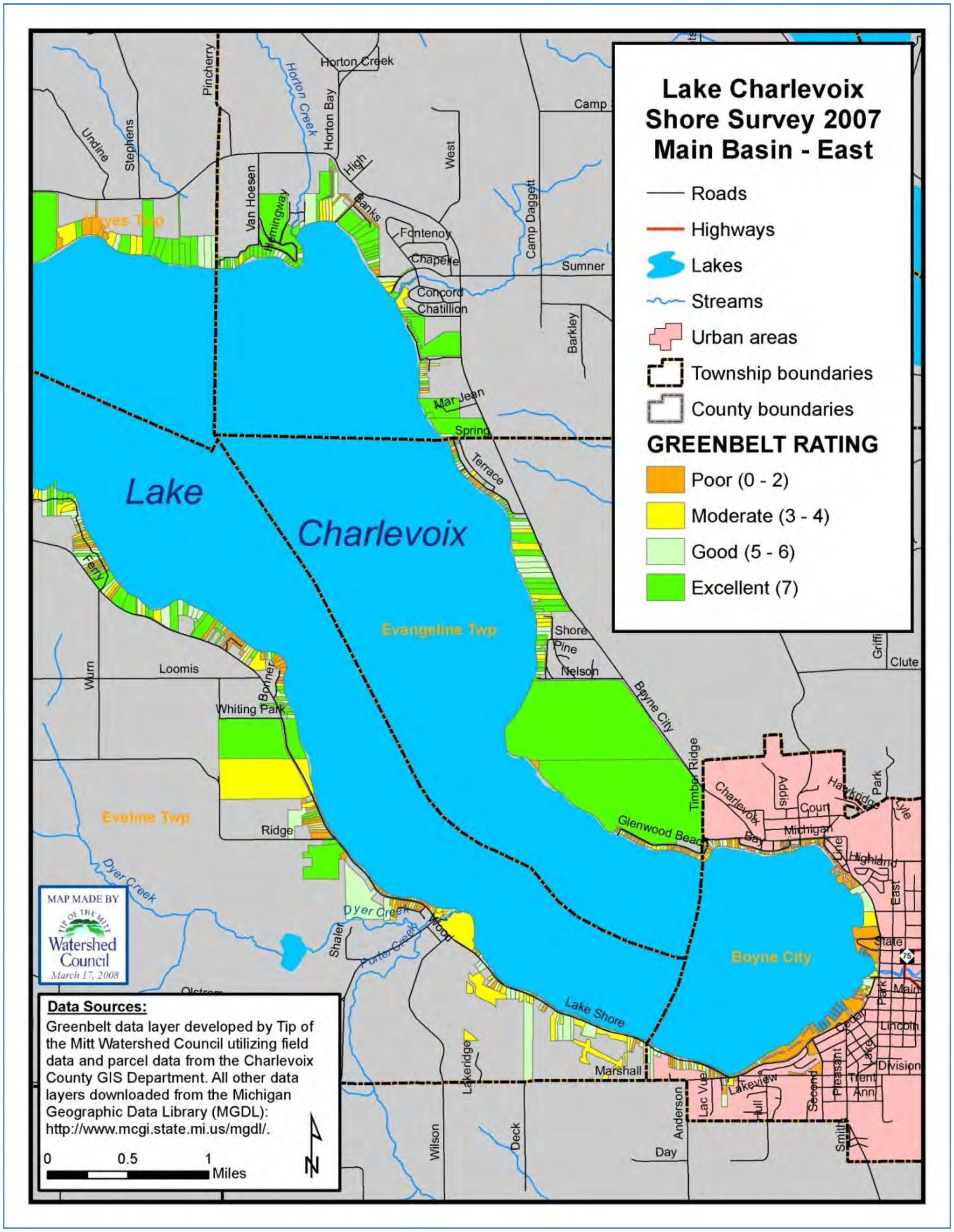


Figure 28: Lake Charlevoix shore survey 2007- greenbelts (Main Basin-East)

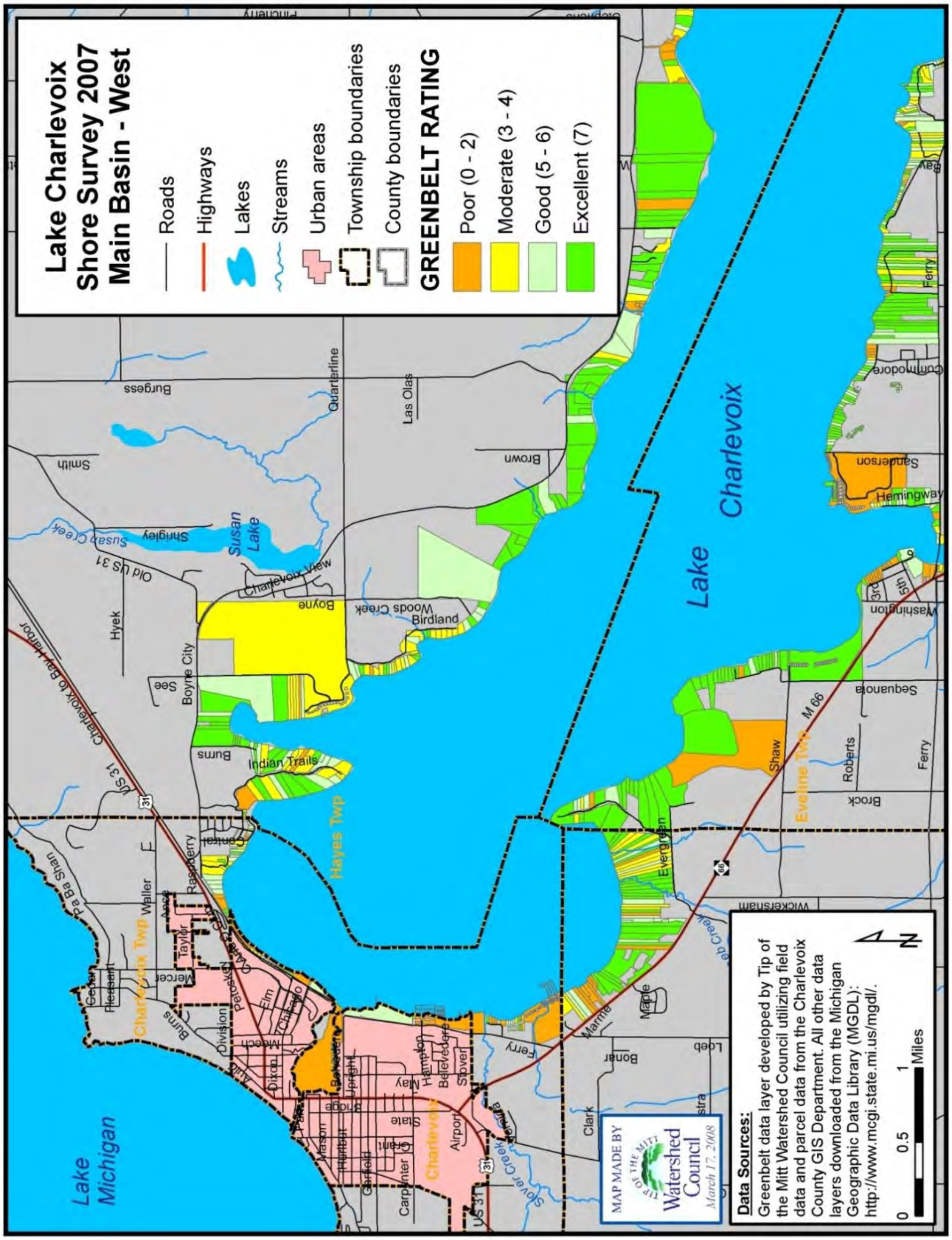


Figure 29: Lake Charlevoix shore survey 2007- greenbelts (Main Basin-West)

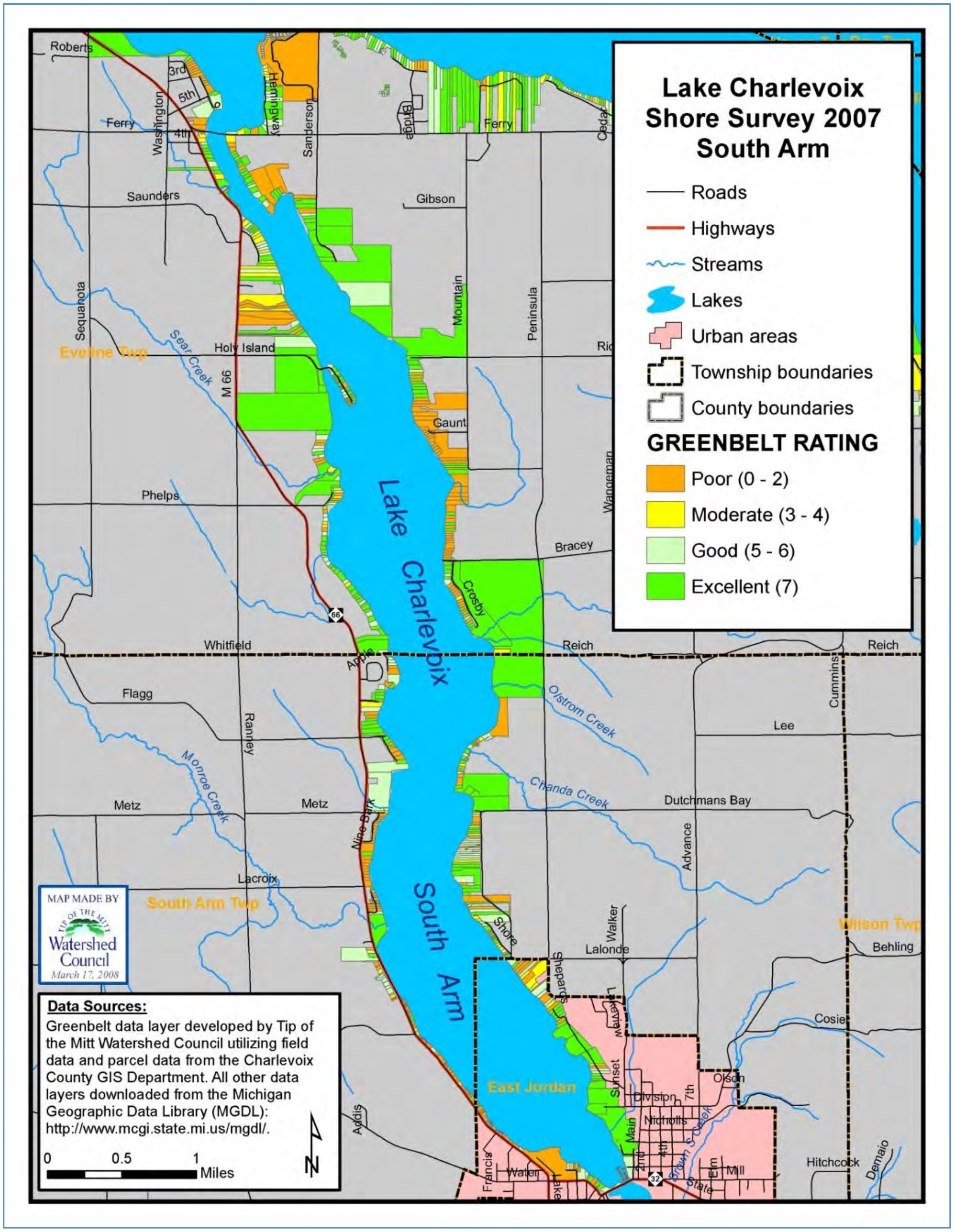


Figure 30: Lake Charlevoix shore survey 2007- greenbelts (South Arm)

LAKESHORE EROSION INVENTORY

Lakeshores and streambanks are areas of dynamic energy. The powerful forces of waves, currents, and ice move soil particles toward, away from, and along the shoreline.

Streams are continually down cutting into their valley, carrying sediments downstream particle by particle. The current moves from side to side, undercutting banks and causing the stream channel to meander. The ice of frozen lakes can expand shoreward with a force of many tons per square foot, moving most obstacles in its path (including shoreline soil). Masses of ice put in motion by winds or currents can scour the banks of lakes and streams. In a lake, the strength of erosive forces depends on its size, the size and direction of waves and currents, ice characteristics, water depth near shore, and the shape and composition of the shoreline.

Erosion and the transport and deposition of sediments are natural processes along shorelines. Typically, natural erosional processes proceed very slowly, and the plants and animals that live along the shoreline can adjust to these slow changes, maintaining a stable, healthy, productive ecosystem. When some catastrophic natural or human disturbance causes this equilibrium to be upset, accelerated erosion can result. Examples of natural disturbances include large trees uprooted by a windstorm, or a flood resulting from a torrential rainstorm. Human disturbances include vegetation removal, dredging or filing, or construction on or near the shoreline.

Erosion and its resulting sediment pollution, also known as sedimentation, have many negative impacts. In an aquatic environment sediment pollution can degrade aquatic and nearshore habitats, thereby killing aquatic organisms and negatively impacting birds and animals which depend on aquatic habitats. Sedimentation also causes warming (which is most serious in cold water trout streams), reduces water clarity and light penetration, and changes the bottom substrates.

Surveys were conducted on lakeshore and streambanks to assess sediment pollution from erosion. In 2000, the Lake Charlevoix Association surveyed the Lake Charlevoix shoreline for erosion. Many parcels appeared to have had some actions in the past to control shoreline erosion. Approximately 20% of parcels surveyed had some erosion-related concerns, typically either steep eroding banks, ineffective past erosion control strategies, or creation of artificial beaches. Eight severe sites were identified in Eveline Township, Sections 16, 17, 19, 21, 28, 29, 32, and 33. Nine moderate sites were identified in Eveline, Evangeline, and South Arm townships. Many other minor sites were also documented.

In 2007, as part of the Lake Charlevoix Shoreline Survey, accelerated erosion was noted at 156 of 1,694 parcels. The severity of erosion at these properties was not noted, but may be evident in photographs taken during the survey. Figure 31 notes the parcels with documented erosion.

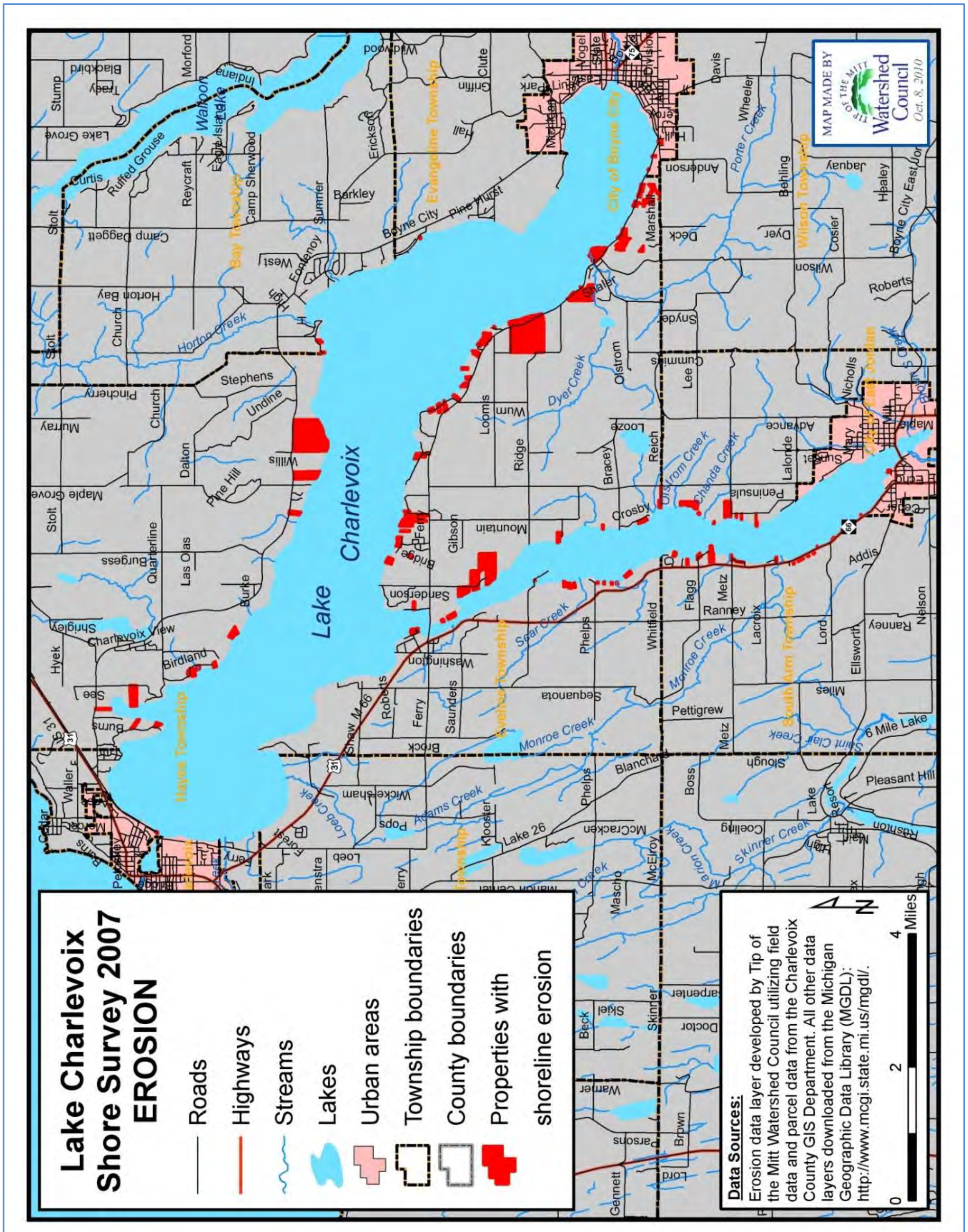


Figure 31: Lake Charlevoix shore survey 2007- erosion

STREAMBANK EROSION INVENTORY

Numerous streambank erosion inventories and restoration projects have been done on the Jordan River, including an inventory in 2010 that included representatives from the Antrim Conservation District, Friends of the Jordan River Watershed, MDNR, and TOMWC. The inventory was conducted between Graves Crossing and State Road to assess streambank erosion associated with recreation. These surveys documented 11 locations on the river with streambank erosion, including two classified as severe and three as moderate. Streambank erosion surveys have not been carried out in the upper Jordan River Watershed (upstream of Graves Crossing). Refer to Recreational Impact Assessment (page 101) for more information.

In 2011, researchers from the Department of Geological Sciences at Michigan State University performed a comprehensive bank erosion survey of the Jordan in the form of geo-tagged photos of all erosion features on the navigable portion of the Jordan River (from Graves Crossing to the mouth). Figure 32 shows locations of streambank erosion noted in the abovementioned inventories.

Conservation Resource Alliance (CRA) and the Friends of the Boyne River (FOBR) conducted a streambank erosion inventory on the Boyne River. Data was collected on each streambank erosion site regarding its size, cause, and severity. Four priority sites were identified on the Boyne River and were corrected by CRA in 2001. Estimates of pollutant load reductions (Table 27) to the Boyne River with the correction of these sites were estimated using the Channel Erosion Equation (MDEQ, 1999) (Appendix A).

Table 27: Boyne River Streambank Pollutant Load Reductions

	Severe	Moderate
Cumulative length of bank	100 feet	255 feet
Sediment reduction	3.6 tons/year	1.15 tons/year
Reduction in phosphorus	30.6 lbs/year	9.78 lbs/year
Reduction in nitrogen	6.12 lbs/year	1.96 lbs/year

In 2007, an additional streambank stabilization project was coordinated by FOBR, with technical assistance from Tip of the Mitt Watershed Council, Conservation Resource Alliance, and others. Approximately 420 feet of streambank was stabilized at the Old City Park in downtown Boyne City utilizing rock and native vegetation. Stairways were also installed as put-in or take-out points for canoeists and to prevent further erosion due to recreational access.

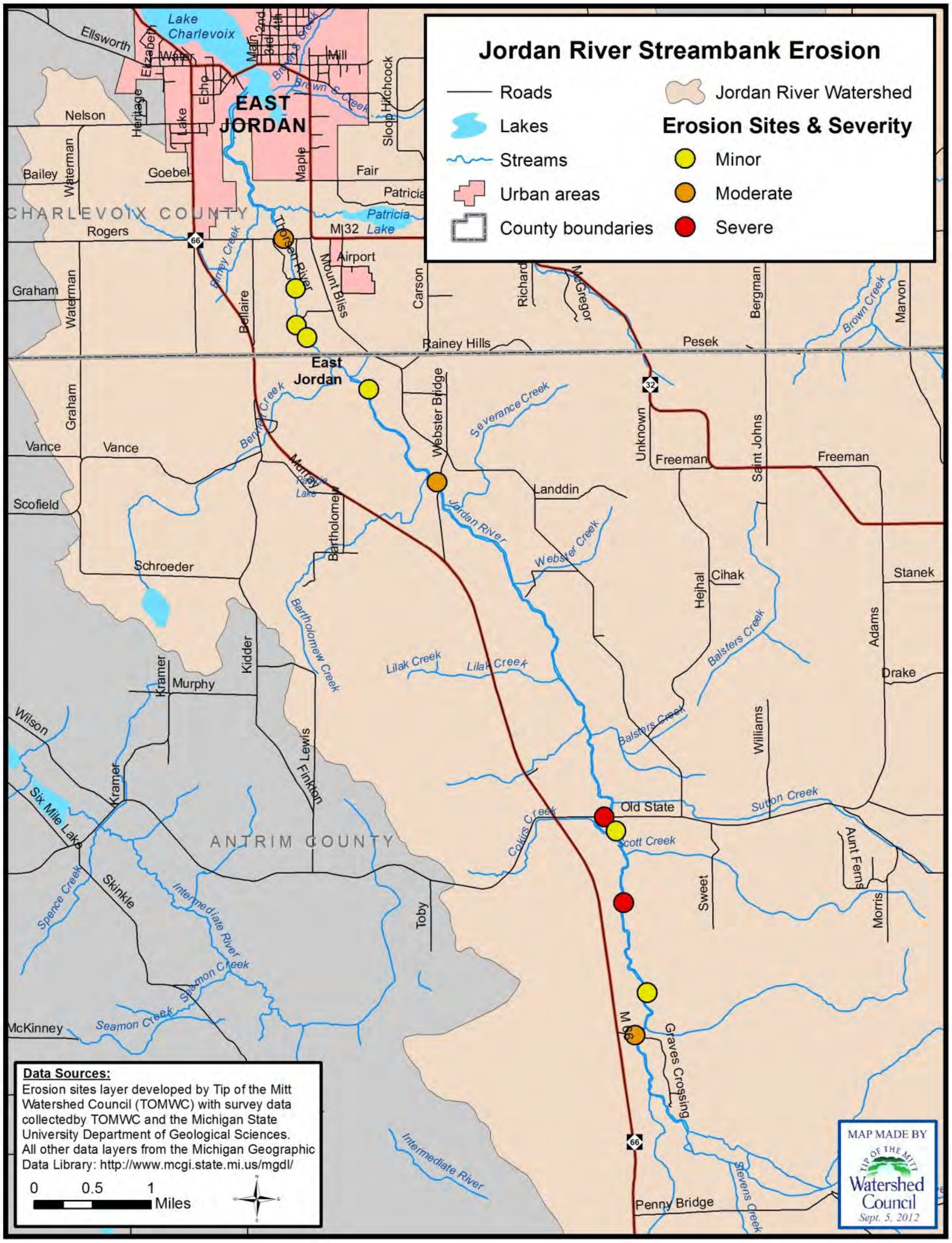


Figure 32: Jordan River streambank erosion

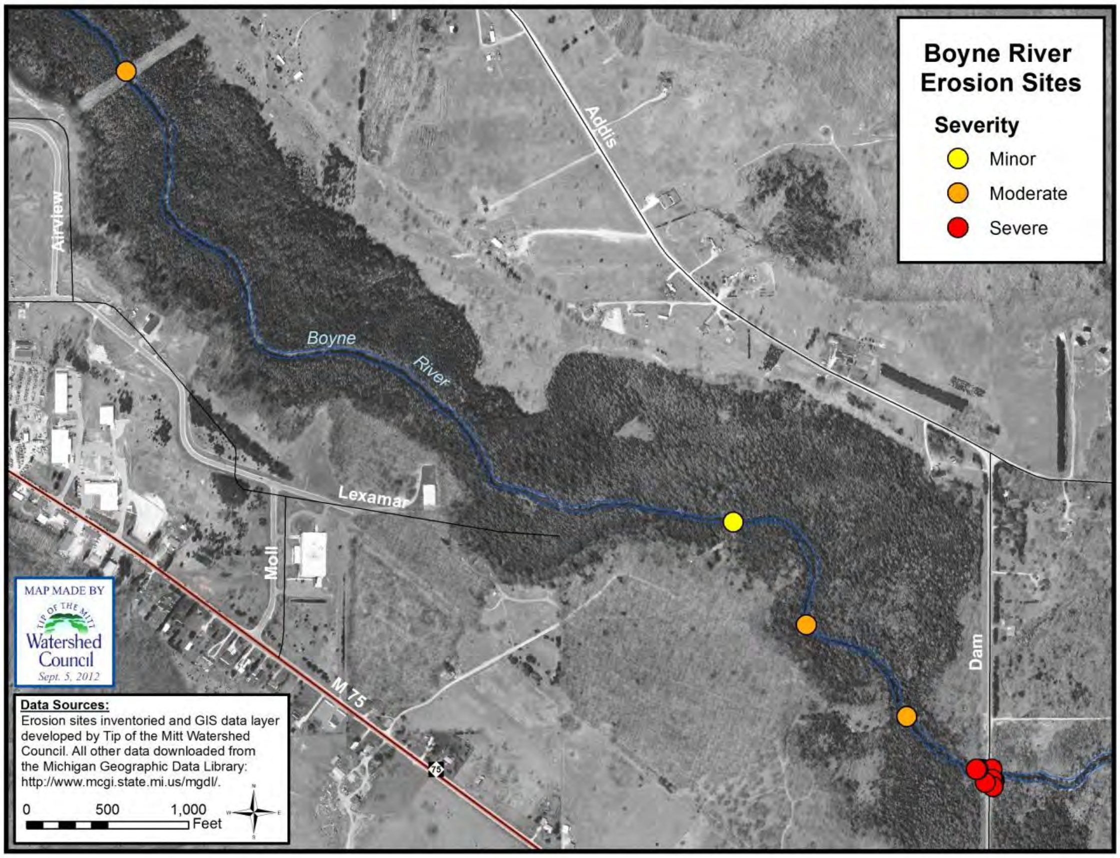


Figure 33: Boyne River Erosion Sites (TOMWC)

In addition, TOMWC conducted an informal erosion survey in July, 2012, and noted 5 sites including severe erosion around Dam Road due to recreational access to the river; three moderate sites also due to recreationalists; and a minor erosion sites associated with a hardened structure (seawall) along the streambank (Figure 33).

ROAD/STREAM CROSSING INVENTORY

The Lake Charlevoix Watershed Road/Stream Crossings Inventory (August 2001) was coordinated by the Conservation Resource Alliance (CRA) under an MDEQ 319 grant led by Tip of the Mitt Watershed Council and the Charlevoix Conservation District. Additional grant support for inventory work in the Boyne and Jordan Subwatersheds was provided by the Frey Foundation through CRA's River Care program. The Charlevoix Conservation District entered all of the data into an Access database and compiled the final report. The Inventory, presented in two volumes, is organized by subwatershed

(Jordan River, Boyne River, Horton Creek, and remaining Lake Charlevoix sites). Volume 1 contains maps showing key information for each crossing. Volume 2 contains the field data forms with site sketches, site severity scoring worksheets, and the cost estimating worksheets used to record all inventory information.

The purpose of the inventory was to comprehensively identify and document all of the road/stream crossing sites on the tributaries in the Lake Charlevoix Watershed. Potential road/stream crossings were identified using a variety of map sources and field exploration. Each crossing that appeared to have regular flow connected to Lake Charlevoix was inventoried. With the exception of private drives, all vehicle access roads were included. All potential sites were investigated. In some instances, no crossing was present, or there appeared to be no significant flow (and therefore no significant pollutant contribution) during any time of the year. These locations were not identified as numbered crossings and do not appear in the inventory.

Each site was visited to assess potential impacts and problems. Data collected at the crossings included detailed information about the location, road characteristics (width, shoulder, drainage, surface); culvert condition; and erosion and runoff problems. Basic stream characteristics such as width, depth, current, and substrate were also recorded. Field data was collected by both resource professionals and trained volunteers.

In order to help prioritize road/stream crossings for improvement, a severity ranking index was used. The severity ranking system used is identical to that used on a number of previous road/stream inventories completed by CRA and other agencies throughout Michigan. Three classifications are used in the severity ranking, severe (30 points or more); moderate (15-29 points); and minor (under 15 points).

A total of 212 sites (Table 28) were inventoried. Nineteen classified as severe (Figure 34), 140 as moderate, and 53 as minor (Table 29). As of 2010, CRA has coordinated 10 road/stream crossing projects (Table 30). This includes 2 severe and 3 moderate sites in the Antrim County, and 2 severe and 3 moderate in Charlevoix County. In many cases, the existing, undersized culverts were replaced with properly sized culverts. In addition to the road stream crossing projects, CRA has removed the Green River Dam in Antrim County, as well as defunct lamprey and salmon weirs on the Jordan River.

Table 28: Road/Stream Crossings by Subwatershed (Conservation Resource Alliance)

# of sites	Township	Jordan River Subwatershed (incl. Deer Creek)	Boyne River Subw'shed	Horton Creek Subw'shed	Lake Charlevoix remaining tribs and lake sites
2	Bay			BA-1	BA-2
29	Boyne Valley		BV-1 through BV-29		
11	Charlevoix				CX-1 through CX-11
16	Chestonia	CH-1 through CH-16			
11	Echo	EC-1 through EC-11			
9	Evangeline		EG-1 through EG-4		EG-5 through EG-9
8	Eveline				EV-1 through EV-8
3	Hayes			HA-1, HA-2	HA-3
9	Hudson		HU-1 through HU-9		
23	Jordan	JO-1 through JO-23			
11	Marion				MA-1 through MA-11
37	South Arm	SA-1 through SA-16, SA-37			SA-17 through SA-36
14	Warner	WA-1 through WA-9	WA-10, WA-11, WA-12		
30	Wilson	WI-1 through WI-8, WI-15 through WI-30			WI-9 through WI-14

Table 29: Ranking of Road/Stream Crossings

Ranking of Road/Stream Crossings			
Subwatershed	**Severe**	**Moderate**	**Minor**
Boyne River	10	22	15
Horton Creek	0	2	1
Jordan River	6	73	19
Lake Charlevoix (shoreline area, smaller tributaries)	3	43	18

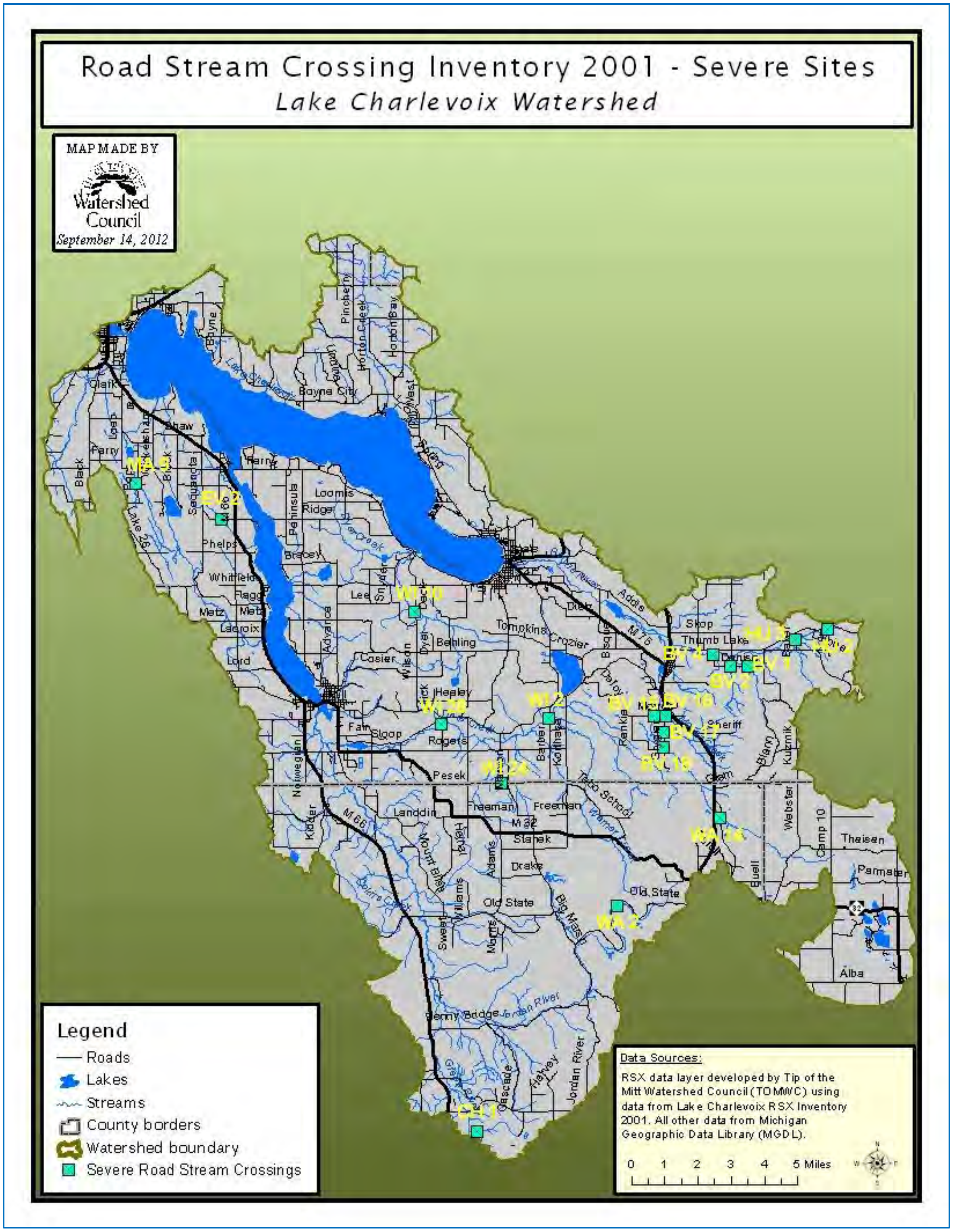


Figure 34: Severe Road Stream Crossing

Table 30: Corrected Road/Stream Crossing Sites (Conservation Resource Alliance)

Site #	Severity	Location or Project Limits	Road Type	Township, Section	Problems	Current Structure	Type of Work (BMPs)	Year
Antrim County Sites								
WA-2	severe	Jordan River and Jordan River Rd.	Seasonal	Warner, Section 20	Streambank erosion beside crossing, pool formation at culvert outlet, culvert perched.	Single 36" culvert, 50'L	Replace with low profile, open bottom 16'Wx5.75'Hx50'L corrugated steel standard arch. Riprap, mulch blankets, revegetation.	2004
WA-7	moderate	Warner Creek and Tebo School Rd.	Dirt road	Warner, Section 6	Embankment erosion, pool formation at culvert outlet.	4.75'Wx 3'Hx40'L culvert	Replace culvert with a 8.6'Wx4.9'Hx60'L arch. Bank stabilization, reveg, rock.	2003
JO-20	moderate	Severance Creek, Mt. Bliss Road	Paved	Jordan, Section 7	perched undersized culvert		Replace with bottomless 54" culvert	2006
		Green River Dam Removal		Chestonia Township Section 8			Dam removal, stream rock step pools installation, reveg	2007
CH-7	severe	Green River and Green River Road	Seasonal	Chestonia Section 20	undersized culverts, embankment eroding, perched culverts	triple culverts 36" dia or less	Timber bridge with concrete footings, rock riprap	2008
CH-10	moderate	Green River and Pinney Bridge Rd.	Dirt seasonal	Chestonia Township Section 8	Failing concrete structure	concrete, timber deck	Timber bridge with concrete footings, rock riprap	2003

Table 30 continued: Corrected Road/Stream Crossing Sites (Conservation Resource Alliance)

Site #	Severity	Location or Project Limits	Road Type	Township, Section	Problems	Current Structure	Type of Work (BMPs)	Year
Charlevoix County Sites								
HU-3	severe	North Branch Boyne River and Baker Rd.	Seasonal	Hudson, Section 7	Culvert too small and short, crossing is low point.	Twin 18' culverts	Replace with 42"x29" elliptical culvert, 30' long, crown road at crossing, rock riprap, slope stabilization.	2004
BV-17, BV-17A	severe	South Branch Boyne River tributaries and Metros/Griegar Rds.	Dirt roads	Boyne Valley, Section 27	Pool formation at outlet, embankment along road eroding into creek.	Single culvert 24"?	Replace with 35"span 24"rise elliptical culvert, 78' long and skewed to fit shape of stream, rock riprap at crossing and along rd., slope stabilization.	2004
C-14	moderate	S. Branch Spring Brook trib.	Howard - dirt road		Culvert is 24" dia, too small & short. Literally "tucked under" road. Embankment erosion.		longer 36" culvert	2004
C-35	moderate	S. Branch Spring Brook trib.	2008-2010		Twin 12" culverts are perched and too small & short. Embankment erosion. Inlet real bad too.		longer 36" culvert	2004
	moderate	Jordan salmon weir and lamprey barrier on Jordan River					removal of defunct lamprey and salmon weirs on the Jordan river	

Sediment pollutant loads were calculated for each category of sites (Table 31). Sediment reduction refers to the annual amount of sediment that would be saved if these sites were repaired. Estimates were calculated using the Channel Erosion Equation (MDEQ, 1999). More information on this method can be found in Appendix A.

Table 31: Potential pollutant Load Reductions from Corrected Road/Stream Crossings

Pollutant	Boyne River	Jordan River
Sediment Reduction	215 tons/year	169 tons/year
Reduction in phosphorus	183 lbs/year	144 lbs/year
Reduction in nitrogen	365 lbs/year	288 lbs/year

In 2011 with funding from the Charlevoix County Community Foundation, CRA started updating the existing Lake Charlevoix road crossing inventory utilizing inventory forms and a database developed by CRA, Huron Pines, US Forest Service and the Land Information Access Association. The revised form and database has been approved by the Lake Michigan Technical Committee lead by US Fish and Wildlife Service. The database now automatically calculates the fish passage determination score and sediment loading amounts for each crossing, and is linked to Google maps and site photos on the website: http://www.northernmichiganstreams.org/lakecharlevoix.asp. CRA and partners will pursue additional grant dollars in 2012-2014 to update the Jordan and Boyne subwatersheds road crossing sites.

River restoration needs for the Boyne and Jordan Rivers, as well as information on completed road/stream crossing projects will be compiled. The overall intent is to have a centralized location for current information pertaining to road/stream crossings, streambanks and other river restoration sites in watersheds throughout Northern Michigan.

AGRICULTURAL INVENTORY

Agricultural activities in Charlevoix and Antrim Counties are predominantly small farms and are quite diverse. The top four crops grown in the area, according to the U. S. Department of Agriculture's 2007 Census of Agriculture, are forage crops (hay), corn, oats, and apples. Agricultural land use has been declining in both counties due to a number of social and economic factors. Family farms are not being continued by the younger generation and many farms are being sold for development as the demand for scenic lands for home sites increases.

Agricultural land comprises approximately 16% of the watershed by area. Of the 16%, the majority is cropland (nearly 30,000 acres or 14% of the overall area) and hay/pasture land comprises approximately 2% (approximately 5,015 acres) of the overall area (Figure 32). To demonstrate the degree of pollutant loading in the Watershed, the Step-L model was used to calculate pollutant loadings from the various land uses within the Watershed. Table 32 compares the land use types by area, and their respective contributions to nutrient and sediment loading. Cropland is by far the primary source of sediment pollution, whereas forested lands, which include several undeveloped land use categories such as grassland, contributes the most to nutrient loading. This unexpected result is likely due to the fact that the forest land use category comprises the overwhelming majority of the land uses within the Watershed.

Table 32: Pollutant Loading by Land Use Type

Sources	Acres	Percent of Watershed	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	9542	5%	30100	4600	112600	700
Cropland	29792	14%	53250	11800	110600	4600
Pastureland	5015	2%	7400	700	23400	200
Forest	122400	58%	6600	3200	16100	300
Wetland	26895	13%	26250	3500	123500	1000
Total	193644	92% (remain. 8% water)	123600	23800	386200	6800

In 2004, the Charlevoix Conservation District conducted an inventory of the agricultural activities within the Lake Charlevoix Watershed. For purposes of the Lake Charlevoix Watershed Management Plan, the locations of agricultural producers associated with nonpoint source pollution were documented. A data sheet was completed for each site that described location and type of farm, distance to nearest tributary, and any obvious nonpoint source pollution problems. Aerial photos, plat maps, topographic maps, along with field checking were used to identify area farms. A ranking of nonpoint source pollution problems of severe, moderate, and minor was given to each site. A total of 41 farms were inventoried (3 severe, 15 moderate, and 23 minor). The most common problems identified at the farm sites were livestock in streams and lack of animal waste storage areas. The herd sizes at the farms were very low. Many of the farms were identified as "hobby" farms.

The three severe sites are all in Charlevoix County. BMP recommendations were made to the producers, including the following: Streambank restoration (erosion from livestock), livestock exclusion fencing and cattle crossing, watering sources, animal waste management, and pasture/grazing management, exclusion fencing, alternate water source, and buffer strips. Animal waste facility and pasture management including filter strips to reduce runoff. At this time, none of the severe sites have been corrected. Lack of funding is the biggest obstacle.

Since the inventory, three agricultural BMPs were installed; two projects were completed in Antrim County and one in Charlevoix County. The BMPs include alternative watering systems, concrete compost pad, critical area treatment, and rotational grazing.

Future agricultural efforts toward protecting water quality are best managed through the Michigan Agriculture Environmental Assurance Program (MAEAP). The local conservation districts use this voluntary, proactive program to help identify BMPs that will serve the producers while protecting natural resources.

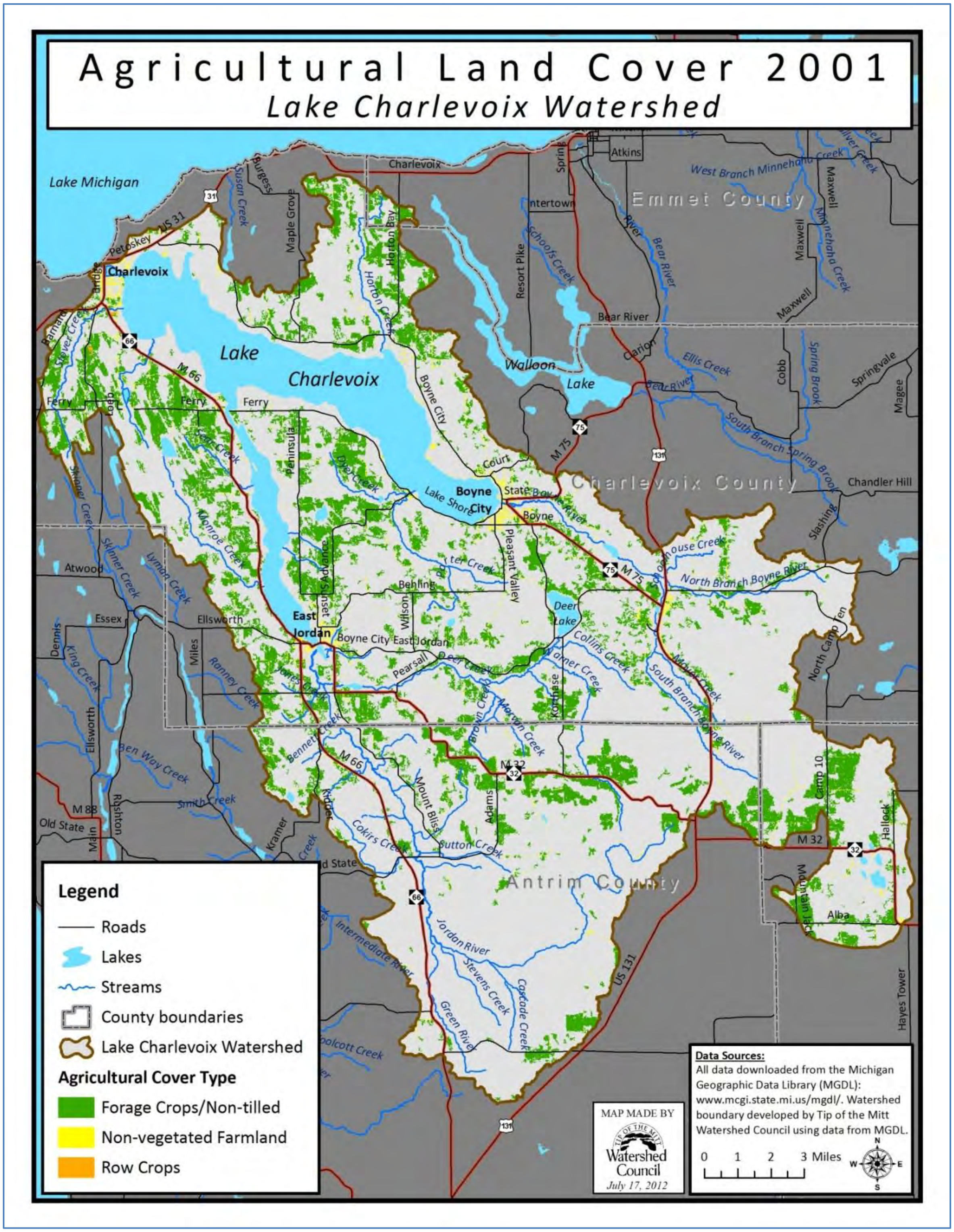


Figure 35: Agricultural Cover Type in Lake Charlevoix Watershed

RECREATIONAL IMPACT ASSESSMENT

Recreational impacts were assessed on both the Jordan River and Lake Charlevoix. The Jordan River is well-known throughout Michigan as an excellent trout stream and a great canoeing river. The Jordan River Pathway, which crosses the Jordan and follows its banks in many locations, is a popular hiking spot. The expansive waters of Lake Charlevoix are popular for all types of boating by both shoreline residents as well as by transient visitors utilizing the many public access sites. These activities are important for fostering an appreciation of natural resources and supporting the local economy that depends on nature-based tourism. However, recreational activities can be a source of nonpoint source pollution. Inventories to assess the impacts of canoeing and canoe access sites, fishing and angler access sites, hiking on the Jordan River Pathway (by Friends of the Jordan River Watershed); and boating on Lake Charlevoix (by the Lake Charlevoix Association) were conducted.

CANOEING

The majority of canoes (or other vessels like kayaks or tubes) using the Jordan River are rentals from two local liveries. Numbers of annual rentals were unavailable, but hundreds of canoes float the river on some days. The local Sheriff's Department is responsible for keeping track of how many registered canoes are allowed to be launched by each livery. Recreational impacts to the River are an ongoing challenge for resource managers.

The primary launch site is Graves Crossing. Canoe navigation upstream of this point is difficult. A terraced, gravel launching platform was constructed at this location in 2000, and has functioned well to protect the streambank. Other popular put-in/take-out spots include the Old State Road crossing, a Michigan Department of Natural Resources (MDNR) public access site just downstream from Webster's Bridge, an MDNR access site at the lamprey weir, and an MDNR access site at Rogers Bridge. All of these sites have some problems related to canoe access (or other types of recreational activity). At Old State Road, a large double culvert unofficially known as "the tubes" creates some standing waves. Canoeists will occasionally take-out just downstream of the tubes and then portage to above the road to float through them again. This is also a popular mid-way stopping point, and the streambanks on the east side of the river downstream of the road are heavily trampled (including on adjacent private property). There is also quite a bit of litter at the site.

Access structures of different types have been constructed at the Webster's Bridge, the lamprey weir, and Rogers Bridge sites. However, due to heavy use, some bank trampling and erosion are still occurring. In addition, surface runoff from the parking areas causes erosion and sedimentation of the river.

In addition to these "official" access sites, there are three sites between roads which are popular take-outs for picnicking, bathroom breaks, etc. Two of these are wetlands, and the heavy use is causing severe bank trampling, erosion of organic soils, and widening of the stream channel. A third is a utility pipeline crossing, where steep sandy banks are eroding. Of particular note is the stopping point known as "Frog Island" (Figure 33). Measures to manage impacts to the streambank have been largely unsuccessful due to the destructive nature of the users. Finding the balance between a more permanent solution, such as a constructed platform, and one that complies with the Natural River guidelines is a challenge. Future efforts to address the site, and others like it, will require collaboration from the MDNR, Friends of the Jordan River, Antrim Conservation District, and other stakeholders.

Figure 36: "Frog Island" on the Jordan River

FISHING

In addition to the sites described above, fishing access to the upper part of the river is mostly gained via a series of popular “pull-over” spots off of the system of unpaved roads throughout the Jordan River Valley. Eighteen access sites, including the Michigan Department of Natural Resources access sites were inventoried and assessed. Some of these sites are linked to short trails to access the river and had campfire circles with accumulations of trash and litter. Streambank erosion was associated with heavily used sites. Since most of the sites are not official access locations, maintenance is not being managed by any government or organization.

HIKING

The Jordan River Pathway crosses the Jordan River and travels through many wetland areas. After many years of use, the cumulative impact of thousands of hikers has led to resource degradation in sensitive areas of the Pathway. Some of these spots are in need of re-routing or some type of repair.

The section of the Pathway most impacting the water resources of the Jordan Valley is along a heavily used portion of the trail which traverses the area below Deadman’s Hill. There are several places there where the Pathway crosses spring-fed seeps or feeder streams in wet, mucky areas that are eroding or washing out.

Another location of the Pathway that is routed through wetlands is near the bank of the main stream near the Jordan River Fish Hatchery. There are a few places in that section that are eroding and feeling the impact of Pathway users. In addition, there are a few other minor repairs needed along the trail to reduce erosion and runoff to the Jordan River.

LAKE CHARLEVOIX BOAT COUNTS

The Lake Charlevoix Association tabulates the number of boats on Lake Charlevoix and Round Lake in August each year (Table 33). Boats on moorings, lifts, at slips, at anchor, on the beach, and dinghies on board larger craft were counted from aboard small boats early in the morning before there was traffic on the Lakes. Boats in marina slips were counted by walking the docks. Launching ramps were surveyed sequentially that same afternoon between 1PM and 4PM. At the ramps, boats seen launching, being retrieved, and empty trailers were all counted. The general principle was to count every boat that could be/is used on the lakes that day. Most of the boats there were power boats and personal water craft–very few sail or paddle boats were seen at public access sites.

Boating is known to cause water quality problems in several ways. Discharges from engines contain toxic hydrocarbons, nutrients, and other pollutants. Prop wash from powerful engines can disturb bottom sediments (especially in shallow areas with soft bottom sediments) causing turbidity and releasing nutrients and toxins. Large wakes can cause accelerated shoreline erosion, especially in the South Arm or protected coves or bays. Boat launching is a vector for exotic organisms. Access sites often have shoreline erosion, litter, and polluted surface runoff.

Table 33: Lake Charlevoix Boat Counts 1998-2011

Lake Charlevoix Boat Counts- 1998-2011														
Type of boat	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Oars/ paddle	1360	1428	1086	780	938	857	894	863	879	597	778	709	655	648
Sail, all sizes	648	760	656	663	597	660	611	603	605	566	706	664	693	692
Power, <26'	1962	1806	1875	1959	1865	2175	1921	1995	1945	2102	1916	1733	1851	1824
Power, 26" and up	662	662	681	584	619	587	579	636	588	529	568	558	554	454
PWC	801	802	725	736	748	724	732	715	684	659	668	583	592	554
Totals	5433	5458	5023	4722	4767	5003	4737	4812	4701	4453	4636	4247	4335	4170
Launch Ramps	154	143	179	120	208	139	227	189	271	259	203	148	207	

FORESTRY INVENTORY

Forestlands make up the majority of the Lake Charlevoix Watershed. Unlike other large watersheds in Northern Michigan (e.g., Black and Mullett Lakes) that contain a significant amount of state land, the forestlands in the Lake Charlevoix Watershed are predominantly privately owned. In 2002, the Charlevoix Conservation District conducted an assessment of private forestlands in the Watershed (Table 34). The assessment included site visits with property owners and road-side review.

District staff met with 19 property owners to discuss their forest management plans. These on-site assessments looked at more than 750 acres of private forestlands. A drive-by road survey was also conducted throughout the entire watershed. State forest management activities were not inventoried. No adverse impacts from past logging activities were identified in this phase of the assessment. However, the potential for impacts is significant; therefore, appropriate best management practices should be implemented to prevent future problems.

Table 34: Summary of Forestlands in Charlevoix County

Summary of Forestlands in Charlevoix County			
Township	Total Private Forestland	Acres Fractionalized 1967-2000	2000 Forestland Remaining
Bay	6,692	1,972	4,720
Boyne Valley	12,987	6,999	5,988
Chandler	4,216	826	3,390
Charlevoix	1,159	1,159	-0-
Evangeline	5,695	1,624	4,061
Eveline	6,170	2,914	3,256
Hayes	9,645	4,762	4,883
Hudson	17,250	3,433	13,817
Marion	5,212	2,104	3,108
Melrose	9,162	3,069	6,093
South Arm	9,886	3,496	6,390
Wilson	15,670	4,323	11,347
Total	103,744	36,681	67,053

CHAPTER FOUR: THREATS TO WATER QUALITY IN THE LAKE CHARLEVOIX WATERSHED

WATER QUALITY STANDARDS AND DESIGNATED USES

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 or 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 Lake Charlevoix Watershed, included in the Boardman-Charlevoix Watershed (HUC#04060105), will be monitored by the MDEQ in 2013.

The Water Resources Commission Act (P.A. 451 of 1994, Part 31, Chapter 1) requires all surface waters in the State of Michigan are designated for and shall be protected for all of the following uses:

1. Agriculture: Surface water must be of the quality that it can be used for livestock watering, irrigation and spraying crops.
2. Industrial water supply: Surface waters must be clean enough to be used for commercial or industrial applications or non-contact food processing.
3. Navigation: Applies to water bodies that were historically used to float commercially-harvested logs.
4. Warmwater fishery: Water bodies designated as warmwater fisheries should be able to sustain populations of fish species such as bass, pike, walleye and panfish.
5. Other indigenous aquatic life and wildlife: Surface waters must support fish, other aquatic life and wildlife that use the water for any stage of their life cycle.
6. Partial body contact recreation: Residents of the state should be able to use surface waters for activities that involve direct contact with the water but does not involve the immersion of the head. Such partial body contact activities include fishing, wading, hunting and dry boating.
7. Total body contact recreation (May 1-October 31): The waters of the state should allow for activities that involve complete submersion of the head such as swimming. Activities that have considerable risk of ingesting the water are also part of this designated use.
8. 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 Lake Charlevoix Watershed.

In addition to the abovementioned designated uses, the coldwater fishery designated use applies to certain portions of the watershed. 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”(refer to Appendix B) or “Designated Trout Lakes” for the State of Michigan.

- All inland lakes identified in the publication entitled "Coldwater Lakes of Michigan," as published in 1976 by the Michigan Department of Natural Resources, are designated and protected for coldwater fisheries. Listed lakes within the Lake Charlevoix Watershed include: Lake Charlevoix, Deer Lake, and Round Lake.
- 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. Listed lakes within the Lake Charlevoix Watershed include: Lake Charlevoix.

- 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.

Table 35: State of Michigan Water Quality Standards

(as required by sections 3103 and 3106 of 1994 PA 451, MCL 324.3103 and 324.3106)

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	Total body contact
	300 E.coli per 100 ml 30-day	Total body contact
	1,000 E.coli per 100 ml 30-day mean	Partial body contact
	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
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	Cold water fishery
	Minimum 5 mg/L daily average	Warm water 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 0 N D 45 45 50 60 70 75 80 85 80 70 60 50	Cold water fishery Other indigenous aquatic life and wildlife
	Monthly averages for warm water inland streams in this watershed: J F M A M J J A S 0 N D 38 38 41 56 70 80 83 81 74 64 49 39	Warm water fishery
	Monthly averages for cold water inland streams in this watershed: J F M A M J J A S 0 N D 38 38 43 54 65 68 68 68 63 56 48 40	Cold water fishery

If a body of water or stream reach is not meeting the water quality standards set for a specific designated use, then it is said to be in 'nonattainment.'

THE LAKE CHARLEVOIX WATERSHED: MEETING THE DESIGNATED USES OF THE STATE

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

<u>At this time, no water bodies in the Lake Charlevoix Watershed are included on the 303(d) list.</u>

According to the *Integrated Report* (Michigan Department of Natural Resources and Environment Water Bureau, April 2010):

> *"Lake Charlevoix has excellent water quality and currently meets all eight of the designated uses. Active designated uses include agriculture, navigation, industrial water supply, warm water fishery, other indigenous aquatic life and wildlife, and total body contact recreation. Although Lake Charlevoix's water quality is good enough for public water supply it is not being used for this purpose. Lake Charlevoix's major tributaries– Boyne and Jordan Rivers, and Deer Creek meet all eight of the designated uses. The remaining tributaries (Horton, Stover, Porter, Loeb Creeks) meet seven of the designated uses; they are not required to meet the navigation designated use because of their small size."*

Although the abovementioned waterbodies have been assessed and currently meet the designated uses, MDEQ Nonpoint Source (NPS) Program staff have identified the Lake Charlevoix Watershed as one of their priority watersheds "in which to focus pollution control activities to achieve the restoration and protection goals identified in the NPS Program Plan". The Integrated Report (page 35) states:

> *"Lake Charlevoix is a high quality oligotrophic lake and its largest tributary, the Jordan River, is a state designated Natural River. The watershed also includes the Boyne River.*

Lake Charlevoix is Michigan's fourth largest inland lake with the second longest shoreline and the fifth largest watershed. The primary lake pollutants of concern are nutrients. Nutrients and sediment are pollutants of concern in the tributaries. The Lake Charlevoix Watershed Advisory Committee is one of the most active in northern Michigan and has excellent participation by local governments. Area organizations have implemented numerous projects over the last several years as identified in the CMI approved WMP. Work is currently underway to update the WMP to meet Section 319 criteria."

Although the Lake Charlevoix Watershed is currently meeting all of the designated uses of the State, it remains vulnerable to nonpoint source pollution. Existing and future activities will invariably threaten some or all of the designated uses; therefore, it is critical to remain vigilant and to not allow these threats to be realized.

The designated uses may be considered most threatened by nonpoint source pollution include 1) other indigenous aquatic life and wildlife 2) cold water fishery 3) total body contact recreation and 4) navigation. Implementation of the Lake Charlevoix Watershed Management Plan recommendations will work to support *all* designated uses, but will have the greatest impact on the abovementioned uses.

The primary pollutants of concern, as recognized by the MDEQ and the Lake Charlevoix Watershed Management Plan Advisory Committee, are ranked according to their priority in Table 36. Table 37 identifies the priority ranking for each pollutant with respect to its impact on each of the four designated use identified as *most relevant* to watershed management implementation actions.

Table 36: Lake Charlevoix Watershed Priority Pollutants

Lake Charlevoix Watershed Priority Pollutants	
Pollutants	Priority Ranking
Nutrients	1
Sediment	1
Oils, grease, and heavy metals	2
Pesticides	3
Pathogens	4

Table 37: Pollutant Priorities for Designated Uses

Pollutant Priorities for Each Designated Use		
Designated Uses	Pollutant	Priority Ranking
Other indigenous aquatic life and wildlife	Sediment Nutrients Oils, grease, heavy metals, and pesticides	1 2 3
Cold water fishery	Sediment (streams) Nutrients (lake) Oils Pesticides	1 1 2 3
Total body contact recreation	Nutrients Bacteria Sediment	1 2 3
Navigation	Sediment	1

Nonpoint source pollutants pose different threats to different designated uses. A brief description of the potential impacts to the four designated uses follows:

OTHER INDIGENOUS AQUATIC LIFE AND WILDLIFE

Other indigenous aquatic life and wildlife is threatened throughout the Watershed by sediment, nutrients, and toxic chemicals, such as oils, grease, heavy metals, and pesticides. Sediment impacts aquatic habitat by covering spawning areas, which clogs gills and makes feeding difficult. Sediments can also increase water temperatures (thermal pollution) and, as a result, impact metabolic rates of organisms. Nutrients harm wildlife by encouraging excessive aquatic plant growth that can deplete oxygen supplies when it decomposes. Toxic chemicals harm aquatic life by weakening immune systems and making organisms more susceptible to disease. They can also harm reproduction and if concentrations of the toxic materials are high enough they can kill aquatic life.

COLD WATER FISHERY

Lake Charlevoix is fortunate to be able to support both a warm and cold water fishery. The majority of the rivers and streams in the Watershed also support a cold water fishery. However, the cold water fishery is threatened by sediment, nutrients, and toxic chemicals. Lakes tend to be most vulnerable to nutrient impacts, whereas rivers are more burdened by sediments. Excessive aquatic plant growth as a result of nutrient pollution can decrease the oxygen available in the bottom of the lake (hypolimnion) during the summer months. In rivers and streams, sediment degrades habitat and can impact the fish health. Sediments can also play a role in causing thermal pollution. Thermal pollution can impact cold water fisheries because as water temperatures increase, so do the body temperatures of fish. In addition, increased body temperatures affect the metabolic rate of fish; therefore, as fish become stressed the fishery is impacted.

TOTAL BODY CONTACT RECREATION

Nutrient pollution can stimulate nuisance levels of aquatic plant and algae growth that disrupt recreational activities and make swimming and boating undesirable. In addition, high bacteria counts can make it unsafe for swimming. Although none of these scenarios currently exist for Lake Charlevoix and its tributaries, preventative measures are important to maintain the diversity and quality of recreational opportunities in this Watershed.

NAVIGATION

Navigation is threatened in the Boyne River, Pine River, parts of Lake Charlevoix, and to some extent the Jordan River, from increasing sediment accumulation. Several private and public marinas require regular dredging, as does the Pine River, in order to accommodate boats. Lake Charlevoix shoreline has numerous private boat wells and access channels, which also require regular maintenance. In addition to dredging, the marinas and boat wells must regularly address aquatic invasive species because of extent of growth; herbicide is the most common treatment method. Dredging and herbicide applications, however, have their drawbacks. Dredging is expensive, provides only a temporary fix, and causes unnecessary lake ecosystem disturbance. Herbicide application can negatively impact fish and other aquatic organisms, is costly, and is also only a temporary fix.

SOURCES AND CAUSES OF POLLUTANTS IN THE LAKE CHARLEVOIX WATERSHED

There is a range of land use types within the Lake Charlevoix Watershed; from large tracts of state forests to the resort communities (urban areas) of Charlevoix, Boyne City, and East Jordan and everything in between. Different land uses (sources) and activities (causes) have the potential to impact water quality, and subsequently, threaten the designated uses of a water body. It is critical to identify and understand the link between the source of nonpoint source pollutants and the potential cause. It is this understanding that forms the framework for developing the goals and action strategies of the watershed management plan.

SEDIMENT SOURCES AND CAUSES

Sediment pollution comes from a variety of sources and causes. Lakeshore and streambank erosion along with road/stream crossings are known **sources**; suspected **sources** of sediment include agricultural practices including livestock in streams, new construction, and logging activities.

Causes include:

- Lakeshore and streambank erosion is often a result of the removal of shoreline vegetation. Angler and canoeing access points are another source of erosion on the Jordan River.
- Improperly sized culverts and lack of runoff diversions are the main reason for erosion and sedimentation associated with road/stream crossings.
- Livestock access to streams for a watering source can destroy the bank and cause erosion and sedimentation.
- New construction in the shoreline area can also contribute sediment, particularly if inadequate erosion controls are used.
- Not maintaining buffer strips during logging is also suspected of contributing to erosion and sedimentation.

NUTRIENT SOURCES AND CAUSES

Nutrient pollution may also be derived from a variety of sources, and oftentimes is a linked with sediment pollution because nutrients often attach to sediment particles. Consequently, shoreline, streambank, and road/stream crossing erosion contribute sediment *and* nutrient pollution. Therefore, sources of nutrient pollution include shoreline and streambank erosion, road crossings, as well as lawn care on residential properties. Other sources of nutrient pollution include septic systems, agricultural practices, stormwater discharges in urban areas, manure application and management, golf courses, and new construction.

Causes include:

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

Sources of oils, grease, and heavy metals include stormwater discharges in urban areas and road/stream crossings. Sources of pesticides include agricultural fields and residential, commercial and municipal turf management. Sources of bacteria include stormwater discharges in urban areas, manure application and storage, and livestock access to streams. Stormwater discharge in urban areas can collect and deposit pet and wildlife waste into Lake Charlevoix. Excessive application of manure, runoff from manure piles, or livestock access to streams can all be causes of bacteria pollution from agricultural sites.

Causes include:

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

Reducing and preventing the nonpoint source pollutants lies in addressing the priority pollutants, their sources, and causes. The sources were first prioritized by category, e.g., all of the road/stream crossing sites were compared and prioritized according primarily to severity.

The Advisory Committee discussed and voted on the ranking across the categories. Table 38 describes the results for the ranking of the pollutants, their main sources, and causes.

Table 38: Lake Charlevoix Watershed Pollutant Sources and Causes

Lake Charlevoix Watershed Pollutant Sources and Causes				
Rank	Pollutants	Pollutant Source	Rank	Cause (listed in priority order by source)
1	Nutrients (P and N)	Urban stormwater (k)	1	Inadequate treatment of stormwater that may contain oils, grease, heavy metals, pet waste, etc. (s)
		Lawn care/shoreline property management (k)	2	Use of phosphorus fertilizer (s)
				Over-application of fertilizers (s)
				Removal of native shoreline vegetation (k)
		Agriculture (s)	3	Heavy use of pesticides and chemical fertilizers (s)
				Over application of manure (s)
				Inadequate testing of soil properties (s)
				Inadequate soil erosion control (s)
		Road/stream crossings (k)	4	Undersized and short culverts (k)
				Lack of runoff diversions (k)
				Inadequate fill on road surface (k)
				Lack of vegetation (k)
		Livestock (s)	5	Lack of proper storage for manure (s)
				Unrestricted stream access and no alternative water source (s)
		Septic systems (s)	6	Outdated, poorly maintained, and improperly designed systems (s)
		Golf courses (s)	7	Heavy applications of fertilizers and pesticides (s)
				Lack of buffer strips in riparian areas (s)
1	Sediment (k)	Road/stream crossings (k)	1	Undersized and short culverts (k)
				Lack of runoff diversions (k)
				Inadequate fill on road surface (k)
				Lack of vegetation (k)
		Lakeshore and streambank Use (k)	2	Angler and canoeist access (k)
				Lack of buffer strips in riparian areas (s)
		Urban stormwater (k)	3	Sand used in winter for traffic safety, construction, and general runoff (s)

Lake Charlevoix Watershed Pollutant Sources and Causes				
Rank	Pollutants	Pollutant Source	Rank	Cause (listed in priority order by source)
		New development and construction	4	Lack of proper erosion control and stormwater management measures (s)
				Shoreline development and removal of shoreline vegetation (k)
				Inadequate buffer strips near streams (s)
		Livestock (s)	5	Unrestricted stream access and no alternative water source (s)
2	Oils, grease, and heavy metals (k)	Urban stormwater (k)	1	Inadequate treatment of stormwater that may contain oils, grease, heavy metals (s)
		Road/stream crossings (k)	2	Undersized and short culverts (k)
				Lack of runoff diversions (k)
				Inadequate fill on road surface (k)
				Lack of vegetation (k)
3	Pathogens (k)	Urban stormwater (k)	1	Pet waste, wildlife (k)
		Livestock (s)	2	Unrestricted stream access and no alternative water source (s)
		Septic systems (s)	3	Outdated, poorly maintained, and improperly designed systems (s)
3	Pesticides	Lawn care/shoreline property management (k)	1	Misuse and over use of pesticides (s)
		Agriculture(s)	2	Heavy use of pesticides (s)
		Golf courses (s)	3	Heavy use of pesticides (s)

* k = known s = suspected

BUILD-OUT ANALYSIS

Future development of the Watershed will significantly influence water quality. While it is difficult to accurately predict development within the Watered, one method for projecting is to do an in-depth build-out analysis and map. A build-out analysis projects what an area will look like if it were completely built-out according to local land use regulations.

To produce a realistic build-out map a number of factors have to be taken into account. These include past and present development trends, projected population changes, natural features and a community's land use regulations. With this information it is possible to produce a realistic picture of the future if present trends continue. Unfortunately, developing a complete build-out analysis of the entire Watershed is impractical given its size and the number of municipalities within in its boundaries. However, a build-out analysis of one of the most "typical" municipalities, Wilson Township, was completed as a representative for the Watershed. Wilson Township, located in Charlevoix County, is 35 square miles in area. The township contains portions of Lake Charlevoix and Porter Creek. The rate of growth and nature of land use regulations are representative of most townships in the Watershed.

A computer-based geographic information system (GIS) was used to develop the build-out map. The first step involved identifying areas not well suited for development. Using data from the *Soil Survey of Charlevoix County,* all hydric (wetland) soils and areas with slopes greater than 25% were identified. The next step was to outline areas already developed. This was completed using 1983 MIRIS data updated with recent aerial photography. The last step was mapping out the property ownership using data from the Charlevoix County Equalization Department. In this step, public lands were also delineated.

A map showing existing conditions was made using the base data described along with information on prime farmland and timberland soils (Figure 34). The build-out map illustrates how this area would likely appear if completely developed per the existing provisions of the Wilson Township zoning and private road ordinances (Figure 35).

According to the 2000 census, Wilson Township currently has 2,022 residents, up 32% from 1990. There are 852 housing units within the Township, a 35% increase from 1990. According to the build-out map, if the Township were completely developed there would be an additional 2,764 housing units in the township. Using the current average household size of 2.65 persons the population would increase to 9,346 residents. At current rates of growth the Township would be completely built out within 45 years.

What will be the impact of this pattern of development on water resources in Wilson Township? Some of the areas most destined for development are the shoreline areas and river corridors. More roads, new road/stream crossings, and increases in impervious surface will contribute additional runoff and nonpoint source pollution to Lake Charlevoix and its tributaries.

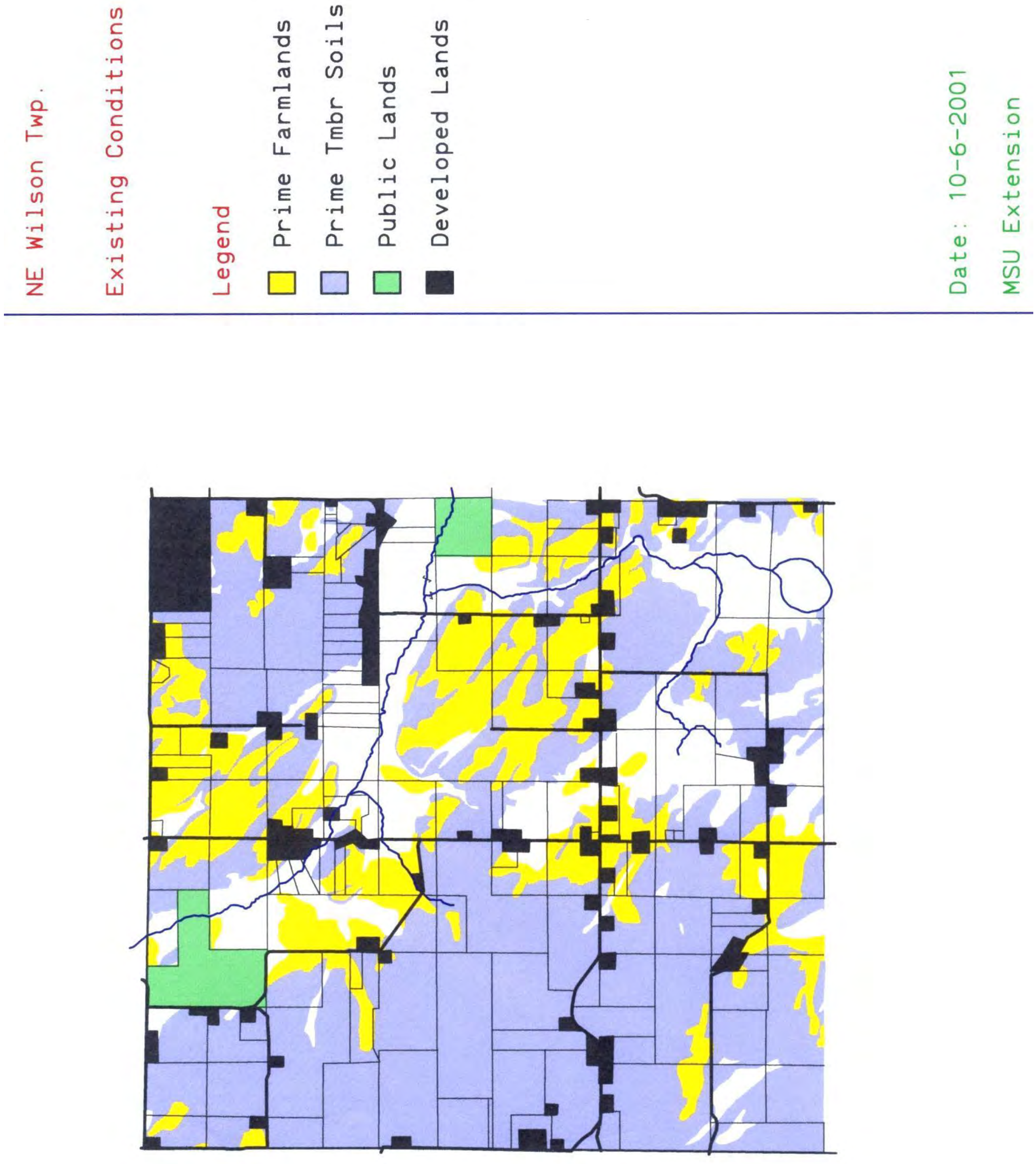


Figure 37: Wilson Township existing conditions

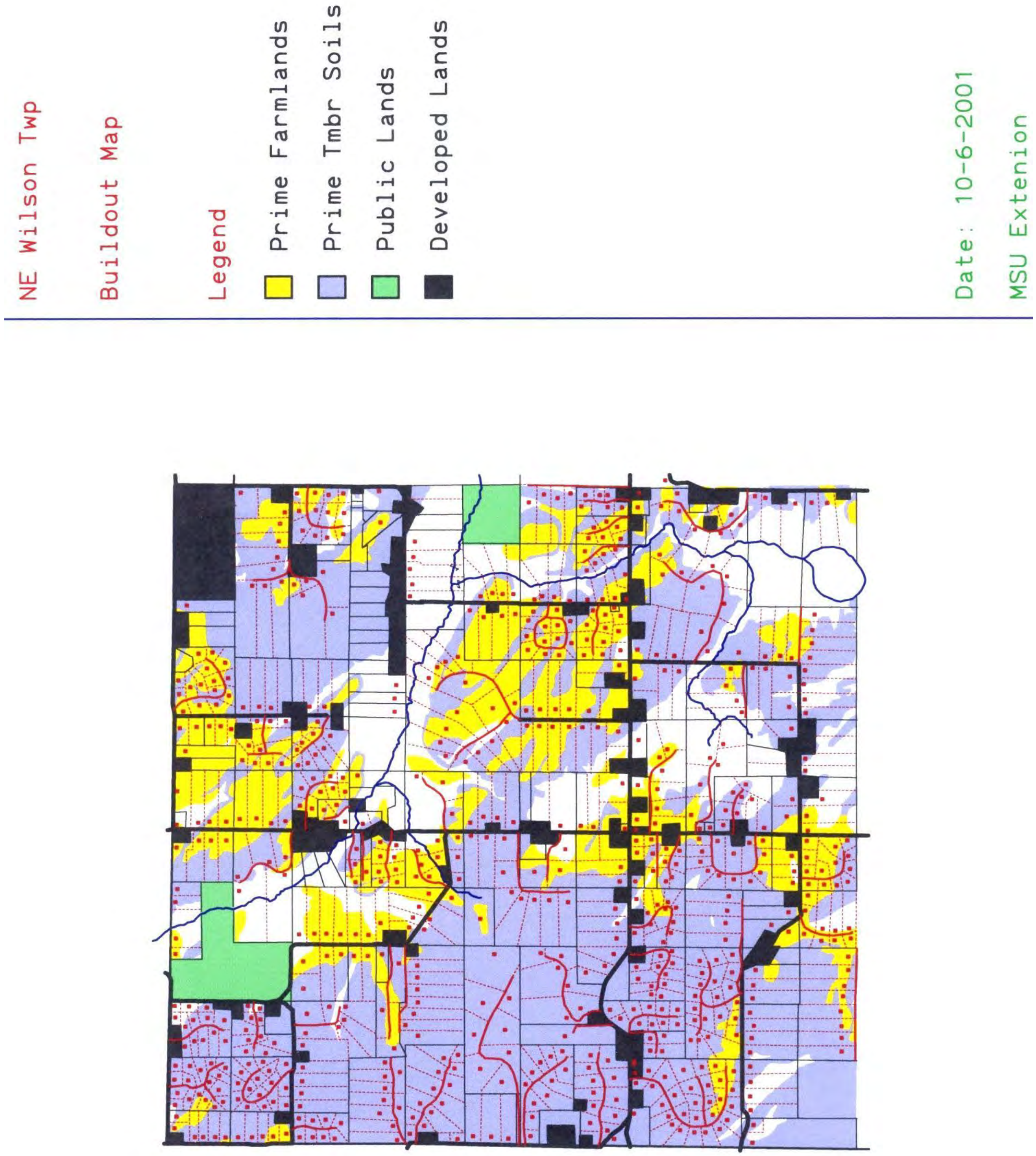


Figure 38: Wilson Township buildout map

FOCUS AREAS: PRIORITY PROTECTION AREAS AND CRITICAL AREAS

The following discussion identifies specific areas within the Lake Charlevoix Watershed that warrant either protection or restoration efforts. Addressing the needs of these targeted areas in the near future will help to achieve watershed-wide water quality protection.

PRIORITY PROTECTION AREAS

Priority areas are considered the areas within the Watershed with features that are most vulnerable to development and other land uses. Protecting these features, including steep slopes, riparian areas, groundwater recharge areas, and wetlands, will provide long-term protection of water quality within the Watershed. The below map (Figure 36) shows features individually to better depict their respective proportion to the whole. The connection between these features, or priority areas, and water quality protection is as follows:

Steep Slopes: Areas with steep slopes are at greater risk of erosion, particularly when developed. To prevent erosion and reduce sedimentation of surface waters in the Lake Charlevoix Watershed, areas with the steepest slopes should be protected. Areas with 20% or greater slopes are considered the most vulnerable.

Riparian Areas: Riparian areas, or lake shorelines and streambanks, are the critical interface between land and water; where human activity has a significant potential for degrading water quality. Developing riparian properties for residential, commercial or other uses typically alters the riparian ecosystem and invariably has negative impacts on the lake ecosystem. Preserving natural shorelines and streambanks is essential to protecting water quality.

Groundwater Recharge Potential: Groundwater discharge is essential for maintaining healthy cold water fisheries. Land with highly permeable soils allows precipitation to percolate relatively quickly through the ground and recharge groundwater supplies.

Wetlands: Wetlands provide a variety of important functions that contribute to the health of a Watershed, including fish and wildlife habitat, water quality protection, flood control and erosion prevention.

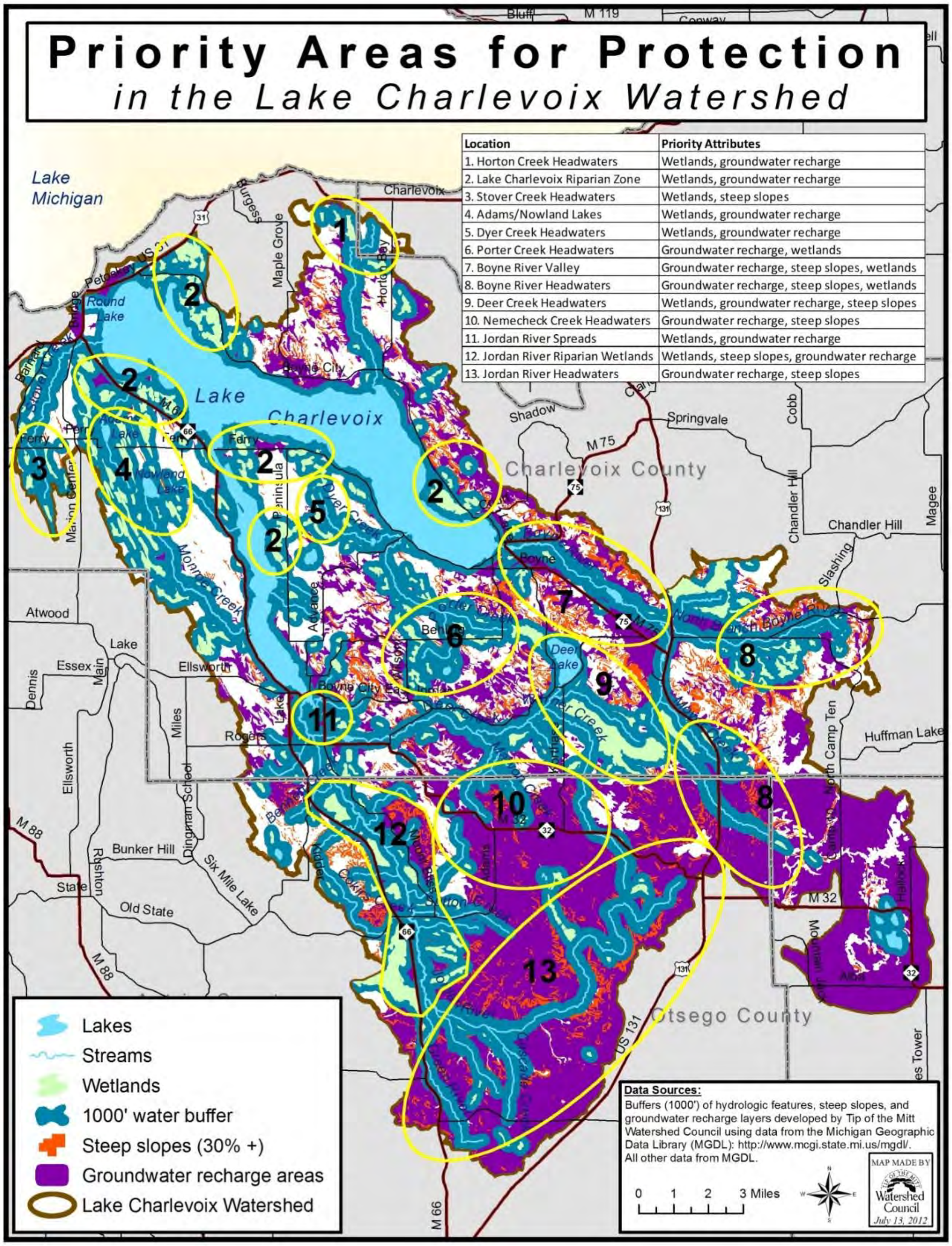


Figure 39: Priority areas

PRIORITY PARCEL ANALYSIS

One of the most effective tools for long-term water quality protection is permanent protection of land, particularly sensitive lands such as those containing wetlands. Large tracts of land in the southeastern portion of the Lake Charlevoix Watershed are already protected due to State of Michigan ownership. In addition, protected lands owned by the federal government, tribal governments, local governments, land conservancies, and private owners (conservation easements) are scattered throughout the watershed. In spite of the abundance of protected lands that currently exist in the Watershed, there remain many land parcels in sensitive areas that should be protected to safeguard the Watershed's lakes, streams, wetlands, and groundwater.

In order to protect sensitive areas, a system is needed to assess land parcels in terms of ecological values. To that end, Tip of the Mitt Watershed Council collaborated with the Little Traverse Conservancy (LTC) and Grand Traverse Regional Land Conservancy (GTRLC) to conduct a "Priority Parcel Analysis": a GIS process that evaluates individual land parcels based on multiple ecological criteria and ranks parcels accordingly. The final product provides a tool to land conservancies, governmental entities, and others to assist in prioritizing land protection efforts in a manner that provides the greatest benefit to local ecosystems while also complementing existing land protection efforts. Descriptions of selection criteria and the scoring system used to determine priority parcels are described below:

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

Groundwater Recharge Potential: As previously discussed, groundwater plays an important role in water quality protection. Predominant soil type and associated permeability were determined for each parcel using the physical properties found in county soil surveys. Parcels were scored based on acreage containing soils with high groundwater recharge potential, the minimum threshold set at one acre.

Presence of Wetlands: As noted earlier, wetlands are a critical to protecting water quality. Digital GIS data layers containing results of the National Wetlands Inventory (NWI) were used to determine the presence of wetlands on individual parcels. Parcels were scored based on wetland acreage identified in the NWI, any parcel with wetlands scoring at least one point.

Lake Shoreline/Riparian Ecosystems: Protecting the land/water interface, the riparian area, is essential to good water quality. The length of lake shoreline was determined for individual properties using hydrography GIS data layers from the State of Michigan. Scores were based on the total shoreline distance contained within the parcel, with a minimum threshold of 100 feet.

Stream Shoreline/Riparian Ecosystems: The length of streambank was determined for individual properties using hydrography GIS data layers from the State of Michigan. Scores were based on the total streambank distance contained within the parcel, with a minimum threshold of 200 feet.

Steep Slopes: Land parcels with steep slopes should be permanently protected. GIS data from the State of Michigan was used to determine the highest percent slope on a parcel and scored accordingly. Properties with slopes greater than 20% received points.

Protected Land Adjacency: Properties adjacent to protected lands such as State Forests or conservancy lands have a high ecological value because they provide a buffer to pre-existing protected lands and increase the contiguous protected area, which essentially expands the biological corridor for species migration and interaction. Protected lands include properties owned by the federal government, tribal governments, State of Michigan, local governments, universities, land conservancies, and private owners (conservation easements). Properties bordering protected lands were scored based on the number of adjacent protected land parcels.

Presence of State or Federally Listed Threatened or Endangered Species: Threatened and endangered species represent an important aspect of biodiversity. The Michigan Natural Features Inventory developed a probability model and rarity index based on existing threatened and endangered species information. Properties within or touching upon the model's grid cells that had a high probability of threatened and endangered species occurrence scored points; receiving a higher score as the rarity index number increased.

All 22,748 land parcels in the Lake Charlevoix Watershed were analyzed and scored using the eight listed criteria. The scores for each criterion were summed to produce a total "priority" score for each land parcel. Nearly 200 parcels received a total score of 15 or greater and grouped into the high priority tier as they are considered to be the most vital for water resource protection. Over 4,000 parcels were grouped into a second tier of medium priority, with total scores ranging from 5 to 14. The remaining parcels received a score of less than five and are considered low priority. Figure 37 illustrates the results of the prioritization process.

GIS data layers developed during the prioritization process contain both county equalization information and priority criteria scores for all parcels in the Lake Charlevoix Watershed. The GIS data, associated databases, and maps will be provided to local land conservancies, state agencies, and local governments to prioritize land protection activities and guide landscape development planning. Permanent protection or low-impact development in high priority areas will help maintain the ecological integrity of the most sensitive areas and protect water resources throughout the watershed. Results of the Priority Parcel Analysis will also provide valuable assistance in conservation efforts to protect threatened and endangered species, as well as improve wildlife corridors throughout the Watershed.

See Appendix E for the GIS Procedure for Prioritization of Parcels Process.

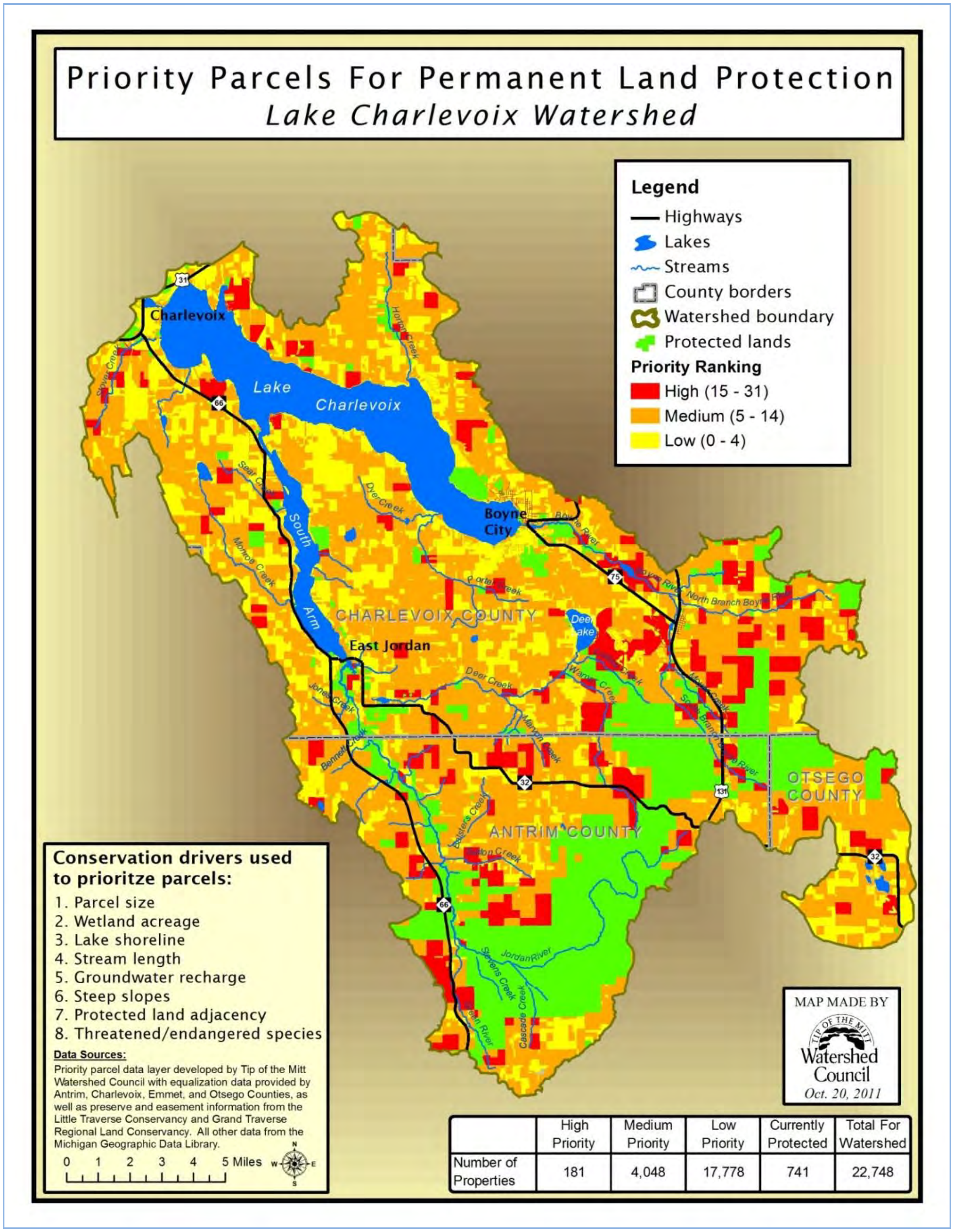


Figure 40: Priority parcels for permanent land protection: Lake Charlevoix Watershed

CRITICAL AREAS

Critical areas within the Lake Charlevoix Watershed are the areas in which management measures need to be implemented to achieve load reductions identified in the plan. Critical areas refer to locations where actions are needed to address ongoing sources of nonpoint source pollutants. The process of identifying critical areas relies upon a combination of methods including resource inventories, GIS, and reports from resource managers and others familiar with a particular aspect of the Watershed.

The critical areas identified (Figure 38) reflect the primary sources of nonpoint source pollution including agriculture, urban stormwater, shoreline management, hydrologic manipulation, road/stream crossings, and malfunctioning septic systems. Critical areas are shown at two levels: general critical areas and acute critical areas. General critical areas represent broader areas where, in general, attention is needed. Acute critical areas are the priority locations where attention is needed first and foremost. Circled areas on Figure 38 and the corresponding legend help to identify the acute critical areas.

General Critical Areas:

The four major municipalities are included because they contribute to urban stormwater. Although their individual contributions vary according to many factors including total impervious surface, implementation of stormwater best management practices, and pollutant loadings, it is reasonable to assume they are all contributing NPS pollutants to some extent, and therefore, should be continually managed to reduce their loadings.

Agricultural areas are included because water quality monitoring has shown higher levels of nitrates in areas where agricultural practices are hydrologically connected via groundwater or runoff. The application of nitrogen-rich fertilizers, particularly in sandy, well-draining soils is suspected as one of the sources of these nitrates.

The degree of severity of road/stream crossing varies; consequently, the impacts to the resources vary as well. Severe and moderate road/stream crossing sites are included because of their potential to contribute large amounts of sediments and other nonpoint source pollutants.

Segments of degraded shorelines on Lake Charlevoix shoreline are included where a significant alteration is likely resulting in an impact to the resource. Alterations include road ends, structures such as extensive seawalls, groins, boat wells, and boat launches.

Areas of identified concentrated nutrient pollution are included because they likely indicate areas where nutrient loading from septic systems are no longer adequately treating waste water. It is not unusual to see concentrated nutrient pollution along segments of the shoreline where cottages have been expanded or replaced with larger cottages (septic systems are inadequate for the new cottage); shoreline parcels have been subdivided; or older cottages with their original septic systems are still in use. Maintaining, updating or replacing septic systems is a relatively 'easy' fix given the potential to either adversely or positively impact water quality. Critical areas where septic systems are suspected to be failing in any capacity should be addressed either individually or on a community level.

Impoundments are included because of the significant resource impacts. Impoundments, or dams, restrict sediment transport, increase water temperatures (thermal pollution), and impede fish passage.

Acute Critical Areas

1. <u>City of Charlevoix (urban stormwater):</u> The center of the City is a critical nonpoint source pollution area because concentrated urban land use adjacent to Round Lake and the Pine River. Sediments, nutrients, and bacteria are the primary pollutants. Degraded shorelines on the Pine River and Round Lake are also a concern.

2. <u>Stover Creek Watershed (urban and agricultural stormwater, road-stream crossings):</u> Stover Creek is impacted by expanding urban land cover in its lower section and by agricultural activity (a mix of row crop, dairy, orchards, and livestock-sheep) in the upper Watershed. Sediments, nutrients, pesticides, and bacteria are the primary pollutants. There are also several problematic road-stream crossings in the Watershed, as well as a minor impoundment and fish passage barrier at the stream mouth.

3. <u>Adams and Nowland Lakes (agricultural stormwater, road-stream crossings):</u> Agricultural operations, primarily livestock rearing, produce nonpoint source pollution around Adams and Nowland Lakes, which includes the headwaters of Loeb, Sear, and Monroe Creeks. Sediments, nutrients, and bacteria are the primary pollutants of concern. There are also several problematic road-stream crossings in this area.

4. <u>Horton Creek Watershed, East (agricultural stormwater, road-stream crossings):</u> In an area to the east of Horton Creek and Horton Bay, manure from livestock (primarily horses and cows) contribute nonpoint source pollution. Sediments, nutrients, and

bacteria are the primary pollutants of concern. There are also several problematic road-stream crossings in this area.

5. Lake Charlevoix Shoreline (degraded shoreline): Nonpoint source pollution is occurring in these concentrated shoreline areas due to erosion and excessive nutrient inputs. Sediments and nutrients are the primary pollutants, though bacteria are the biggest concern at Young State Park.

6. Lake Charlevoix Shoreline (sewers and septic systems): Sewer systems are needed in shoreline areas along Lake Charlevoix due to dense development, inadequate soils, highway runoff, and proximity to Lake Charlevoix and its tributaries.

7. Northern Peninsula, Dyer Lake (agricultural stormwater, road-stream crossings): Manure from intense dairy operations and pesticides from orchards are a critical source of nonpoint source pollution in this area. Sediments, nutrients, pesticides, and bacteria are the primary pollutants of concern. There are also a few problematic road-stream crossings in this area.

8. South Arm Shoreline (degraded shoreline): Nonpoint source pollution is occurring in these concentrated shoreline areas due to erosion and excessive nutrient inputs. Sediments and nutrients are the primary pollutants of concern.

9. City of East Jordan (urban stormwater): The center of the City is a critical nonpoint source pollution area because concentrated urban land use adjacent to Lake Charlevoix and the Jordan River. Sediments, nutrients, and bacteria are the primary pollutants, particularly in the Tourist Park area. Degraded shorelines on Lake Charlevoix, the Jordan River, and Brown Creek are also a concern.

10. Patricia Lake Impoundment (thermal pollution and fish passage): The aging dam at Patricia Lake elevates water temperatures and is a barrier to fish passage.

11. Birney Creek Watershed (agricultural stormwater): Runoff from agricultural operations, particularly horse farms, threatens the Birney Creek ecosystem. Sediments, nutrients, and bacteria are the primary pollutants of concern.

12. Jordan River, State Road (road-stream crossing): Streambank erosion is severe at this site due to foot traffic and culvert-caused scour and back-up pools. Sediment pollution is the primary concern.

13. City of Boyne City (urban stormwater): The center of the City is a critical nonpoint source pollution area because concentrated urban land use adjacent to Lake Charlevoix and the Boyne River. Sediments, nutrients, and bacteria are the primary pollutants of concern, particularly at Peninsula Beach and the Lower Lake Street stormwater outfall. Degraded shorelines on Lake Charlevoix and the Boyne River are also a concern.

14. Boyne River, Dam Road (road-stream crossing): Streambank erosion is severe at this site due to foot traffic and channel erosion caused by the culverts. Sediment pollution is the primary concern.

15. Boyne River Impoundments (thermal pollution and fish passage): The Boyne USA and Boyne Falls Mill Pond dams elevate water temperatures and are barriers to fish passage.

16. Elmira, Thumm Road Area (agricultural stormwater): Manure from livestock, primarily cattle, is a critical nonpoint source pollution concern in this area. Sediments, nutrients, and bacteria are the primary pollutants of concern.

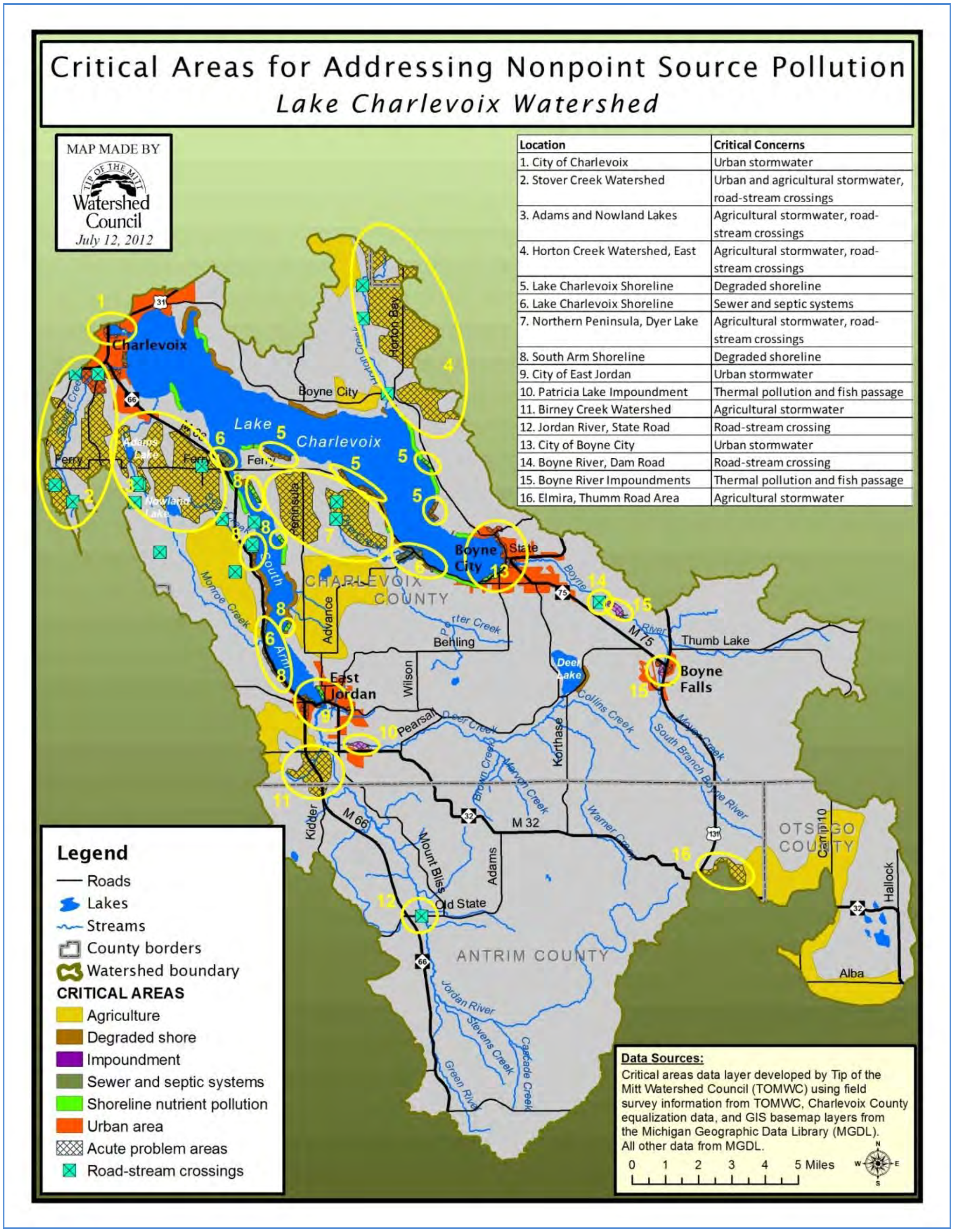


Figure 41: Lake Charlevoix Watershed critical areas

CHAPTER FIVE: PREVIOUS WATERSHED MANAGEMENT EFFORTS

LAKE CHARLEVOIX MANAGEMENT PLAN

The first efforts toward watershed management in the Lake Charlevoix Watershed began in December of 1984 when the Charlevoix County Planning Commission formed the Lake Charlevoix Management Plan Advisory Committee as a means to develop the *Lake Charlevoix Management Plan (1988)*, a document for managing the use, growth, and quality of Lake Charlevoix and its adjacent lands. The 15-member committee consisted of representatives from each of the townships and cities around the Lake, the County Planning Commission, the Lake Charlevoix Association, development and environmental interests. The Committee had three primary objectives:

1. Accumulate all relevant data on the Lake Charlevoix Watershed.
2. Generate additional data necessary for the planning process.
3. Make recommendations to appropriate governmental units on what a Lake Charlevoix Management Plan should contain.

LAKE CHARLEVOIX WATERSHED PROJECT

In September 2001, the Charlevoix Conservation District and the Tip of the Mitt Watershed Council, along with an expanded Advisory Committee (27 member organizations), produced the *Lake Charlevoix Watershed Project: Preserving Water Quality for Today and Tomorrow Nonpoint Source Pollution Inventory*. Its focus incorporated management recommendations aimed at maintaining water quality interests, such as:

- Recreational Quality: support high water quality to encourage all forms of recreation - swimming, boating, and fishing - by reducing inputs of sediment, nutrients, and bacteria.
- Fishery Quality: sustain an excellent cold water fishery by reducing sediment and nutrient loads that can threaten fish habitat and result in higher water temperatures in the lake and its river tributaries.
- Habitat Quality: protect Watershed biodiversity by protecting vital aquatic plant and animal habitats from pollution.
- Navigational Quality: maintain Lake and river tributary navigation by promoting methods to reduce all means of sediment input.

Implementation projects were completed during 2001-2005 with Michigan Nonpoint Source Program funds from both the Clean Michigan Initiative (CMI) bond program and Section 319 of the federal Clean Water Act, (h) Nonpoint Source Program funds during 2001-2005. These projects included a variety of restoration actions as well as information and education activities and restoration projects.

In 2006, the Advisory Committee decided to update the plan to meet the then recently established U.S. EPA's Nine Elements criteria. Implementation projects were completed with Clean Michigan Initiative (CMI) and Section 319(h) Nonpoint Source Program grants during 2001-2005, which included a variety of information and education activities and restoration projects. The CMI program supported the goals of protecting the diversity of aquatic habitats, including cold water fisheries, and maintaining the excellent recreation opportunities of Lake Charlevoix and its tributaries by reducing nutrient and sediment loads from priority road crossings, lakeshore erosion, recreation access to tributaries, agricultural activities, and urban stormwater. Restoration projects installed for the Lake Charlevoix Watershed Project included three road/stream crossing improvements in Charlevoix County; two road/stream crossing improvements in Antrim County; erosion control and habitat improvement at four sites on the Jordan River; installation of best management practices at three agricultural sites (two in Antrim County and one in Charlevoix County); restoration of three lakeshore erosion sites and one road end all on Lake Charlevoix; the installation of a detention basin in Boyne City.

In 2006, the Advisory Committee decided to update the plan to meet the then recently established U.S. EPA's Nine Elements criteria. In 2007 and 2008, Tip of the Mitt Watershed Council obtained private dollars to complete a draft of an updated plan.

THE LAKE CHARLEVOIX WATERSHED MANAGEMENT PLAN: ADVISORY COMMITTEE

The Lake Charlevoix Watershed Advisory Committee (AC), along with the groups and agencies the AC members represent, is not only one of the most active watershed groups in Northern Michigan, but also in the State. The AC is a diverse group of dedicated stakeholders who recognize the value in coming together to protect the Watershed. Successful partnerships continue to spur new projects to the benefit of the Watershed.

Historically, Advisory Committee (AC) meetings were held every other month until about 2006 when meetings were changed to a quarterly schedule in response to members' schedules and conflicts. Meetings remain open to the public and are typically held at the Charlevoix Public Library, a convenient location for most AC members. Meetings are typically scheduled for 2 hours and an agenda is sent electronically in advance of the meetings by the Tip of the Mitt Watershed Council. Meeting minutes are also taken and electronically distributed by the Watershed Council prior to the following meeting. Although attendance varies, most meetings have in excess of 10 AC members with an average being closer to 20. AC member retention has been good; however, some original agencies or organizations are no longer in existence or active. A core group of engaged AC members attend most meetings. The meetings are considered productive, informative, and serve as an effective means of networking.

Today, the Lake Charlevoix Watershed Advisory Committee (Committee) remains a very active group of stakeholders that represent natural resource agencies, local governments, non-profits organizations, and others that serve as voices for the waters of the Lake Charlevoix Watershed. The goal of the Committee is:

> <u>To protect the water quality and high quality uses of the water resources of Lake Charlevoix and its tributaries by reducing the amount of nonpoint source pollution and preventing future contributions.</u>

The Committee is a forum to exchange information, obtain input into the watershed plan, and keep interested partners informed about other projects and regional issues that affect the Lake Charlevoix Watershed. The following stakeholders participate:

Antrim Conservation District
Antrim County
Antrim County Road Commission
Charlevoix Conservation District
Charlevoix County Board of Commissioners

Charlevoix County Planning Commission
Charlevoix County Road Commission
City of Boyne City
City of Charlevoix
City of East Jordan
Conservation Resource Alliance
Friends of the Boyne River
Friends of the Jordan River Watershed
Grand Traverse Band of Ottawa and Chippewa Indians
Grand Traverse Regional Land Conservancy
Keep Charlevoix Beautiful
Lake Charlevoix Association
Little Traverse Bay Bands of Odawa Indians
Little Traverse Conservancy
Michigan Department of Environmental Quality
Michigan Department of Natural Resources
Michigan State University Extension
Natural Resources Conservation Service
Northwest Michigan Community Health Agency
Northwest Michigan Council of Governments
Tip of the Mitt Watershed Council
Water and Air Team Charlevoix, Inc. (WATCH) & CARE Committee

With such a broad and diverse AC, it is a challenge to account for all of the watershed-related programs, activities and effort put forth over the last decade; however, a few more notable projects include the following:

LAKE CHARLEVOIX WATERSHED: LOCAL GOVERNMENT SOLUTIONS

In 2009, the Tip of the Mitt Watershed Council received funding through the MDEQ 319 program to implement the project "Lake Charlevoix Watershed: Local Government Solutions." The project included four components and four project partners including Michigan State University Extension (MSUE), Antrim Conservation District (ACD), Northwest Michigan Council of Governments (NWMCOG), and Tip of the Mitt Watershed Council (TOMWC). The components include:

1. Local Zoning Ordinance GAPS Analysis: analysis of local water protection ordinances for all jurisdictions in the Lake Charlevoix Watershed, with report and workshops to local governments.
2. Social Indicators Survey: Includes mail surveys at the beginning and end of the project to gauge attitudes and behaviors of watershed residents as a whole, as well as targeted

local officials and riparian landowners, and seasonal residents. (see appendix XX for questionnaire(s))

3. Rural Site BMP Demonstration: Installation of Stormwater Best Management Practice (BMP) on dirt/gravel road with workshop to road commissions and others on the technique.
4. Update the Lake Charlevoix Watershed Management Plan to meet the U.S. EPA's Nine Elements.

The plan update was completed by the Tip of the Mitt Watershed Council. In addition to including the EPA's Nine Element requirements, many of the sections from the 2001 plan were expanded to include broader material and new information (e.g. shoreline survey data) was added. The Watershed Council relied upon Advisory Committee meetings and personal contact with Advisory Committee members to ascertain their opinions and insight regarding the plan.

STORMWATER MONITORING IN BOYNE CITY AND EAST JORDAN

Currently, stormwater is being monitored by TOMWC in East Jordan and Boyne City as part of a project funded by the Charlevoix County Community Foundation. Prior to monitoring, TOMWC met with the city governments to discuss program objectives and to identify monitoring site locations. Four different sites, two in each city, were monitored in the summer and fall of 2011 and will be monitored one more time in the spring of 2012. Monitoring is timed to catch the initial flush of stormwater from a rain event following an extended period of dry weather, typically greater than one week.

Two automated stormwater samplers are being utilized to collect water samples at one stormwater outfall in each city. Water samples are physically collected by TOMWC staff on-site at the other outfalls. Water samples are sent to laboratories for analyses of nutrients, chloride, bacteria, metals, and oil and grease. In addition, physical parameters, including dissolved oxygen, pH, conductivity, and water temperature, are monitored on-site with a Hydrolab MiniSonde. Results from the summer and fall monitoring events are reported in Appendix F.

Data collected in the field will be used in conjunction with landcover data to estimate pollutant loadings for stormwater drainage areas that correspond to the outfall being monitored. All field data and a summary report will be provided to each City. Following completion of the monitoring component of the project, TOMWC will meet with each city government to present findings, discuss problems, and strategize improvements to respective stormwater systems. TOMWC also provides regular updates regarding this stormwater monitoring project to members of the Lake Charlevoix Watershed Advisory Committee.

EXPERIENCE LAKE CHARLEVOIX

The Lake Charlevoix Association and the Tip of the Mitt Watershed Council have partnered together annually for to host the educational event "Experience Lake Charlevoix", an on-the-water excursion where approximately 300 middle-school students from area schools learn about the Lake and the Watershed. Students rotate between stations aboard the ferry, "the Beaver Islander," where volunteers , including many of the Advisory Committee members, present short, hands-on lessons on aquatic macro-invertebrates, Lake Charlevoix history, pH and Secchi disk measurements, the nonpoint source pollution watershed model, aquatic invasive species, the groundwater model, as well as a safety presentation from the U.S. Coast Guard. 2012 marked the 19th year of this successful, fun event.

DAY ON THE BAY

In 2010, the Inland Seas Education Association (ISEA), in partnership with the Michigan Department of Natural Resources and Environment (MDNRE) Coastal Management Program, Tip of the Mitt Watershed Council, and the Lake Charlevoix Association, hosted a day-long workshop for landowners and community leaders that included discussions about some of the major threats facing the Great Lakes, as well as specific ways help mitigate these problems. Topics included reducing property run-off, stormwater, greenbelts, and invasive species such as *Phragmites*. Also included in the event was a walking tour of the Lake Michigan shoreline, a visit to the Michigan DNRE's Fisheries Research Station, and a sail aboard a schooner, the *Inland Seas*, where participants engaged in hands-on activities to learn more about the ecosystem.

DISCOVER LAKE CHARLEVOIX

In 2006, many of the of the AC members participated in the summertime program "Discover Lake Charlevoix", a successful education and outreach event held on two different dates and locations. Both were open to the public, with free admission, at public parks (Ferry Beach in Charlevoix, Veteran's Park in Boyne City), were several hours in duration, and included free refreshments. About 60 people attended each event, which included educational displays and representatives from the Lake Charlevoix Association, Friends of the Boyne River, Friends of the Jordan River Watershed, Department of Natural Resources, Trout Unlimited, Little Traverse Bay Band of Odawa Indians, Charlevoix County Health Department, WATCH, United States Coast Guard, Boyne City and Charlevoix Harbormasters, Michigan State University Extension and MDNR Fisheries.

TREASURE LAKE CHARLEVOIX PROJECT

In 2007-2009, a grant through the Frey Foundation supported several components of the Tip of the Mitt Watershed Council's Treasure Lake Charlevoix (TLC) Project. TLC supported the efforts of the Lake Charlevoix Watershed Management Plan and included designing and make available storm drain curb inlets that display a pollution prevention message and providing the City of Charlevoix a stormwater management design for Park Avenue.

Watershed Council staff worked with designers from East Jordan Iron Works (EJIW) to develop a personalized storm drain curb inlet hood that had a pollution prevention message. Two products were designed and produced for use in the municipalities around Lake Charlevoix. One is a storm drain curb inlet hood that features a fish image and states "No Dumping- Drains to Lake Charlevoix." The other is a round storm drain cover with an image of Lake Charlevoix and the locations of Charlevoix, Boyne City and East Jordan. It also has the message "No Dumping- Drains to Lake Charlevoix" and "Treasure Lake Charlevoix." A total of 20 curb inlet hoods and 26 storm drain covers were produced and are available to the cities, free of charge, on a first come first serve basis. Once these run out of stock, the die created will be used to make new ones as ordered for new construction projects, and will be the standard design available for the municipalities around Lake Charlevoix.

Watershed Council staff worked with the City of Charlevoix to develop a plan containing stormwater management recommendations and streetscape design guidelines for the drainage basin surrounding Park Avenue in downtown Charlevoix. The City has since implemented several of the stormwater design elements into their Park Avenue construction projects.

RUNOFF REMEDIES

In 2007, two rain gardens were installed within the Lake Charlevoix Watershed with support from the Charlevoix County Community Foundation, the City of Charlevoix, the City of East Jordan, and the Charlevoix Public Library. The larger of the two is at the Charlevoix Public Library (Figure 39) and features dozens of different Michigan native plants species. It collects drainage from an adjacent city-owned parking lot and the nearby landscape. Its large size and prominence has made it a feature of the library's landscape. A perimeter path encourages visitors to view the rain garden up close and nearby signage highlights the concept of the rain garden. A second, smaller rain garden was installed in East Jordan near its waterfront and also features Michigan native plants.

Figure 42: Native plants in the Charlevoix Public Library rain garden

LAKE CHARLEVOIX ASSOCIATION

The Lake Charlevoix Association (LCA) has had a significant increase in their membership over the last decade. The increase is likely due to concerted efforts to promote the organization and high-profile projects, including the *Phragmites* control project and the Fish Habitat Improvement Project. Efforts to improve their website and new leadership may also play a role in the membership increase.

PUBLICATIONS

In addition, several publications have been developed, produced and distributed to various audiences throughout the Watershed. Two publications, *Sensible Shoreline Development* and *Lake Charlevoix: Jump In. Enjoy. Explore. Protect.* target lakeshore property owners and encourage water-quality friendly shoreline management techniques.

LAKE CHARLEVOIX FISH HABITAT IMPROVEMENT PROJECT

In 2011, the Lake Charlevoix Association (LCA) began working on an ambitious, comprehensive fish habitat improvement plan to install natural cover and improved spawning habitat for both game fish and feeder fish, in the form of trees, stumps and other woody debris. The project aims to improve the overall health of the fishery in Lake Charlevoix and improve angler success.

The lack of natural structure in the lake has been attributed to a less than robust fishery, which is critical to fish spawning and survival. As the shoreline has become more developed, property owners have been increasingly less likely to leave fallen trees along the shoreline. Fallen trees are quickly removed due to their perceived unsightliness. Research has shown, however, this near shore cover is vital to spawning success and survival of the young of both feeder fish and game fish.

The LCA fish habitat improvement plan includes installing both deep water reefs, in 15 to 30 feet of water, and shallow water structures, 1 to10 feet, in locations around the lake. The LCA has identified potential locations for 125 deep water reefs (Figure 40). The reefs will consist of 5 - 20 or more individual structures arranged together.

The project is expected to span five years. The LCA will depend on volunteers to install the structures.

Visit LCA at www.lakecharlevioxassociation.org for more information.

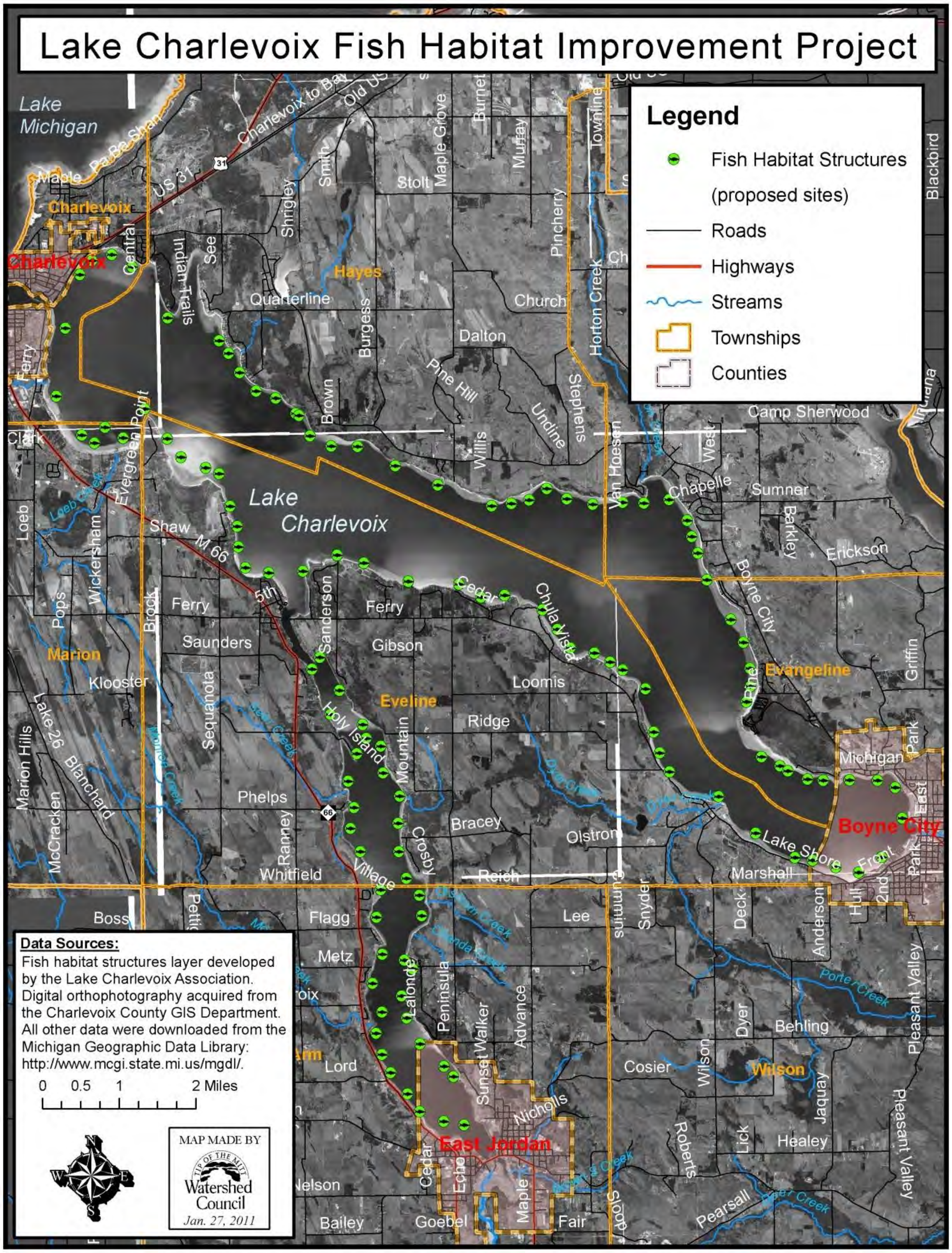


Figure 43: Lake Charlevoix fish habitat improvement project

CHAPTER SIX: LAKE CHARLEVOIX WATERSHED: GOALS AND OBJECTIVES

The following goals and objectives reflect the Advisory Committee's determination of how to best protect the Watershed; maintain the designated uses of the State; support additional desired uses; and increase community support of Watershed protection projects, practices, and programs.

GOAL 1: PROTECT THE DIVERSITY OF AQUATIC HABITATS

OBJECTIVE:

- 1.1 Inventory and monitor aquatic habitats to document conditions and changes
- 1.2 Protect and restore critical habitat including headwater streams, springs and seeps, and wetlands
- 1.3 Protect wildlife corridors
- 1.4 Protect and restore natural hydrologic connectivity

GOAL 2: PROTECT AND IMPROVE THE QUALITY OF WATER RESOURCES IN THE LAKE CHARLEVOIX WATERSHED

OBJECTIVE:

- 2.1 Reduce nutrient and sediment inputs to surface waters and groundwater from residential sources
- 2.2 Reduce nutrient and sediment inputs to surface waters and groundwater from agricultural sources
- 2.3 Reduce nutrient and sediment inputs to surface waters and groundwater from urban and developed areas
- 2.4 Reduce nutrient and sediment inputs to surface waters and groundwater from road/stream crossings and recreational impacts
- 2.5 Protect groundwater recharge areas
- 2.6 Monitor water quality

GOAL 3: MAINTAIN EXCELLENT RECREATIONAL OPPORTUNITIES

OBJECTIVE:

- 3.1 Maintain navigation for boating recreation
- 3.2 Support fisheries for quality sport fishing opportunities
- 3.3 Support and promote Clean Marinas
- 3.4 Support and promote boater safety and stewardship practices
- 3.5 Provide safe access to lakes and streams

GOAL 4: PRESERVE AND PROTECT THE NATURAL CHARACTER AND HERITAGE OF THE LAKE CHARLEVOIX WATERSHED

OBJECTIVE:

4.1 Protect significant viewsheds throughout the Watershed
4.2 Protect the rural character of the Watershed
4.3 Protect valuable lands that are critical to water quality, fisheries, and wildlife

GOAL 5: SUPPORT SUSTAINABLE WATERSHED MANAGEMENT PROGRAMS AND PRACTICES IN THE LAKE CHARLEVOIX WATERSHED

OBJECTIVE:

5.1 Promote watershed protection practices, such as permanent land protection and low impact development techniques, to Watershed stakeholders
5.2 Work with local units of government to develop strategies and implement programs that protect water quality and natural resources
5.3 Work cooperatively with Watershed stakeholders to leverage funds, pool resources and skills, broaden outreach, and implement projects of the Watershed Management Plan.

GOAL 6: DEVELOP EFFECTIVE EDUCATIONAL AND COMMUNICATION EFFORTS AND PROGRAMS THAT SUPPORT AND PROMOTE WATERSHED PROTECTION ACTIVITIES.

OBJECTIVE:

6.1 Work collaboratively with all stakeholders to capitalize on their talents, skills, knowledge, and the opportunities and resources available to them.
6.2 Stay current with resource issues affecting the Lake Charlevoix Watershed and, in turn, convey issues and their potential impact on local resources to wider Watershed audience(s).
6.3 Develop innovative programs to engage Watershed audience(s)
6.4 Utilize innovative methods of communication to effectively reach Watershed audience(s).
6.5 Develop clear, concise, and consistent messages to Watershed audience(s) that effectively communicates their respective role(s) in watershed protection efforts.

CHAPTER SEVEN: RECOMMENDED IMPLEMENTATION TASKS AND ACTIONS

OVERVIEW OF IMPLEMENTATION TASKS AND ACTIONS

The Lake Charlevoix Watershed Management Plan Advisory Committee encourages an integrative approach to reduce existing sources of nonpoint source pollution and prevent future contributions. Effective watershed management must rely upon an integrative approach that includes 1) best management practices (BMPs); 2) partnerships, community consensus building, and work with local governments; and 3) information and education components.

In an era when grant opportunities are very competitive, the Advisory Committee recognizes the importance of not only prioritizing the needs of the watershed, but also the value in building partnerships with stakeholders and leveraging funds. The recommended implementation tasks and actions represent the best management practices and initiatives identified by the Advisory Committee as being the most critical for water quality protection within the Lake Charlevoix Watershed.

PROPOSED BEST MANAGEMENT PRACTICES (BMPS)

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

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

Structural and non-structural BMPs will be used in combination in the Watershed to obtain the maximum reduction or elimination NPS pollutants. BMPs should be selected according to their potential to reduce the targeted NPS pollutant, as well as budget, maintenance requirements, available space, and other factors. Some examples of possible BMPs for the most common sources of nonpoint source pollutants are listed in Table 39. Specific BMP recommendations for the Lake Charlevoix Watershed are located in the Recommended Implementation Tasks table beginning on page 153.

Table 39: Best Management Practices to Address Nonpoint Source Pollution

Source	Potential Systems of BMPs
Road/Stream Crossings	Extend or enlarge culverts, install runoff diversions to direct runoff, install box culverts or elliptical culverts, install clear-span bridges
Streambanks/ Lakeshores	Biotechnical erosion control, vegetative buffer strips, rock riprap, tree revetments, land conservation easements
Stormwater	Rain gardens (bioretention), runoff diversions, infiltration basins or trenches, sand filters, oil/grit separators, pervious pavers
Recreation	Runoff diversions, walkways/stairways, parking lot barriers, canoe landings, biotechnical erosion control, rock riprap, tree revetments
Lawn/Shoreline Care	Zero-phosphorus fertilizers, soil testing, vegetative buffer strips
Agriculture-Livestock	Fencing, alternative watering devices, vegetative buffer strips, land conservation easements
Agriculture-Manure	Nutrient management, animal waste storage, manure application plan
Septic	Regular maintenance
Golf Courses	Soil testing, fertilizer and pesticide management, vegetative buffer strips

BMP EFFECTIVENESS

The actual effectiveness or efficiency of a BMP is determined by the size of the BMP implemented (e.g., feet of vegetated buffer or acres of stormwater detention ponds), and how much pollution was initially coming from the source. Table 40 (Huron River Watershed Council, 2003) lists estimates of pollutant removal efficiencies for stormwater BMPs that may be used in the Watershed.

Table 40: Pollutant Removal Efficiencies of Stormwater BMPs

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

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

LOCATION OF BMPS IN THE WATERSHED

The location of structural BMPs depends on the site and site conditions. Table 41 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 41: General Guidelines for Locating Structural BMPs

<table>
<tr><th></th><th>Undeveloped</th><th>Developing</th><th>Developed</th></tr>
<tr><td>Philosophy</td><td>Preserve</td><td>Protect</td><td>Retrofit</td></tr>
<tr><td>Amount of impervious surface</td><td><10%</td><td>11-26%</td><td>>26%</td></tr>
<tr><td>Water quality</td><td>Good</td><td>Fair</td><td>Fair-Poor</td></tr>
<tr><td>Stream biodiversity</td><td>Good-Excellent</td><td>Fair-Good</td><td>Poor</td></tr>
<tr><td>Channel stability</td><td>Stable</td><td>Unstable</td><td>Highly unstable</td></tr>
<tr><td>Stream protection objectives</td><td>Preserve biodiversity and channel stability</td><td>Maintain key elements of stream quality</td><td>Min. pollutant loads delivered to downstream waters</td></tr>
<tr><td>Water quality objectives</td><td>Sediment and temperature</td><td>Nutrients and metals</td><td>Bacteria</td></tr>
<tr><td rowspan="3">BMP selection and design criteria</td><td colspan="2">Maintain pre-development hydrology</td><td>Max. pollutant removal and quantity control</td></tr>
<tr><td>Minimize stream warming and sediment</td><td>Maximize pollutant removal, remove nutrients</td><td rowspan="2">Remove nutrients, metals, and toxics</td></tr>
<tr><td colspan="2">Emphasize filtering systems</td></tr>
</table>

Grit chambers: Large, below-ground concrete structures designed to remove large particles and debris from stormwater. Water flows via pipes into each device through a stainless steel screen, which filters out sediment and other particles and allows them to settle at the bottom of the chamber. A vacuum truck periodically cleans out the settled material.

LOW-IMPACT DEVELOPMENT

Of particular importance are the more innovative stormwater BMPs known collectively as Low-Impact Development (LID) techniques. LID is a stormwater management practice or approach, based on natural systems. The emphasis of LID is on managing stormwater locally rather than conveying it through costly infrastructure to a "end-of-pipe" facility. LID is applicable to new and existing development and can be integrated into virtually any site, from the residential scale to larger sites, such as commercial areas. The range of techniques continues to expand and new advances in design provide greater water quality benefits.

Promoting LID throughout the Lake Charlevoix Watershed is an increasingly important component of watershed management efforts. No longer must engineers be the only stormwater practioners, but laypeople can have their hand in stormwater management as well. Encouraging Lake Charlevoix Watershed residents to take ownership in "their" stormwater through implementing LID projects will ultimately result in increased water quality and watershed protection.

GREEN INFRASTRUCTURE

Effective watershed management must take into consideration the watershed's green infrastructure. Green infrastructure is an ecological framework needed for environmental, social and economic sustainability, and refers to an interconnected network ofopen space, woodlands, wildlife habitat, parks and other natural areas that sustains clean air, water and natural resources and enriches our quality of life. Green infrastructure is a scientific and community-based approach to identify land best suited for conservation and recreation. It differs from conventional approaches to open space planning because it looks at conservation values and actions in concert with land development, growth management and built infrastructure planning.

According to the New Designs for Growth manual *Planning for Green Infrastructure (An implementation Resource of the New Designs for Growth Guidebook):*

> 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 abovementioned manual also describes the numerous techniques and tools available for implementing Green Infrastructure projects, including the following:

Voluntary Implementation Strategies such as tax incentives, conservation practices by property oweners, smart growth techniques, Low Impact Development, LEED (Leadership in Energy and Environmental Design).

Land Protection through fee simple purchase, conservation easements, purchase of development rights (PDR), transfer of development rights (TDR).

Regulatory Approaches through master plans, zoning ordinances, planned unit development, conservation design, site design and development review, service districts and growth boundaries.

Northwest Michigan Council of Governments (NWMCOG) encourages local governments to incorporate green infrastructure into their planning processes. To facilitate planning efforts, NWMCOG developed county maps (Figures 41 and 42) that include existing green infrastructure elements. Maps down to the Township, City and Village levels are available upon request. For more information on Green Infrastructure: www.newdesignsforgrowth.org

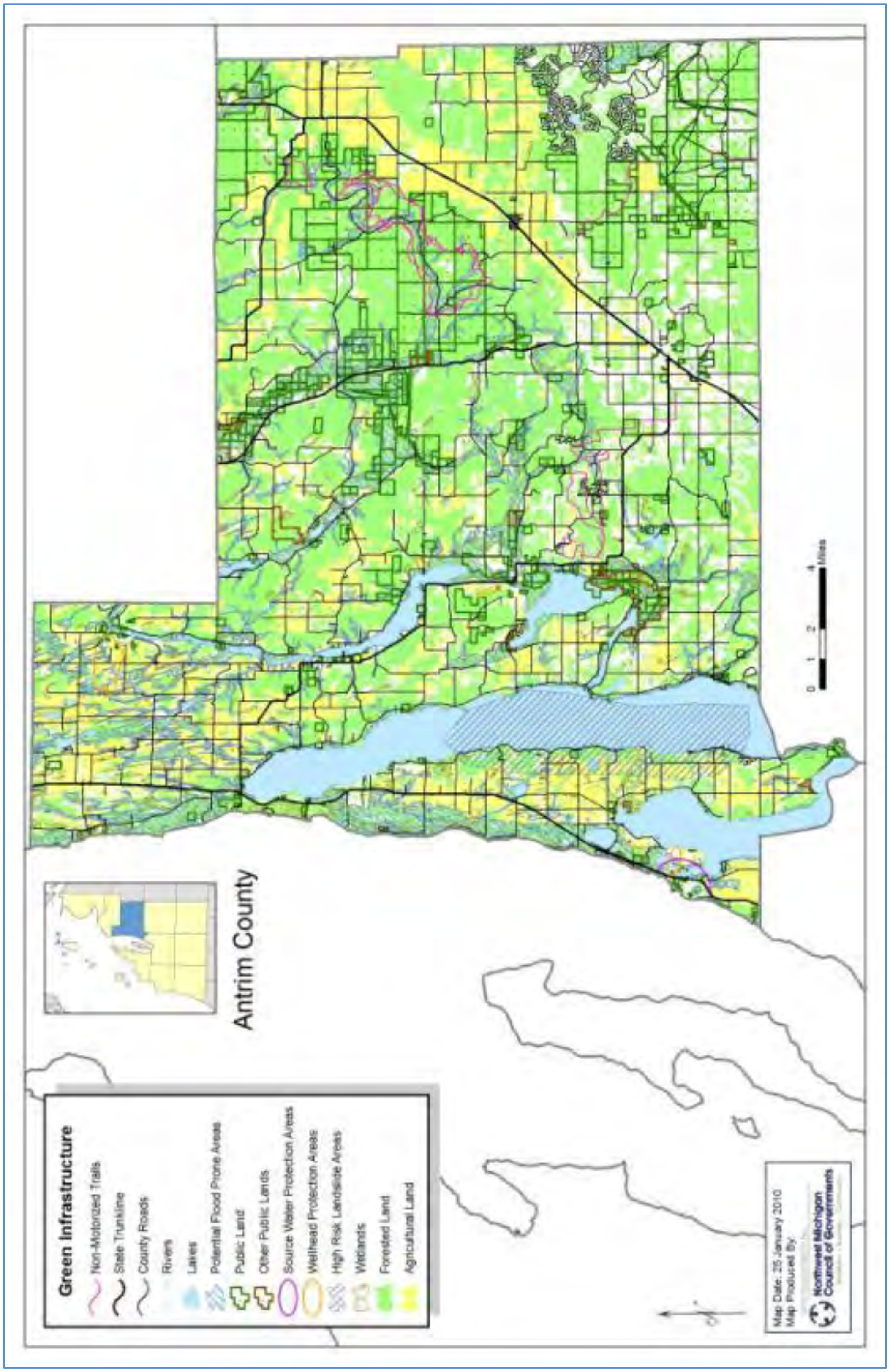


Figure 44: Green infrastructure: Antrim County (NWMCOG)

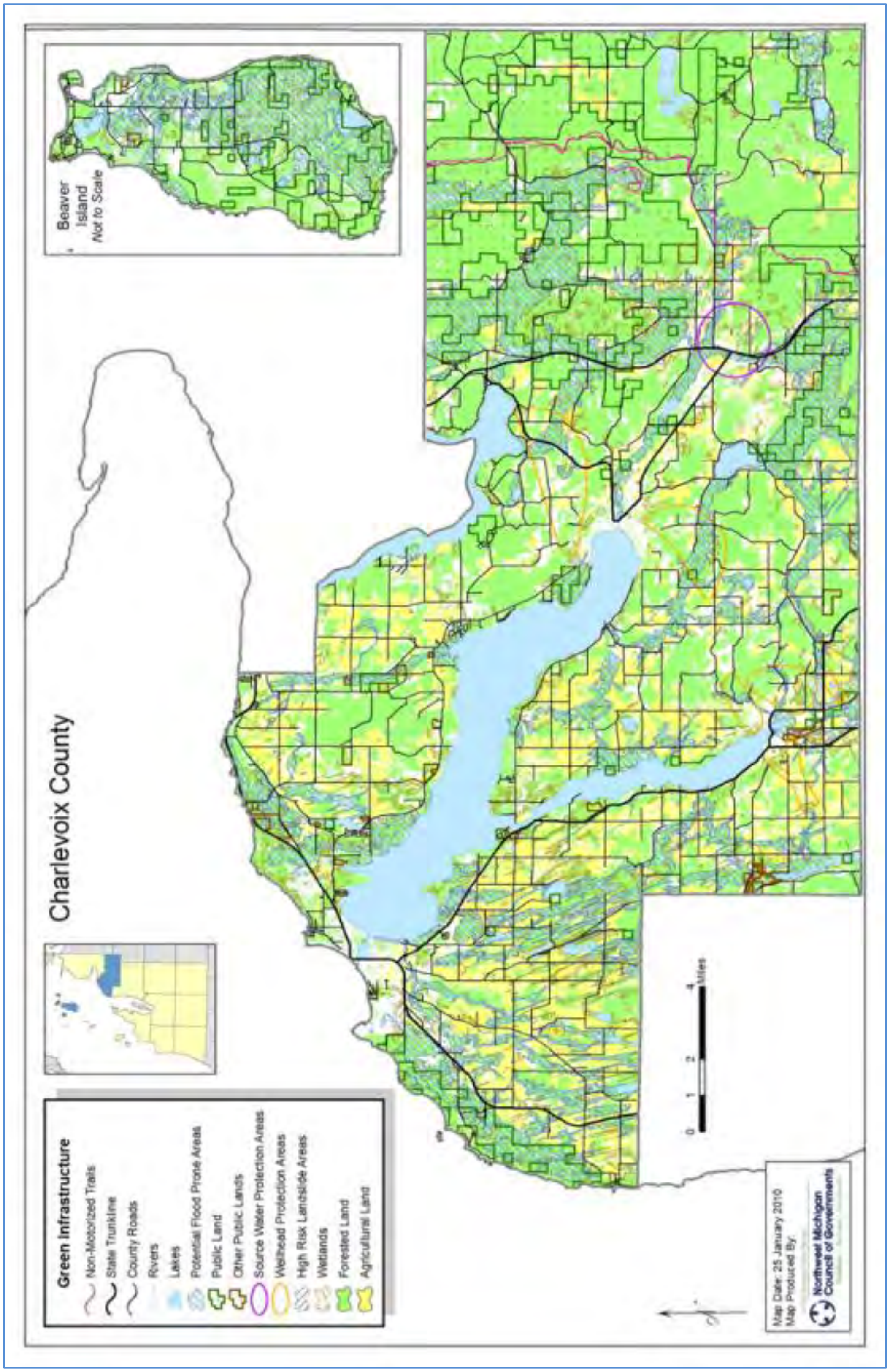


Figure 45: Green infrastructure: Charlevoix County (NWMCOG)

DETAILED IMPLEMENTATION TASKS AND ACTIONS

The following table includes a comprehensive list of proposed tasks and actions that, if implemented, will result in water quality protection or improvements. Tasks and actions are organized by category to facilitate easy reference. The recommendations are based on a 10 year timeline (2012-2021), a standard duration of time for a watershed management plan. Each task and action identifies the following:

Priority Level: Each task and action has been assigned a priority level based on one or more of the following factors: urgency to correct or reduce an existing problem; need to enact a specific task or action before a problem develops; availability of funds, partner(s) or program(s) ready to implement; and the overall need to balance low, medium, and high priorities over the course of then years.

Unit Cost/Cost estimate: An estimated unit cost is provided when applicable. An estimated total cost is provided when applicable and calculable. Table 38 summarizes the Recommended Tasks and Action by category.

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

Timeline: Based on the ten year span of the watershed management plan, the year in which the task or action is to begin or end is noted. When a task or action is ongoing, it is noted as spanning the ten years.

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

Abbreviations:	Antrim Conservation District	ACD
	Antrim County Planning Dept.	ACP
	Antrim County Road Commission	ACRC
	Charlevoix Conservation District	CCD
	Charlevoix County Planning Dept.	CCP
	Charlevoix County Road Commission	CCRC
	Conservation Resource Alliance	CRA

Friends of the Boyne River	FOB
Friends of the Jordan River	FOJ
Grand Traverse Regional Land Conservancy	GTRLC
Lake Charlevoix Association	LCA
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
Water and Air Team Charlevoix	WATCH

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

Objectives Addressed: Each task and action supports one or more of the objectives detailed in Chapter 6 of the Watershed Management Plan.

The Monitoring Plan follows the Implementation Tasks and Actions table, and the Evaluation Strategy and the Information and Education Strategy are presented in Chapters 8 and 9, respectively.

Table 42: Implementation Tasks and Actions

Categories		Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category SP	Shoreline and Streambank Protection																		
SP.1	Conduct shore survey on Lake Charlevoix every 5 years; followup with property owners	H	$20,000	$40,000	Conduct survey in year 1	Conduct follow-up survey in year 6	Survey					Follow-up Survey					LCA, TOMWC	PF, SG, FG, PO	1.1, 2.1, 5.1
SP.2	Conduct littoral biotope study to produce local results of how shoreline development and littoral nearshore health is directly related to development	L	NA	$20,000	Complete study by year 10											Complete Research	TOMWC	PF, SG, FG, PO	1.1
SP.3	Inventory streambank erosion on Boyne and Jordan Rivers, Horton and Stover Creeks every 5 years	H	$10,000	$20,000	Complete inventory by year 3	Complete followup inventory by year 8			Inventory					Follow-up Inventory			ACD, CRA, FOB, FOJ, TOMWC	PF, SG, FG, PO	1.1
SP.4	Restore priority (moderate and severe) streambank erosion sties on Boyne River using bioengineering techniques	H	$100/LF	$40,000	Restore 50 LF/YR begininning year 3	Restore 400 LF by year 10			Restore	Restore	Restore	Restore	Restore	Restore	Restore	Restore	ACD, CRA, FOB, TOMWC	PF, SG, FG, PO, CS	2.1, 2.2, 2.3, 2.4
SP.5	Restore priority (moderate and severe) streambank erosion sties on Jordan River using bioengineering techniques	H	$100/LF	$40,000	Restore 50 LF/YR begininning year 3	Restore 400 LF by year 10			Restore	Restore	Restore	Restore	Restore	Restore	Restore	Restore	ACD, CRA, FOJ, TOMWC	PF, SG, FG, PO, CS	2.1, 2.2, 2.3, 2.4
SP.6	Restore priority (moderate and severe) streambank erosion sties on smaller tributaries using bioengineering techniques	M	$100/LF	$50,000	Restore 100 LF/YR beginning year 5						Restore	Restore	Restore	Restore	Restore	Restore	ACD, CRA, FOJ, FOB, TOMWC	PF, SG, FG, PO, CS	2.1,2.2, 2.3, 2.4
SP.7	Restore priority (moderate and severe) shoreline erosion sites on Lake Charlevoix using bioengineering techniques	H	$75	$67,500	Restore 100 LF/YR beginning year 2	Restore 900 LF by year 10		Restore	Restore	Restore	Restore	Restore	Restore	Restore	Restore	Restore	ACD, LCA, TOMWC	PF, SG, FG, PO, CS	2.1, 2.2, 2.3
SP.8	Reroute impaired sections of Jordan River Pathway to alleaviate stress on sensitive areas; monitor impacts	M	NA	$10,000	Identify sections in need of re-routing and plan alternate routes by year 3	Re-route at least 50% of the sections identified by year 10			Identify Alt. Routes							Re-route	ACD, FOJ, MDNR, TOMWC	PF, SG, FG, PO	2.4
			SP Total	$287,500															

Categories		Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category SW	Stormwater																		
SW.1	Support adoption of stormwater ordinances	H	NA	$10,000	Stormwater ordinance adopted by at least one local govt., by year 2	Stormwater ordinance adopted by remaining local govts., by year 10		Adopt								Remaining Govt.s Adopt	All	PO, LG	5.2
SW.2	Update stormwater infrastructre and impervious surface maps for each municipality	H	$1,500	$4,500	Complete updated maps by year 2			Complete Maps									Municipalities, TOMWC	PO, LG	5.1
SW.3	Develop model stormwater management plan (SMP) to present to local govt.	H	NA	$5,000	Complete model SMP by year 3	Present model SMP to each municipality by year 4			Complete Model SMP	Present Model SMP							MSUE, NWMCOG, TOMWC	PO, LG, PF	2.3
SW.4	Develop individual stormwater management plans (SMPs) for municipalities	H	$15,000	$30,000	Complete SMP for one municipality by year 6	Complete SMP for second municipality by year 10						Complete One SMP				Complete 2nd SMP	Municipalities, TOMWC	LG, PO, PF	2.3
SW.5	Work with municipalities to begin implementing BMPs (including retrofitting infrastructure, installing new infrastructure, and improved maintenance) from SW.4	H	$200,000/city	$600,000	Implement one BMP/year beginning year 3	Implement 6 BMP projects by year 10			Implement 1 BMP							Implement Remaining	Municipalities, TOMWC	PF, SG, FG, LG, PO, RG	2.3
SW.6	Inventory all outfalls (40) to Lake Charlevoix and establish monitoring program; monitor 8 sites/year for two years on a five year cycle (all 40 outfalls are monitored for 2 of 10 years)	H	$3,000/site	$192,000	Begin monitoring by year 3	Monitor 32 outfalls by year 10 (8 monitoring years)			Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	MDEQ, municipalities, TOMWC	PF, SG, FG, LG, PO	2.6

SW.7	Research options for stormwater utilities including utilizing the municipal water utility to fund future stormwater BMPs (operations and management, planning, capital improvements)	L	NA	$3,000	Compile information into report for distribution to municipalities by year 7								Complete				MSUE, NWMCOG, TOMWC	PF, LG, PO	5.2
SW.8	Inventory conditions of road ends on Lake Charlevoix and work with Road Commissions to implement better stormwater BMPs	M	NA	$20,000	Complete inventory; implement 2 road end projects by year 4	Implement 2 additional road end project by year 10				Complete Inventory/2 projects						Complete 2 additional projects	ACD, CCD, LCA, TOMWC	PF, SG, FG, LG, PO	5.1, 5.2
			SW Total	$864,500															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category PZ	Planning, Zoning and Land Use																		
PZ.1	Review each jurisidiction's zoning updates and changes on an annual basis to determine if there have been any adoptions of model ordinances.	M	$2,500	$25,000	Initiate in year 1	Complete 10 years of review by year 10	Review	Review	Review	Review	Review	Review	Review	Review	Review	Review	TOMWC	LG, PO	5.2
PZ.2	Support the use of Purchase of Development Rights for land protection	M	NA	$10,000	One local government to adopt PDR ordinance by year 5						Adopt						MSUE, NWMCOG, TOMWC	LG, SG	4.4
PZ.3	Support and strengthen enforcement of existing land use regulations, soil erosion programs, and ordinances by appropriate local government; provide financial assistance, programs, and educational tools.	M	NA	$40,000			Support	Support	Support	Support	Support	Support	Support	Support	Support	Support	ACD, ACP, CCD, CCP, local govts., NWMCOG, MSUE, TOMWC	PF, LG, PO, RG,	5.2
PZ.4	Develop and adopt ordinances to protect resources against introduction and spread of aquatic invasive species	H	NA	$10,000	One local government to adopt by year 3	Three additional local governments to adopt by year 10			1 Ordinance Adopted							3 Add. Ordin.'s Adopted	ACD, ACP, CCD, CCP, LCA, local govts., NWMCOG, MSUE, TOMWC	PF, LG, PO	1.2
PZ.5	Identify viewsheds and incorporate protection measures into local zoning master plans and ordinances	M	NA	$10,000	50% of local governments to incorporate viewsheds into zoning or master plans by year 8									Support			ACD, ACP, CCD, CCP, LCA, local govts., NWMCOG, MSUE, TOMWC	LG, PO	4.1
			PZ Total	$95,000															

Categories		Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category RSX	Road/Stream Crossings																		
RSX.1	Repeat road stream crossing inventory every 10 years to determine if priorites are the same, and to document newly installed BMPs or improvements	H	$20,000	$20,000	Complete inventory by year 4					Complete Inventory							CRA, TOMWC	PF, SG, FG, LG, PO	1.1
RSX.2	Develop a project schedule and fundraising plan to restore the priority road/stream crossings.	M	NA	$10,000	Form committee to develop schedule and plan by year 2			Committee									ACRC, CCRC, CRA,TOMWC	LG, PO	2.4
RSX.3	Restore, repair, or replace priority road stream crossings as determined in RSX.1 with BMPs appropriate to site (see section X, page. X)	H	Varies	$500,000	Complete 2 crossing projects by year 3	Complete 5 crossing projects by year 10			Complete 2 Projects							Complete 3 Additional Projects	ACD, ACRC, CCRC, CRA, FOB, FOJ, TOMWC	PF, SG, FG, LG PO	2.4
RSX.4	Work with road commissions to minimize impacts to resources. Conduct Better Backroads workshops to encourage better maintenance, design, and installation	M	$2,500	$7,500	Sponsor first "Better Back Roads" workshop by year 3	Sponsor two additional "Better Back Roads" workshops by year 10			Hold First Workshop							Hold Second Workshop	ACD, CRA, TOMWC	PF, SG, FG, LG, PO	5.2
RSX.5	Maintain and update Lake Charlevoix Watershed road/stream crossing database as part of River Care/LIAA website	H	$1,000/yr	$10,000	Ongoing		Update	Update	Update	Update	Update	Update	Update	Update	Update	Update	CRA	PF, SG, FG, PO	5.2
			RSX Total	$547,500															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category LP	Land Protection and Management																		
LP.1	Review priority parcel process every 5 years to identify additional priority parcels for protection.	H	NA	$3,000	Review priority parcel process by year 5						Review						GTRLC, LTC, TOMWC	PF, LG, PO,	1.2, 1.3, 4.1, 4.2, 4.3
LP.2	Distribute information to land owners of High and Medium priority parcels to encourage land protection	M	NA	$5,000	Distribute information by year 6							Distribute					GTRLC, LTC, TOMWC	PF, LG, PO	1.2, 1.3, 4.4
LP.3	Develop a fund to purchase conservation easements on priority parcels plan for land protection	M	NA	$5,000	Develop plan for long-term funding by year 3				Establish Fund								GTRLC, LTC	PF, LG, PO,	1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.5, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3
LP.4	Assist local units of government and the State of Michigan in acquiring land for protection of water quality and sensitive ecological features.	H	NA	$500,000	Acquire 50 additional acres by year 5						Acquire						GTRLC, LTC	PF, SG, FG, PO	1.2, 1.3, 1.4, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3
LP.5	Continue permanent land protection efforts in the throughout the Watershed	H	NA	$1,500,000	Jordan River Watershed: 700 acres total through acquisition (150 acres) and conservation easements (550 acres) by year 10	Outside the Jordan River Watershed: 300 acres total through acquisition and conservation easements by year 10										Protect	GTRLC, LTC	PF, LG, PO	1.2, 1.3, 4.4
LP.6	Promote Michigan Agricultrue Environmental Assurances Program (MAEAP) to encourage BMPs and (farmstead) verification	M	NA	$25,000	Achieve 15 verifications in the Watershed by year 10											Verifications	ACD, CCD, MSUE, NRCS	SG, PO	2.2
LP.7	Expand and conduct agriculture survey to assess water quality impacts	M	$2,500	$2,500	Complete survey by year 10											Survey	ACD, CCD, MSUE, NRCS	PF, SG, LG, PO	2.2
LP.8	Research and apply for funding to support BMP implementation on farms where water quality benefits will be achieved	M	NA	$1,500	Submit 3 grant proposal/applications by year 5						Seek Funding						ACD, CCD, MSUE, NRCS	PF, SG, FG, LG, PO, CS	2.2
			LP Total	$2,042,000															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category HFW	Habitat, Fish, and Wildlife																		
HFW.1	Install additional LWD and other habitat structure projects (reefs) in Lake Charlevoix	M	$1,250/reef	$50,000	Install 10 reefs by year 2	Install 30 additional reefs by year 5		Install			Install						LCA, MDNR, TOMWC	PF, SG, FG, LG, PO	3.2, 5.1
HFW.2	Survey woody debris/fish habitat project in Lake Charlevoix to gauge effectiveness; enhance structures as necessary	M	$2,500	$5,000	Complete survey of all structures by year 5	Complete follow-up survey of all structures by year 10					Survey					Survey	LCA, MDNR	PF, PO	1.1
HFW.3	Support LWD projects on the Boyne and Jordan Rivers, as well as the smaller tributaries	M	NA	$1,000			Support	Support	Support	Support	Support	Support	Support	Support	Support	Support	ACD, CRA, FOB, FOJ, MDNR, TOMWC	PF, SG, FG, LG, PO	1.1, 3.2
HFW.4	Continue to monitor and evaluate the Lake Charlevoix fishery by conducting general fisheries survey every 10 years	H	$6,000	$6,000	Survey year 5 (2016) as part of ongoing 10 survey cycle						Survey						MDNR	PO	1.1, 3.2
HFW.5	Stock Lake Charlevoix with 150,000 (8.7/acre) spring fingerling walleye every other year.	H	$7,000	$35,000	Begin stocking year 2	Complete 5 stocking years by year 10		Stock		Stock		Stock		Stock		Stock	MDNR	SG, FG, PO	3.2
HFW.6	Evaluate walleye stocking program through Serns Index survey in stocking years	H	$1,500	$7,500	Conduct survey in conjunction with walleye stocking; begin year 2	Complete 5 survey years by year 10		Survey		Survey		Survey		Survey		Survey	MDNR	PO	3.2

HFW.7	Stock Boyne River with 3,000 yearling brown trout and 8,000 yearling steelhead annually	H	$16,000	$160,000	Stock annually beginning year 1		Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	MDNR	PO	3.2
HFW.8	Stock Jordan River with 8,000 yearling steelhead annually	H	$12,000	$120,000	Stock annually beginning year 1		Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	Stock	MDNR	PO	3.2
HFW.9	Return Jordan River to the MDNR Fisheries Division as one of their Fixed Sites for Rotational Data Collection	H	NA	$10,000	Resume survey of Jordan River as a Fixed Site by year 8	Complete 3 year survey cycle according to Fixed Site protocol by year 10								Survey	Survey	Survey	MDNR	PO	3.2
HFW.10	Document nearshore habitat in Lake Charlevoix with a widely-used survey method; compile and distribute results to resource agencies and watershed groups	M	NA	$20,000	Complete survey by year 7								Survey				LCA, TOMWC	PF, SG, FG, PO	1.1
HFW.11	Document instream and streambank habitat of the Boyne River with a widely-used survey method; compile and distribute results	M	NA	$15,000	Complete survey by year 7								Survey				FOB, TOMWC	PF, SG, FG, PO	1.1
HFW.12	Document instream and streambank habitat of the Jordan River with a widely-used survey method; compile and distribute results	M	NA	$15,000	Complete survey by year 7								Survey				ACD, CRA, FOJ, TOMWC	PF, SG, FG, PO	1.1
			HFW Total	$444,500															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category RSH	Recreation, Safety and Human Health																		
RSH.1	Continue to monitor public beaches for potential health hazards, report advisories and beach closings	H	$250/per beach/sample =$44,000/yr	$440,000	Monitor 11 beaches on Lake Charlevoix once a week for 16 weeks annually		Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Local governnments	SG, FG, LG, PO	3.5
RSH.2	Conduct annual boat count to assess the number and types of watercraft observed on Lake Charlevoix and Round Lake	M	NA	$2,500	Document and update boat count database for 10 consecutive years		Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	LCA	LG, PO	3.4
RSH.3	Install launches for nonmotorized boats in heavily used areas, including Jordan River access. Work with Natural Rivers staff to comply with program requirements	H	$6,000	$30,000	Install 2 launches by year 5	Install 5 launches by year 10					Install					Install	FOB, FOJ, MDEQ, MDNR, TOMWC	PF, SG, FG, LG, PO, LB	3.5, 4.3
RSH.4	Monitor number of canoes launched by liveries	L	$1,000	$2,000	Conduct two counts (method TBD) by year 7								2 counts				ACD, FOB, FOJ	PF, PO, LG, LB	3.4
			RSH Total	$474,500															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category HG	Hydrology and Groundwater																		
HG.1	Compile known information of existing dams including physical characteristics, primary use, private/public ownership, fish passage issues, etc.	M	NA	$2,500	Complete report by year 5						Report						CRA, FOB, FOJ, TOMWC	PF, SG, FG, PO	1.1, 1.4
HG.2	Conduct feasibility study for removal of at least one dam on the Boyne River	M	NA	$1,000	Complete study by year 7								Study				CRA, TOMWC	PR, SG, FG, PO	1.1, 1.4
HG.3	Limit impervious surfaces in high groundwater recharge areas; work with local govts to develop and adopt ordinances	H	NA	$10,000	One local govt to adopt ordinance by year 3	Three additional local govt to adopt ordinance by year 10			One ordinance							3 additional ordinances	Local govts., MSUE, NWMCOG, TOMWC	LG	2.5
HG.4	Incorporate full study results of MSU modeling on Jordan River into WMP	M	NA	$500	Incorporate into WMP and distribute revised file AC as PDF by year 3				Incorporate								TOMWC	PO	1.1
HG.5	Compile existing watershed-wide groundwater data and assess existing data for gaps and potential studies	M	NA	$5,000	Complete report by year 5 and distribute to local govts and orgs						Report						TOMWC	PF, SG, PO	2.5
HG.6	Evaluate sub-watersheds of the major tributaries using the SWAT model (Soil and Water Assessment Tool) or other comparable tools that model at the landscape scale	M	NA	$50,000	Begin study in year 4	Complete study year 7							Complete study				TOMWC	PF, SG, FG, PO	2.1, 2.2, 2.3, 2.4
HG.7	Develop and distribute maps of priority groundwater discharge and recharge areas to local governments and organizations	L	NA	$2,500	Distribute by year 5						Distribute						TOMWC	PF, PO	2.5
HG.8	Inventory and summarize the status of wellhead protection plans	M	NA	$5,000	Compile results by year 3				Report								Local Governments, NWMCOG, State of MI	PO, LG	2.5

HG.9	Assess change in protected lands area with highly permeable groundwater every 10 years	L	NA	$2,500	Determine change in protected lands by year 10 and incorporate into revised WMP											Assess	TOMWC	PF, PO, LG	2.5
HG.10	Work with area businesses and property owners to encourage proper maintenance and monitoring of underground fuel storage tanks and other potential hazards	L	NA	$20,000	Begin locating potential sites for future removal or replacement; research costs and other needs by year 7								Report				LCA, Local Governments, MDEQ, NWMCOG, State of MI	PF, SG, LG, PO, LB	5.1, 5.2
			HG Total	$99,000															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category WQ	Water Quality Monitoring																		
WQ.1	Continue implementing Comprehensive Water Quality Monitoring (CWQM) program every 3 years on Lake Charlevoix, Nowland Lake, Deer Lake, Boyne, Jordan	H	$3,000	$9,000	Complete 3 CWQM cycles by year 10			Monitor			Monitor			Monitor			TOMWC	PF, LG, PO	2.6
WQ.2	Expand CWQM program sites to include one additional site in the main basin (2 sites total) and one site on the South Arm (3 sites altogether)	H	$3,000	$9,000	Add sites by year 2			Monitor			Monitor			Monitor			TOMWC	PF, LG, PO	2.6
WQ.3	Expand CWQM program sites to include one additional site on both the Jordan and Boyne Rivers; new sites to be upstream of existing sites	M	$500	$3,000	Add sites by year 2			Monitor			Monitor			Monitor			TOMWC	PF, LG, PO	2.6
WQ.4	Continue and expand participation in Volunteer Lake Monitoring program on Lake Charlevoix to include one additional site in the main basin (2 sites for main basin) and one site on the South Arm (3 sites total)	H	NA	$1,000	Recruit volunteers by year 3	Monitor at new sites through year 10	Monitor		Complete Recruitment			Monitor				Monitor	LCA,TOMWC	PF, SG, LG, PO	2.6
WQ.5	Expand Volunteer Lake Monitoring program to Round, Deer, Nowland, Adams and Patricia Lakes	M	NA	$5,000	Begin monitoring two additional lakes by year 4	Remaining lakes incorporated into VLM program by year 10		Monitor		Two additional sites			Monitor			Remaining Sites Incorporated	TOMWC	PF, SG, LG, PO	2.6
WQ.6	Promote participation in Volunteer Stream Monitoring program; develop incentives for participation	H	NA	$2,500	Recruit 10 monitors annually to adequately cover existing and expanded sites		Recruit	Recruit	Recruit	Recruit	Recruit	Recruit	Recruit	Recruit	Recruit	Recruit	FOB, FOJ, TOMWC	PF, SG, LG, PO	2.6

WQ.7	Maintain existing (10) Volunteer Stream Monitoring program sites and expand to include sites on Porter/Dyer, Monroe and Loeb Creeks	M	NA	$5,000	Monitor at least one new creek site by year 2	Monitor at all remaining new creek sites (min. 4) by year 8		One New Site	Monitor					Remaining Sites Incorporated			FOB, FOJ, TOMWC	PF, SG, LG, PO	2.6
WQ.8	Monitor tributaries (including Jordan and Boyne Rivers, Stover, Horton, Porter/Dyer, Monroe, Loeb and Creeks) at mouths to calculate pollutant loadings to Lake Charlevoix	H	$10,000/yr	$30,000	Monitor three consecutive years; 4-8 samples per year per site; begin year 5						Monitor	Monitor	Monitor				LTBB, TOMWC	PF, SG, FG, LG, PO	2.6
WQ.9	Expand monitoring parameters (PAHs, pharmaceuticals, etc) to address newly emerging water quality threats	M	NA	$5,000	Identify most critical parameters and develop strategy to monitor by year 5	Begin monitoring at least one new parameter by year 8					Develop Strategy			Monitor New Parameter			LTBB, MDEQ, TOMWC	PF, SG, FG, PO	2.6
WQ.10	Encourage the continuation of MDEQ fish tissue monitoring for Lake Charlevoix	M	NA	$1,000	Inform MDEQ of interest and support of monitoring on annual basis		Support	Support	Support	Support	Support	Support	Support	Support	Support	Support	MDNR, LTBB	PF, SG, FG, LG, PO	2.6
WQ.11	Develop database (MS Database or other) for all water quaity data and maintain annually	M	NA	$8,000	Create database by year 3 and update annually				Create Database	Update	Update	Update	Update	Update	Update	Update	TOMWC	PF, PO	2.6
WQ.12	Establish new monitoring sites (VSM or VLM) as emerging issues warrant the need	M	$500/site	$1,000	Add sites as needed; min. of two sites est. by year 10											Two additional sites	TOMWC	PF, PO	2.6
WQ.13	Determine the effectiveness of water quality protection efforts achieved through watershed management plan implementation by using the criteria set forth in the Evaluation Strategy	H	NA	$3,000	Compare 10 years of monitoring data with Evaluation Strategy criteria in year 10											Evaluate	TOMWC	PF, SG, FG, PO	2.6
			WQ Total	$82,500															

Categories		Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category WL	Wetlands																		
WL.1	Identify and evaluate wetlands for habitat value, water quality benefits, and flood control contributions	H	NA	$25,000	Compile results into report and distribute to local governments and other groups by year 3				Report Findings								TOMWC	PF, SG, FG, LG, PO	1.1, 1.2
WL.2	Identify potentially restorable wetlands, develop restoration plans, seek funding, and restore	M	$25,000 for planning, $125,000 restoration	$150,000	Complete restoration plans for one wetland (>1 acre) by year 8	Restore 10 acres by year 10								Complete Plans		Restore	LTBB, TOMWC	PF, SG, FG, LG, PO	1.2, 1.2
WL.4	Review MDEQ Part 303 (Wetland) permit applications and work with agencies, developers, and property owners to minimize impacts to resources	H	$5000/yr	$50,000	Ongoing		Review	Review	Review	Review	Review	Review	Review	Review	Review	Review	TOMWC	LG, PO	1.2
			WL Total	$225,000															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category AIS	Aquatic Invasive Species																		
AIS.1	Develop volunteer-based aquatic invasive species monitoring program	H	NA	$15,000	Develop program and begin implementation by year 5	Continue program through year 10					Program	Program	Program	Program	Program	Program	ACD,CCD, FOB, FOJ, LCA,TOMWC	PF, SG, FG, LG, PO	1.1
AIS.2	Develop a comprehensive AIS management strategy based on results of monitoring program (AIS.1)	H	NA	$25,000	Complete management strategy by year 10											Complete Strategy	ACD, CCD, LCA, LTBB, MDNR, TOMWC	PF, SG, FG, LG, PO	1.2
AIS.3	Support efforts to control *Phragmites* on Lake Charlevoix and Round Lake shorelines; work with local governments, resource agencies, and other to monitor and treat infestations	H	NA	$20,000	Keep *Phragmites* from spreading beyond current range		Support	Support	Support	Support	Support	Support	Support	Support	Support	Support	ACD,CCD, LCA, TOMWC	PF, SG, FG, LG, PO, CS, LB	1.2
AIS.4	Support efforts to control *Phragmites* on Lake Michigan coastline; work with local governments, resource agencies, and others to monitor and treat infestations	H	NA	$50,000	Keep *Phragmites* from spreading beyond current range		Support	Support	Support	Support	Support	Support	Support	Support	Support	Support	CCD, LCA, MDNR, TOMWC	PF, SG, FG, LG, PO, CS, LB	1.2
AIS.5	Treat *Phragmites* in Jordan River Watershed along the Jordan River Pathway	H	NA	$10,000	Complete first treatment/herbicide application year 1	Follow-up treatment (if necessary) year 2	Treatment	Treatment									ACD, FOJ, MDNR, TOMWC	PF, SG, FG, LG, PO	1.2
AIS.6	Research latest boat washing technology and promote boat washing stations throughout the Watershed	H	NA	$150,000	Install one boat washing station at heavily-used launch by year 5						Install						ACD, CCD, LCA, LTBB, TOMWC	PF, SG, FG, LG, PO	3.3, 3.4
			AIS Total	$270,000															

	Categories	Priority: High (H), Med. (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Objectives Addressed
Category WS	Wastewater and Septics																		
WS.1	Work with local govts and health departments to establish manadatory point of transfer septic system inspections	H	$2,000	$20,000	Two Antrim County townships to adopt ordinance by year 3; County to adopt by year 5.	Two Charlevoix County townships to adopt ordinances by year 5; remaining townships to adopt by year 10.			2 Antrim Townships Adopt		Antrim Co. Adopts; 2 CHX Townships Adopt					Remaining CHX Townships Adopt	LCA, NWMCOG, TOMWC	LG, PO, RG	5.2
WS.2	Graywater: gather model ordinances/regulations regarding the use of graywater and share with local governments and organizations	L	NA	$3,000	Complete and distribute by year 6							Report Findings					TOMWC, NWMCOG, MSUE	PF, LF, PO, LB	5.2
WS.3	Replace individual septic systems in communities where systems are ineffective or insufficient (refer to critical areas discussion) with community sewer systems	H	$10,000 per residence	$2,500,000	Extend existing or construct sewer systems to serve at least 50 homes by year 10											Replace	ACP, CCP, LCA, MDEQ, MSUE, NWMCOG	PF, SG, FG, LG, PO, RG, CS	2.3, 5.1, 5.2, 5.3
			WS Total	$2,523,000															

Table 43: Implementation Tasks and Actions Cost Summary

Recommended Tasks and Actions Cost Summary		
	Category	**Cost**
SP	Shoreline and Streambank Protection	$287,500
SW	Stormwater	$864,500
PZ	Planning, Zoning, and Land Use	$95,000
RSX	Road/stream Crossings	$547,500
LP	Land Protection and Management	$2,042,000
HFW	Habitat, Fish and Wildlife	$444,500
RSH	Recreation, Safety and Human Health	$474,500
HG	Hydrology and Groundwater	$99,000
WQ	Water Quality Monitoring	$82,500
WL	Wetlands	$225,000
AIS	Aquatic Invasive Species	$270,000
WS	Waste Water and Septics	$2,523,000
	Total	**$7,955,000**

MONITORING PLAN

Implementation tasks and actions include many different types of monitoring activities. Monitoring is essential in order to evaluate effectiveness of the collective watershed efforts or individual actions. The following narrative details many of the Recommended Implementation Actions and Tasks. The analogy of seeing your doctor for your yearly physical exam applies to this process. Monitoring can viewed as the appointment and the various exam techniques. The next step, the Evaluation Strategy, can be compared to a healthcare provider evaluating patient health, and is presented in Chapter Seven.

SURFACE WATER QUALITY MONITORING

Surface water quality monitoring will be used to evaluate the overall effectiveness of the nonpoint source watershed management plan and assess changes resulting from specific implementation activities. Water quality data collected by MDEQ, USGS, TOMWC, LTBB, academic institutions, and other sources will be used to assess changes over time in Lake Charlevoix, Deer Lake, Nowland Lake, the Boyne River, the Jordan River, Stover Creek, Horton Creek and any other tributaries and lakes for which there are available data. Monitoring programs will be expanded to include additional monitoring sites on large water bodies, such as Lake Charlevoix and the Jordan River, and on smaller lakes and streams that are currently not monitored, which will improve water quality assessments. If water quality data are not available in areas affected by implementation projects, additional sites will be monitored to evaluate effects of the projects.

Physical and chemical parameters to be monitored include, but are not limited to: dissolved oxygen, pH, temperature, conductivity, chemical oxygen demand, biological oxygen demand, suspended solids, dissolved solids, water clarity, turbidity, light, carbon, phosphorus, nitrogen, chloride, zinc, copper, lead, cadmium, nickel, mercury, and arsenic. Biological monitoring of bacteria, algae, aquatic macrophytes, aquatic macroinvertebrates, fish, and other aquatic organisms will supplement physicochemical data. A fish tissue monitoring program will be developed and implemented to assess changes in bioaccumulation of mercury. Discharge will be measured at sites on any lotic systems that are monitored. Additional physical, chemical, or biological parameters will be included in monitoring efforts in response to emerging water quality threats.

A Lake Charlevoix tributary survey will be conducted every 10 years, wherein all major tributaries of Lake Charlevoix are monitored concurrently throughout the course of three years to determine relative pollutant loadings from each stream. At a minimum, tributaries will be monitored two times per year and under a variety of hydrologic conditions (e.g., from low flow during dry periods of late summer to high flow from snowmelt and rainstorms in the spring). The primary pollutants of concern that will be monitored in the tributaries are sediments and nutrients, but will also include other parameters such as chloride. Discharge measurements will be made to determine pollutant loads and make comparisons among tributaries in terms of pollutant loads relative to discharge.

RIPARIAN MONITORING

Shoreline protection will be achieved by monitoring lake shorelines and streambanks on a regular basis. Shore surveys will be conducted every 5 years on Lake Charlevoix and every 10 years on smaller, developed lakes in the watershed. Parameters to be monitored on shorelines include indicators of nutrient pollution, erosion, greenbelt health, and shoreline alterations. Streambank surveys to document erosion, greenbelt health, and bank alterations will be conducted every five years on the Boyne and Jordan River systems and every ten years on Dyer, Loeb, Horton, Monroe, Porter, and Stover Creeks. The results of surveys will be used to conduct follow-up activities directed toward riparian property owners, which will identify specific problems and encourage corrective actions. Survey results will also be used for trend analyses to determine if riparian areas of lakes and streams are improving or deteriorating over time.

STORMWATER MONITORING

Stormwater discharge from urban areas will be monitored to determine negative impacts to surface waters and to evaluate changes in the quality and quantity of stormwater runoff. Considering that stormwater has only been monitored at a handful of sites in the watershed; the first priority is to collect baseline water quality data from all stormwater outfalls in the cities of Charlevoix, Boyne Falls, and East Jordan, which discharge into surface waters. Stormwater runoff from the 40 outfalls identified in inventories will be monitored on a rotating basis; eight outfalls monitored for a period of two years and rotating through to comprehensively monitor all 40 outfalls in a ten-year period. Baseline data will be used to identify serious water quality problems, investigate problem sources, and determine and implement corrective actions. In addition to identifying and correcting problems, subsequent monitoring will provide the means to evaluate BMP implementation projects, increases in impervious surface area, and other changes that have the potential to affect the quality and quantity of stormwater runoff. Stormwater system inventories will be updated every ten years and additional outfalls will be incorporated into the monitoring rotation.

Another priority is to monitor all rivers and large creeks in the watershed to calculate pollutant loadings and assess relative impacts of each tributary to Lake Charlevoix. By adjusting for discharge (i.e., volume per unit time), a tributary monitoring program could determine if a tributary was contributing excessive sediments, nutrients, or other pollutants to Lake Charlevoix. In addition, this monitoring would provide baseline data in many of the tributaries, which could be used in future monitoring to determine if pollutant loadings were being reduced through restoration and education efforts.

LAND USE MONITORING

Land use change and landscape alterations caused by humans will be monitored because of the strong potential to influence nonpoint source pollution. Although primarily done using remotely sensed data in a GIS, field surveys may also be required. Specific attention will be given to monitoring areas where BMPs have been implemented. Landcover data will be used to assess changes in land use every 10 years; comprehensively for the entire watershed, but also at the sub-watershed level. Increases or decreases in landcover associated with people (e.g., agricultural or urban) will be examined in context of changes in water quality and aquatic ecosystem health.

ROAD-STREAM CROSSING MONITORING

Road-stream crossings throughout the watershed will be surveyed every 10 years to document current conditions, update prioritization, and to evaluate improvements or BMP installations. As is the practice with road/stream crossings, most are not given attention until they are failing and resulting in a significant problem. Therefore, monitoring should also include informal discussion with resource managers and other partners to ascertain whether or not any road/stream crossings need more immediate attention.

LAND PROTECTION AND MANAGEMENT MONITORING

The priority parcel process is a tool that reduces nonpoint source pollution impacts to water resources by identifying parcels that are high priority for permanent protection based on ecological value and other criteria. This prioritization process will be carried out every five years to monitor land protection efforts; reevaluating all parcels in the watershed and assigning updated rankings. Progress in land protection will be evaluated by determining change over time in the number of parcels and the total land area in the watershed considered to be protected from development. Updated prioritization information will be shared with land conservancies that are active in the watershed to assist with land protection efforts. Agricultural surveys will be performed every five years to assess changes in both the amount and types of agricultural activity throughout the watershed.

HABITAT MONITORING

Habitat diversity is important for maintaining healthy, vibrant aquatic ecosystems, particularly in small streams and the littoral zone of lakes. Nonpoint source pollution can reduce the variety of available habitat in an aquatic ecosystem through excessive sedimentation and cultural eutrophication. Therefore, monitoring habitat conditions throughout the watershed is an important component for evaluating the effectiveness of nonpoint source pollution management plans.

Because little habitat information is available for the lakes and streams in the Lake Charlevoix watershed, the first step will be to collect baseline data. Field surveys will be conducted over the course of 10 years to document existing habitat in the streams and littoral zones of lakes, with a particular emphasis on large woody debris, gravel, and cobble. Volunteer water quality monitoring programs can be expanded to include and assist with habitat monitoring, both in lakes and streams. Future surveys will provide the necessary information for comparisons to determine trends in the amount and diversity of habitat in the watershed's lakes and streams.

Currently, the Lake Charlevoix Association is coordinating a fish habitat improvement project that involves placement of up to 125 wood structures throughout Lake Charlevoix. This project will be evaluated every 10 years; visually surveying structures to assess conditions and evaluating fish survey information to determine if structures have had positive impacts on the lake's fisheries. The effectiveness of future habitat improvement projects will also be evaluated on a 10-year basis.

RECREATION, HUMAN HEALTH, AND SAFETY MONITORING

Monitoring of recreation, human health and safety can be measured by the health alerts issued by the local health agencies. Oftentimes, health alerts are issued when water-related recreation, such as swimming, is prohibited due to a detected pathogen or other health threat. Beach closings are the most common alert; they are usually due to elevated *E. coli* levels. Other threats include avian botulism and swimmer's itch. Monitoring of mercury is also important. Mercury accumulates in fish tissue. Fish consumption, therefore, results in ingestion of mercury. Although the most significant source of mercury in the Lake Charlevoix Watershed is air deposition (which is outside the scope of Watershed Management efforts), monitoring of mercury levels in local fish should be a priority for the MDEQ.

GROUNDWATER AND HYDROLOGIC MONITORING

Groundwater is susceptible to contamination by nonpoint source pollution. In addition, landscape development and groundwater withdrawals (e.g., agricultural irrigation and drinking water) have the potential to reduce the amount of available groundwater. Therefore, groundwater monitoring is needed to assess the effectiveness of the nonpoint source management plan.

The status of the quality and quantity of groundwater in the Lake Charlevoix watershed is currently unknown. Some data are available through sources such as well testing records and a hydrologic study recently completed for the Jordan River watershed. Thus, the first step will be to compile all existing groundwater information, identify problems, determine data gaps, and develop a strategy for feasible, effective, and long-term groundwater monitoring in the Lake Charlevoix watershed. This assessment of existing information and development of a monitoring plan will be completed in 10 years.

High groundwater recharge areas are determined by the presence of permeable soils that allow for relatively rapid recharge of groundwater stores. They have been delineated for the Lake Charlevoix watershed because groundwater in these areas is particularly vulnerable to landscape development and nonpoint source pollution. The same permeability that lends itself to high groundwater recharge rates can also result in nonpoint source pollution passing relatively quickly through the soils and contaminating groundwater stores. Furthermore, increased impervious surface area as a result of landscape development leads to relatively greater decreases in groundwater recharge in areas with highly permeable soils (versus areas with lower soil permeability).

One approach for protecting high groundwater recharge areas is to limit impervious surface coverage. This can be accomplished through various means, such as implementing ordinances that limit the amount of impervious surface area on a parcel or limiting build out potential through permanent land conservation. Efforts focused on protecting high groundwater recharge areas will be evaluated every ten years by determining changes (net gain or loss) in the extent of permanently protected lands in areas with high groundwater recharge rates.

Sedimentation in surface waters is considered one of the most damaging forms of nonpoint source pollution; smothering fish and invertebrate habitat, clogging fish gills, raising water temperatures, increasing nutrient levels, and reducing dissolved oxygen concentrations. Sediments enter streams, lakes, and wetlands naturally, but a variety of human activities causes sedimentation rates to increase, such as plowing in agricultural areas, building and road construction, and deforestation. Hydrologic studies of the major tributaries in the Lake Charlevoix Watershed will be performed to evaluate sediment contributions, identify sources of sediments, and prioritize actions to address sediment pollution. Sediment inputs will be evaluated for sub-watersheds of the major tributaries using the SWAT model (Soil and Water Assessment Tool) or other comparable tools that model at the landscape scale. Sediment transport will be monitored in streams by monitoring suspended and dissolved solids. Field surveys will be conducted to document sediment sources, such as eroding stream banks, road-stream crossings, agricultural activity, and erosion caused by stormwater runoff. Sediment pollution problems identified during modeling, monitoring, or field surveys will be ranked to prioritize remediation.

WETLAND MONITORING

Wetland restoration and protection efforts will be monitored by performing land cover change analyses in a GIS. A watershed-level analysis will be performed every 10 years using remote sensing data to determine increases or decreases in wetland acreage throughout the watershed. Focused analyses will be performed at the sub-watershed level to evaluate changes where wetland restoration has occurred.

High-value wetlands will be identified and mapped out by assessing wetlands throughout the watershed in terms of ecological and environmental values (e.g., habitat value, water quality benefits, and flood control contributions). Following identification and mapping, the areas containing high value wetlands will be calculated every 10 years to determine any net change.

AQUATIC INVASIVE SPECIES

Numerous aquatic invasive species have been documented in the surface waters of the Lake Charlevoix Watershed including *Phragmites*, purple loosestrife, Eurasian watermilfoil, zebra mussels, quagga mussels, and round gobies. The documented invasive species primarily afflict Lake Charlevoix, but are gradually spreading to other water bodies in the watershed. Using databases maintained by TOWMC and USGS, both the introduction of additional aquatic invasive species and the spread within the watershed of documented aquatic nuisance species will be tracked. Aquatic invasive species control, such as LCA's current efforts to locate and treat all *Phragmites* stands on the Lake Charlevoix shoreline, will be monitored through follow-up surveys conducted every five to ten years.

LOW IMPACT DEVELOPMENT (LID) MONITORING

Implementation of LID practices is an important aspect of the recommended tasks and actions. As more LID projects are implemented, public interest, awareness and familiarity with LID practices will increase. Tracking the number of implemented projects through Information/Education (I/E) efforts, as well as public interest and awareness, will be ongoing.

SOCIO-ECONOMIC MONITORING

Many projects carried out as a result of the watershed plan will have social and economic impacts. For example, nonpoint source pollution education of watershed residents may affect behavior and result in a reduction of nonpoint source pollution, or nonpoint source pollution reductions in surface waters may increase local tourism revenues and boost the economy. Therefore, monitoring activities should also include social and economic elements.

There are many methods for monitoring social and economic changes as a result of the management plan. Some of the primary tools for conducting this type of monitoring include surveys and demographic/economic change analyses. To establish relationships between socio-economic factors and nonpoint source pollution, data from other monitoring activities (e.g. surface water quality monitoring) will be incorporated into this monitoring effort.

CHAPTER EIGHT: EVALUATION STRATEGY

To ensure that the recommended actions are meeting the goals of the watershed plan, an evaluation will be required to determine the progress and effectiveness of the proposed activities. The evaluation step is an important part of any watershed planning effort in that it provides feedback on the success of an activity or the project's goals. It also provides communities with important information about how to conduct future efforts, or how to change the approach to a specific problem in order to be more successful the next time. If activities are successful, this will gain more support for future activities amongst decision makers.

The success of the Lake Charlevoix Watershed Management Plan will be evaluated by determining

- Progress in completing the recommended actions and tasks (plan implementation)
- Effectiveness in protecting water quality

EVALUATION STRATEGY FOR PLAN IMPLEMENTATION

An evaluation strategy for plan implementation will be used to determine progress in completing the recommended actions and tasks identified in the plan. The Advisory Committee will review the recommended tasks and actions annually during one of their quarterly meetings and identify what has been accomplished during the last year.

A more thorough assessment every 5 years will also identify what actions and tasks have been completed, as well as review the priority ranking of individual actions. As priority actions are accomplished, lower priority actions may be reassigned to be medium or high priority. In addition, new recommendations may be added in response to new issues and concerns, methodologies, data, and as other information is learned. The 5 year assessment will include an advisory committee "stocktaking" based on an effective evaluation strategy developed for the Little Traverse Bay Watershed Management Plan in 2011. The Little Traverse Bay Advisory Committee decided to "take stock of the progress that had been made on the actions recommended in the Plan; to identify the highest priorities for action today, given developments over the past five years; and to get input from partners on how to improve implementation of the LTB Watershed Protection Plan." The evaluation was based on soliciting opinions of the Advisory Committee on a one-on-one basis. A series of interview questions (see Appendix D) were used to elicit responses that would gauge the interviewee's sense of the effectiveness of the plan, its strengths and weaknesses, areas in need of change, usefulness, etc. Interviewee responses were compiled into a report of key findings and suggestions. The stocktaking effort was considered very insightful and will influence the future success of the Advisory Committee through implementing change, such as meeting structure and agendas. As an example, one key finding includes:

> The scope of the Plan and, thus, the agendas for many of the Committee's meetings, is too broad for many partner organizations and their representatives, and may have contributed to lower participation at Committee meetings. To address this, one suggestion was to convene smaller working group meetings around a few priority topics and hold general meetings less frequently (e.g., once a year). Another was to focus each meeting on a different aspect of the plan and target speakers, field visits, and participation accordingly.

Based upon the informative result of this evaluation method, the Lake Charlevoix Watershed Management Plan Advisory Committee will undergo a similar stocktaking strategy every five years. Although a fairly intensive process, the results will be very valuable to the success of the overall watershed management effort.

EVALUATION STRATEGY FOR THE OVERALL MANAGEMENT PLAN

The evaluation strategy for the overall management plan in protecting water quality is based on comparing criteria with monitoring results. The Monitoring Strategy in the (add detail/page number, etc.) provides the framework in which to collect the appropriate data. Continuing the analogy of a health exam, when your healthcare provider takes your blood pressure, pulse, and listens to your lungs, they are collecting data. They then apply standards, or criteria, based on your age and other factors, to gauge your degree of health. For the Lake Charlevoix Watershed, the following criteria have been identified as a way to determine its health. Blood pressure and pulse, however, are not the only indicators of health; a trained medical professional can also understand patient health by noting qualitative measurements, such as movement, mood, and speech. The same applies to evaluating watershed health; therefore, qualitative measurements are an important part of the evaluation strategy and should be noted when appropriate.

CRITERIA USED TO DETERMINE EFFECTIVENESS OF WATER QUALITY PROTECTION EFFORTS

A set of criteria were developed to determine if the proposed pollutant reductions in the Lake Charlevoix Watershed are being achieved and that water quality is being maintained or improved. The water quality criteria for parameters that reflect nutrient and sediment pollution are as follows:

1. **<u>Total phosphorus concentrations in Lake Charlevoix remain below 5 PPB</u>**

   Total phosphorus concentrations in large, deep, oligotrophic lakes are typically less than 10 PPB, which is the case for Lake Charlevoix whose phosphorus has been about 1 to 2 PPB in recent years.

2. **<u>Total phosphorus concentrations in tributaries to Lake Charlevoix remain below 20 PPB.</u>**

   Phosphorus concentrations in surface waters are not regulated by the State of Michigan or the USEPA. However, the USEPA recommends that total phosphorus concentrations in streams discharging into lakes not exceed 50 parts per billion (PPB).

3. **<u>Total Nitrogen concentration in Lake Charlevoix and its tributaries should remain below 1 PPM.</u>**

   Nitrogen concentrations in surface waters are also not regulated by the State of Michigan or the USEPA.

4. **<u>Maintain high dissolved oxygen levels in Lake Charlevoix and tributaries.</u>**

   Dissolved oxygen concentrations in Lake Charlevoix and its tributaries are typically above the 7 PPM standard that is required by the State of Michigan for water bodies that support cold-water fisheries. The small, shallow lakes and small slow-flowing streams in the Watershed, such as Nowland Lake and the upper section of Stover Creek, may naturally support a warm-water fishery and, therefore, only be required to maintain a minimum dissolved oxygen level of 5 PPM. Thus, it should be considered that water quality throughout the watershed is being maintained if dissolved oxygen concentrations in Lake Charlevoix, Round Lake, the Boyne River, the Jordan River, the Green River, and the Pine River are above 7 PPM and those of Adams Lake, Deer Lake, Nowland Lake, and the minor tributaries of Lake Charlevoix are above 5 PPM. In the event of the occasional reading that falls outside of these criteria, efforts to determine if the reading is inaccurate (e.g. faulty equipment) or if the reading marks the beginning of a trend will be noted.

5. **<u>Reduce nutrient inputs from stormwater in urban areas.</u>**

   Depending on numerous factors, such as drainage area, land-cover type, and time period between rain events, nutrient loads in stormwater can vary widely. Current monitoring efforts in Boyne City and East Jordan will provide some idea of nutrient loading to Lake Charlevoix and its tributaries from urban stormwater. However, much more data will be needed to generate a comprehensive baseline data set and accurately assess stormwater impacts throughout the watershed. Once baseline data are available, implementation projects that aim to reduce nutrient loads from stormwater in urban areas can be assessed through future stormwater monitoring.

6. Maintain or reduce sediment loads in tributaries and stormwater draining into Lake Charlevoix and its tributaries.

Similar to nutrient inputs in stormwater, sediment data are being generated through ongoing stormwater monitoring projects, which can then be used to determine load reductions as a result of implementation projects. Sediment load data are also quite limited for tributaries flowing into Lake Charlevoix. Once baseline data are generated, comparisons can be made to determine changes in time as related to implementation projects.

7. **Maintain pH levels within range of 6.5 to 9.0 in Lake Charlevoix and tributaries as required by the State of Michigan.**

Data from the TOMWC Comprehensive Water Quality Monitoring program show that pH levels consistently fall within this range.

8. Maintain or reduce the level of conductivity in Lake Charlevoix and tributaries.

Conductivity levels have been monitored in Lake Charlevoix, Deer Lake, Adams Lake, the Boyne River and the Jordan River as part of the TOMWC CWQM program and typically ranged from 200 to 400 µS/cm. Therefore, conductivity levels should consistently be less than 1000 µS/cm and generally be less than 500 µS/cm in surface waters of the Lake Charlevoix watershed.

9. Maintain low water temperatures in all water bodies in the Lake Charlevoix Watershed that are designated or capable of sustaining cold-water fisheries.

Lake Charlevoix, the Boyne River, and the Jordan River must maintain low water temperatures to sustain their cold-water fisheries. Water temperatures below the thermocline in Lake Charlevoix should generally not exceed 15° Celsius throughout summer months. Water temperatures in the Jordan River upstream of Rogers Road should not exceed 15° Celsius. Water temperatures in the Boyne River, upstream of the eastern limits of Boyne City and excluding impounded areas, should not exceed 15° Celsius.

10. Prevent beach closings on Lake Charlevoix due to bacteriological contamination.

Prevent beach closings on Lake Charlevoix due to *E. coli* levels that exceed the State of Michigan water quality standard for single day (>300 *E. coli* per 100 ml of water). Prevent extended beach closings (there have been none to date) on Lake Charlevoix that result from a 30-day geometric mean measurement that exceeds State standards (>130 *E. coli* per 100 ml of water in 5 samples over 30 days).

11. **<u>Maintain or improve aquatic macroinvertebrate community diversity in streams that have been monitored and expand monitoring efforts to document and assess aquatic macroinvertebrate diversity in other streams throughout the watershed.</u>**

Aquatic macroinvertebrate diversity in a stream varies depending on many variables, including stream size, stream flow, habitat diversity, water temperature, riparian vegetation, land use, and more. Therefore, aquatic macroinvertebrate diversity at a given location on a stream must be viewed through a lens that accounts for such variables and then, compared with like sites in the same stream system or in other streams to accurately gauge stream ecosystem health. Reliable baseline data requires monitoring a site for a minimum of three years, after which the site can be compared to others using diversity indices to determine if the site and stream are normal and healthy. Thereafter, future monitoring can be conducted to assess the benefits of implementation projects to stream ecosystem health.

12. **<u>Reduce *Cladophora* algae growth on the Lake Charlevoix shoreline that is caused by nutrient pollution.</u>**

Cladophora algae occurs naturally in small amounts along the shorelines of Northern Michigan lakes, but grows more extensively and densely as nutrient availability increases. Surveys on Lake Charlevoix, the most recent completed in 2007, have documented the occurrence of *Cladophora* on the shoreline, as well as the density of growth. Results tallied from the survey provide statistics for the number of shoreline properties where *Cladophora* was observed, and more importantly, the number of properties where heavy-density growth occurred. Thus, the same information generated during future surveys can be used to determine if there were reductions in the number of properties with *Cladophora* growth or the number with heavy-density growth as a result of implementation projects.

13. **<u>Maintain chlorophyll-a concentrations in surface waters typical for lakes in Northern Michigan.</u>**

Chlorophyll-a concentrations should be maintained within normal ranges for similar lakes in Northern Michigan to prevent problems associated with large phytoplanktonic algae blooms that can cause water quality problems (e.g., low dissolved oxygen levels). Based on TOMWC VLM data from lakes throughout the region, typical summer-averaged chlorophyll-a concentrations for Lake Charlevoix should range from 0-4 PPB, with action needed to investigate if levels surpass 5 PPB. The smaller lakes in the watershed are more biologically productive, should maintain summer-averaged chlorophyll-a concentrations of less than 6 PPB, with action needed if levels surpass 8 PPB.

14. <u>Maintain low chloride concentrations in surface waters</u>

Data from the TOMWC CWQM program show that chloride concentrations have increased significantly over the last 20 years in most lakes and streams monitored in Northern Michigan. Chloride levels in Lake Charlevoix increased from ~5 PPM to ~10 PPM from the 1970s to 2010, though the highest level recorded in the watershed was in Deer Lake at 15 PPM. Chloride is monitored because it is a good indicator of human activity in a watershed, i.e., as human population increases and urban and agricultural landuses increase, chloride levels tend to increase. In addition, monitoring chloride is valuable because it indicates that more damaging pollutants associated with chloride, such as leaking fluids and metals from automobiles that accumulate on roads along with deicing salts, are washing into and negatively impacting adjacent surface waters. Although most aquatic life is not affected by chloride reaches very high concentrations (>1000 PPM), some sensitive organisms may be lost at lower levels over the long-term. Considering the naturally low levels found in the surface waters of the Lake Charlevoix Watershed and the fact that rising chloride levels may indicate increasing levels of other associated pollutants, chloride concentrations in the watershed's surface waters should not surpass 50 PPM and remedial actions should be taken if levels reach 100 PPM.

In addition to applying the abovementioned criteria, more qualitative evaluation methods will be used. Field assessments of BMPs, such as LID or streambank or shoreline bioengineering projects, will determine effectiveness by taking photographs, gathering physical, chemical, and/or biological data. We will also document projects with photographs to evaluate their effectiveness or need for improvement or modification. For example, shoreline and streambank restoration projects will be photographed before any restoration begins, during project installation, and after project completion. Other project types that may also warrant photographic documentation include road/stream crossings, stormwater and agricultural best management practices (BMPs), recreational access sites, etc.

CHAPTER NINE: INFORMATION AND EDUCATION STRATEGY

The long-term protection of the Lake Charlevoix Watershed largely depends on the actions of its residents and visitors. Educating and increasing awareness of how their actions impact water quality is a priority. Effective communication is the vehicle for education, and ultimately, to change attitudes that lead to better water quality protection efforts. Seasonal and permanent riparian property owners, landscape professionals, local government officials, developers, and many other groups comprise the overall Lake Charlevoix Watershed audience; however, more narrow, or target, audiences should be addressed through the appropriate information and education lens. Table 38 includes the Watershed's most common pollutants, their sources and causes, target audiences, effective messages, delivery mechanisms, and evaluation strategies that pertain to them.

A significant step toward better understanding current attitudes of watershed residents was made in 2009, as part of the MDEQ 319-funded "Lake Charlevoix Watershed: Local Government Solutions." Michigan State University Extension coordinated the Social Indicators Survey component of the project; a survey of 3 distinct audiences within the watershed. The survey was designed to assess the attitudes and practices of watershed landowners, local elected and appointed officials, and Lake Charlevoix riparian property owners. MSUE has expanded their efforts to include a fourth survey component, which includes focus groups with local officials. Interview results for this component will be available in late 2012.

The survey responses exceeded expectations; survey responses are typically much lower.

Landowner Survey:	sent: 934; received responses: 401 = 43% return
Officials Survey:	sent: 315; received responses: 192 = 61% return
Riparian Survey:	sent: 664; received responses: 395 = 60% return

Survey information for the more rural watersheds, like the Lake Charlevoix Watershed, is not typically available. Therefore, this insight is very valuable for formulating information and education actions. Based on the available results from the survey, the following recommendations include:

1. General awareness education programs do not need to persuade residents or local leaders about the importance of good water quality, nor the relationship between water quality and economic development. Survey results indicate that watershed residents and local officials have very positive attitudes about the value of water quality in the Lake Charlevoix watershed. They strongly agree that both economic development and quality of life depends on good water quality.

2. Education programs should *focus on specific pollutant and source risks*, especially phosphorus. Although most survey respondents perceived few watershed impairments, a high percentage didn't know if a specific pollutant or condition was a problem or not. For instance, 63 percent of watershed residents and 51 percent of local officials didn't know if phosphorus is or is not a problem in the watershed.
3. Education programs targeting homeowners should *concentrate on information, skills and demonstrations of specific practices*. The survey indicated that landowners are very willing to make changes to their lawn and garden practices, and perceive few limitations to doing so. When they did perceive limitations, it was most often related to a need for information, skills or demonstration of the practice.
4. Information efforts should *directly address out-of-pocket expenses for implementing priority practices*. Cost of a practice was the most frequently mentioned limiting issue, although still not a major barrier.
5. *Focused attention is needed to increase awareness of newer practices such as rain gardens and porous pavement.* Even though these techniques have been promoted and described in educational materials for some time, understanding and adoption rates of these practices is low, both for landowners and local officials.
6. *Education programs for landowners should not rely on workshops, demonstrations and meetings as a primary method.* Only one of six survey respondents listed workshops, demonstrations and meetings as a place where they seek water quality information. Most common sources were newsletters, brochures and factsheets, followed by Internet, newspaper and magazines.
7. *Education programs for local officials should continue to focus on written materials and workshops/demonstrations/meetings.* Written materials are the most common source of water quality information for local officials. In contrast to watershed residents, two-thirds of local officials seek water quality information through meetings.
8. New efforts emphasizing *peer-to-peer learning may increase success of water quality education ef*forts, especially with local officials. Six of ten local officials and four of ten watershed residents see water quality information through "conversations with others." Research supports the idea that individuals often learn best from people like them – their peers – more than from technical experts.
9. Information and education materials and education efforts should continue to be hosted and branded by Tip of the Mitt Watershed Council, The Lake Charlevoix Watershed Management Plan Advisory Committee, MSU Extension, Conservation Districts and other conservation organizations. These organizations have a long history of water quality education and are trusted by watershed residents and local officials.

10. Education efforts for local officials should continue to help communities understand and assess water quality provisions within their own plans and ordinances. Between 8 and 60 percent of local officials didn't know if their community used a specific practice.
11. Water quality education efforts for local officials should facilitate communication and coordination of water quality between neighboring communities. Even though cooperation between governmental units has been promoted by organizations and agencies, only one of four local officials reported that they knew how to coordinate their water quality zoning provisions with neighboring communities, and just one of five indicated that their community uses the practice.
12. To reduce barriers to adoption or revision of water quality-related plan or zoning ordinance changes, education efforts could emphasize public participation in exploring options and crafting new/changed regulations. Local officials reported that the top three barriers to changing planning and zoning practices to protect water quality are resistance to new regulations, concern about economic impacts, and approval by community residents. Public engagement throughout the process may help reduce those barriers.
13. The surveys of local officials and shoreline owners should be repeated periodically to assess change and effectiveness of educational programs. The local official's survey will be repeated in January 2012. Both surveys should be repeated every 3-5 years.

Although the Social Indicators Survey captured the perspectives of residents of the Lake Charlevoix Watershed and more specifically, local government officials, other segments of the overall population should also be surveyed to better gauge their knowledge. Table 44 identifies specific messages and delivery mechanisms for each of the target audiences. Tailoring messages to each audience is important to maximize effectiveness.

Table 44: Information and Education Communication Strategy

Pollutant	Source/Cause	Target Audience	Messages	Delivery Mechanism	Potential Evaluation
Sediment	Lakeshore erosion	Homeowners, riparian property owners	Protect lake water quality for future generations and to protect your investment.	Install demonstration shoreline (using bioengineering methods/greenbelt), feature in newsletters and brochures.	Photographic and survey to homeowners with erosion
	Streambank erosion	Canoeists, anglers, canoe liveries	Protect the Jordan River.	Build partnership with local canoe liveries, involve local groups with restoration and other creative education approaches.	Interviews
	Livestock in streams	Agricultural landowners	Help protect water quality and save money.	Conservation District and NRCS to meet with contacts and provide assistance.	Photographic and interviews
	Road/stream crossings	Road Commissions	Help protect water quality and save money.	Meet with road commissions to discuss standard designs that reduce pollution and are cost effective.	Photographic and interviews
	Lakeshore development-construction	Contractors, Realtors, Local Government Officials, Homeowners	Protect water quality and property values.	Give presentations at workshops, work with local governments to standardize setback distances, and use print media to educate riparians about the importance of setbacks.	Focus group
Nutrients	Lawn maintenance	Landscaping and lawn care companies, homeowners, riparian property owners	Protect water quality and protect your investment.	Sponsor seminars for landscaping companies to learn more about water quality friendly yard maintenance. Sponsor workshops and use print media to reach riparians.	Survey
	Failing septic systems	Riparian property owners	Protect water quality and keep the water safe for swimming.	Meet one-on-one with property owners who may have potential septic system problems. Provide assistance to address problems.	Interview
	Manure application	Agricultural landowners	Protect water quality	Conservation District and NRCS to meet with	Photographic and

Pollutant	Source/Cause	Target Audience	Messages	Delivery Mechanism	Potential Evaluation
	management	with livestock	and save money.	contacts and provide assistance.	interview
Toxins -- oil, heavy metals, grease, etc.	Urban stormwater	Homeowners	We are all lakefront property owners (via drains).	Media campaign with local newspapers, radio, and TV. Mail information on reducing nonpoint source pollution to residents	Survey
Pesticides	Lawn maintenance	Homeowners, riparian property owners	Protect lake water quality for future generations and your investment.	Sponsor seminars for landscaping companies to learn more about water quality friendly yard maintenance. Sponsor workshops and use print media to reach riparians.	Focus group and survey
	Agricultural fields	Agricultural landowners	Protect water quality and save money.	Conservation District and NRCS to meet with contacts and provide assistance	Photographic and interview
Pathogens	Stormwater	Urban pet owners	Keep the water safe for swimming and protect water quality.	Implement media campaign about proper disposal of pet waste	Survey

Implementation of the IE Strategy will support the following Information and Education goal (included in Chapter 6 as Goal #6) and objectives:

I/E GOAL: DEVELOP EFFECTIVE EDUCATIONAL AN D COMMUNICATION EFFORTS AND PROGRAMS THAT SUPPORT AND PROMOTE WATERSHED PROTECTION ACTIVITIES.

OBJECTIVES:	
1	Work collaboratively with all stakeholders to optimize their talents, skills, knowledge, and the opportunities and resources available to them.
2	Stay current with resource issues affecting the Lake Charlevoix Watershed and, in turn, convey issues and their potential impact on local resources to wider Watershed audience(s).
3	Develop innovative programs to engage Watershed audience(s)
4	Utilize innovative methods of communication to effectively reach Watershed audience(s).
5	Develop clear, concise, and consistent messages to Watershed audience(s) that effectively communicates their respective role(s) in watershed protection efforts.

The I/E activities include a variety of approaches including installing demonstration sites, building partnerships, sponsoring seminars and workshops, and developing new and informative educational materials. The cumulative impact of these efforts will result in the support of not only the IE Strategy goal and objectives, but also the five goals of the Watershed Management Plan (Chapter Five).

The Table 44 includes a comprehensive list of proposed I/E tasks and actions that, if implemented, will result in water quality protection or improvements. Tasks and actions are organized by category to facilitate easy reference. The recommendations are based on a 10 year timeline (2012-2021), a standard duration of time for a watershed management plan. Each task and action identifies the following:

Priority Level: Each task and action has been assigned a priority level based on one or more of the following factors: urgency to correct or reduce an existing problem; need to enact a specific task or action before a problem develops; availability of funds, partner(s) or program(s) ready to implement; and the overall need to balance low (L), medium (M), and high (H) priorities over the course of then years.

Unit Cost/Cost estimate: An estimated unit cost is provided when applicable. An estimated total cost is provided when applicable and calculable. In addition, Table 40 summarizes I/E Tasks and Actions costs by category.

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

Timeline: Based on the ten year span of the watershed management plan, the year in which the task or action is to begin or end is noted. When a task or action is ongoing, it is noted as spanning the ten years.

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

Abbreviations:	Antrim Conservation District	ACD
	Antrim County Planning Dept.	ACP
	Antrim County Road Commission	ACRC
	Charlevoix Conservation District	CCD
	Charlevoix County Planning Dept.	CCP
	Charlevoix County Road Commission	CCRC
	Conservation Resource Alliance	CRA
	Friends of the Boyne River	FOB
	Friends of the Jordan River	FOJ
	Grand Traverse Regional Land Conservancy	GTRLC
	Lake Charlevoix Association	LCA
	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
	Water and Air Team Charlevoix	WATCH

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

Objectives Addressed: Each task and action supports one or more of the five I/E objectives.

Table 45: Information and Education Strategy Recommended Tasks and Actions

Categories/Tasks		Priority: High (H), Medium (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Goal and Objectives Addressed
Category G	General																		
G.A	Continue to bring attention to the Lake Charlevoix Watershed through partners' newsletters, e-news, websites, and other published updates.	H	$10,000/yr	$100,000	Ongoing						Ongoing						All	PO	6.2,6.4, 6.5
G.B	Provide regular press releases to local media featuring watershed management efforts	H	$1,000/yr	$10,000	Ongoing						Ongoing						All	PO	6.2, 6.4
G.C	Offer field trips (paddling, hiking) to community to explore and learn about local natural resources.	H	$1,500/yr	$15,000	Ongoing						Ongoing						ACD, CRA, FOB, FOJ, LCA,	PO, RG	6.3
G.D	Continue to host Experience Lake Charlevoix, an on-the-water science-based field trip for local middle schoolers	H	$5,000/yr	$50,000	Ongoing						Ongoing						FOB, FOJ, LCA, TOMWC, WATCH	PF, PO	6.1, 6.3
G.E	Update Lake Charlevoix Watershed Permit Guide with current regulations and contacts; distribute print and electronic copies	M	NA	$3,000	Update by year 3	Second update by year 8			Update					Update			LCA, local governments, TOMWC	PF, PO	6.5
G.F	Coordinate and implement quarterly Lake Charlevoix Watershed Advisory Committee meetings	H	$5,000/yr	$50,000	Ongoing						Ongoing						ALL	PF, SG, FG, LG, PO	5.3
G.G	Evaluate plan implementation progress, via Stocktaking Strategy , with Acvisory Committee every five years	H	$2,500	$5,000	Perform stocktaking in year 5	Perform stocktaking in year 10					Evaluate					Evaluate	ALL	PF, SG, FG, LG, PO	5.3
			G Total	$233,000															

Categories/Tasks		Priority: High (H), Medium (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Goal and Objectives Addressed
Category 1	Shoreline and Streambank Protection																		
SP.A	Install demonstration riparian buffers on publicly-owned properties	H	$10/SF	$50,000	Install 5,000 SF by year 7								Install				ACD, CCD, FOB, FOJ, LCA, local govts., TOMWC	PF, SG, FG, LG, PO, CS	6.1, 6.3
SP.B	Develop incentive program for riparian buffers that may include tax credit, awards, vouchers, discounts on landscape supplies and services, etc.	L	NA	$10,000	Develop program by year 7 and present to appropriate authorities, agencies, and vendors; include details of proposed economics								Develop Program				ACD,CCD, LCA, local govts., MSUE, TOMWC	PF, LG, PO, RG, LB	6.3
SP.C	Develop comprehensive booklet for riparians that details best management practices for shorelines, shoreline ecology, as well as geological and human histories of Lake Charlevoix; include information on local resource groups and agencies	M		$30,000	Convene committee for booklet development by year 3	Produce booklet and distribute by year 6			Committee			Produce Booklet					FOB, FOJ, LCA, NWMCOG, TOMWC, WATCH	PF, PO, RG, LB	6.1, 6.4, 6.5
			SP Total	$90,000															

Categories/Tasks		Priority: High (H), Medium (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Goal and Objectives Addressed
Category 2	Stormwater																		
SW.A	Develop media tool-kit about nonpoint source pollution including advertisements, print materials, social media, website tools and links, etc.	H	NA	$25,000	Identify audience, message, and best methods of communication by year 4	Complete development of tool-kit by year 5					Develop Toolkit						MSUE, NWMCOG, TOMWC	PF, PO, LB	6.4, 6.5
SW.B	Work with local govts., area businesses, and property owners to install stormwater BMPs; sponsor an annual installation of demonstration rain garden at 1 residence, business, or public land	M	$7,500	$37,500	Begin sponsorship by year 5	Sponsor 5 rain gardens by year 10 (average rain garden of 100 SF)					Begin Sponsorship					5 Rain Gardens	Counties, Municipalities, TOMWC	PF, SG, FG, LG, PO, RG, CS, LB	6.1, 6.3
SW.C	Sponsor biennial workshop for architects, builders, excavators, contractors on BMP design and applications	M	$6,000	$18,000	Begin workshops by year 5	Hold 3 workshops by year 10					Begin Workshops					3 Workshops	Local governments, NWMCOG, TOMWC	PF, LG, PO, RG. LB	6.1, 6.3, 6.5
SW.D	Develop watershed-wide rain garden campaign	H	NA	$10,000	Begin campaign concurrent with rain garden sponsorship (year 5)	Register 50 rain gardens by year 10					Begin Campaign					50 Rain Gardens	ACD, CCD, LCA, NWCOG, TOMWC	PF, LG, PO	6.3, 6.4, 6.5
SW.E	Using updated stormwater infrastucture maps (SW.2), identify storm drains in need of "Drains to Lake" marking and implement program to re-mark or mark new drains on a regular basis	L	NA	$2,500	Mark all drains in need by year 6							Mark Drains					LCA, Municipalities, TOMWC	PF, LG, PO, LB	6.1, 6.3, 6.4
			SW Total	$93,000															

Categories/Tasks		Priority: High (H), Medium (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Goal and Objectives Addressed
Category 3	Planning, Zoning and Land Use																		
PZ.A	Utilize the recommendations of both the Charlevoix and Antrim Counties GAPS Analysis (2011) to encourage jurisdictions to adopt model standards in zoning ordinances to protect water quality.	H	NA	$100,000	3 model standards adopted by year 3				Adopt								ACP, CCP, local governments, NWMCOG, MSUE, TOMWC	PF, LG, PO	6.1, 6.2, 6.3, 6.5
PZ.B	Develop formal report highlighting progress made by jurisdictions post-GAPS Analysis. Distribute report to all jurisdictions.	H	$6,000	$12,000	Compile results and produce 1st report in year 5	Compile results and produce 2nd report in year 10					Report					Report	TOMWC	LG, PO	6.1, 6.4
PZ.C	Develop and implement ongoing education program for local governments on land use planning tools and principles, such as Smart Growth and Green Infrastructure, that protect water quality and encourage better coordination between communities	H	$10,000/yr	$80,000	Implement first program by year 3	Implement on an annual basis; 8 programs by year 10			Implement Program							Implement	Local governments, MSUE, NWCOG, TOMWC	PF, LG, PO,	6.1, 6.2, 6.3, 6.4
PZ.D	Promote the use of Low Impact Development (LID) to local govts, developers and others workshops, publications, including a Lake Charlevoix Watershed-specific publication	M	NA	$20,000	Develop and print Lake Charlevoix publication by year 3	Hold two workshops by year 10			Print							Two Workshops	ACD, CCD, MSUE, NWMCOG, TOMWC	PF, LG, PO, LB	6.1, 6.3, 6.5
			PZL Total	$212,000															
Category 4	Road/Stream Crossings																		
RSX.A	Maintain road/stream crossing database through LIAA for common access to current information	M	$1,000/yr	$10,000							Ongoing						CRA, TOMWC	PF, PO	6.1, 6.2
			R/S Total	$10,000															

Categories/Tasks		Priority: High (H), Medium (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Goal and Objectives Addressed
Category 5	Land Protection and Management																		
LP.A	Distribute information to land owners of High and Medium priority parcels (as determined by Priority Parcels Process)	M	NA	$5,000	Distribute by year 6							Distribute					GTRLC, LTC, TOMWC	PF, PO	6.1, 6.4, 6.5
LP.B	Inventory hobby farms within watershed and develop education strategy to address their NPS contributions	L	NA	$3,500	Complete inventory by year 10											Inventory	ACD, CCD, MSUE, NRCS	PF, SG, FG, LG, PO	6.5
			LP Total	$8,500															
Category 6	Habitat, Fish, and Wildlife																		
HFW.A	Promote large woody debris (LWD) to property owners through print materials, media and other I/E methods	H	NA	$25,000	Ongoing		Ongoing										LCA, MDNR, TOMWC	PF, SG, FG, PO, LB	6.1, 6.2, 6.4, 6.5
HFW.B	Implement CRA's Wildlink Program within the Lake Charlevoix Watershed	H	NA	$20,000	Ongoing		Ongoing										CRA	PF, SG, FG, PO	6.1, 6.3, 6.5
			HFW Total	$45,000															

Categories/Tasks		Priority: High (H), Medium (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Goal and Objectives Addressed
Category 7	Recreation, Safety and Human Health																		
RSH.A	Promote Clean Marinas: Develop support media (signs, brochures, etc.)	M	NA	$20,000	Ongoing						Ongoing						FOB, FOJ, LCA, TOMWC, WATCH, local businesses	PF, SG, FG, PO, LB	6.1, 6.3, 6.4, 6.5
RSH.B	Promote boating safety through the County Sheriff Departments' boating safety classes	M	NA	$10,000	Ongoing						Ongoing						LCA	LG, PO	6.1, 6.4
RSH.C	Promote MI Sea Grant's "Clean Boats, Clean Waters" program	H	NA	$2,000	Ongoing						Ongoing						LCA	SG, LB, PO	6.1, 6.4
RSH.D	Provide information and education (print materials, press releases, radio/television, presentations, etc) about swimmer's itch	M	NA	$4,000	Ongoing						Ongoing						LCA, TOMWC	PF, PO, LG	6.2, 6.5
RSH.E	Develop a canoeist education program to encourage low-impact use of tributaries	M	NA	$3,500	Develop and implement program by year 5						Implement Program						ACD, CRA, FOB, FOJ, TOMWC	PF, PO, LB	6.1, 6.3, 6.5
RSH.F	Install signage on Jordan River Pathway to promote low-impact use	L	NA	$2,000	Install signage by year 8									Install			ACD, FOJ	PF, SG, PO	6.5
RSH.G	Install signage at public boat launches and other public sites to bring awareness to invasive species and other issues	M	NA	$10,000	Install 5 signs by year 6							Install					FOB, FOJ, LCA, TOMWC, WATCH	PF, SG, FG, PO, LB	6.5
RSH.H	Deploy volunteers to monitor boats/trailers at heavily trafficked launches during holidays and other busy time periods for AIS	H	NA	$2,000	Begin volunteer program by year 2; 20 volunteers	Continue monitoring through year 10		Begin Program				Ongoing					FOB, FOJ, LCA, TOMWC, WATCH	PF, PO	6.1, 6.3, 6.4
RSH.I	Promote and conduct river and beach cleanups on Lake Charlevoix and tributaries	L	$2,500	$5,000	Hold two cleanup events by year 7								Two Cleanups				FOB, FOJ, LCA, TOMWC	PF, LG, PO	6.1, 6.3
RSH.J	Install monofilament boxes at boat launches and other angler spots	M	$500	$4,000	Install 4 boxes by year 5	Install 4 additional boxes by year 10					Install					Install	FOB, FOJ, LCA, TOMWC, WATCH	PF, LG, PO	6.3
			RSHH Total	$62,500															

Categories/Tasks		Priority: High (H), Medium (M), Low (L)	Unit Cost	Estimated Total Cost	Milestone	Milestone	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Potential Project Partners	Potential Funding Sources	Goal and Objectives Addressed
Category 8	Hydrology and Groundwater																		
HG.A	Remain current on the issue of hydrfracking including the development of state regulations and provide updates and information to local govts and watershed residents through media, websites, presentations, etc.	H	$5,000/yr	$50,000	Ongoing						Ongoing						TOMWC	PF, PO	6.2, 6.4
			HG Total	$50,000															
Category 9	Water Quality Monitoring																		
WQ.A	Produce Lake Profile publication for Lake Charlevoix every three years (includes assessment of monitoring data) and distribute throughout the Watershed	H	$5,000	$15,000	Produce 3 Lake Profiles by year 8			Lake Profile			Lake Profile			Lake Profile			TOMWC	PF, PO	6.4, 6.5
			WQM Total	$15,000															
Category 10	Wetlands																		
WL.A	Work with private property owners to facilitate restoration and protection of valuable wetlands; seek funding on their behalf to implement restoration projects	L	NA	$5,000	Obtain funding for one wetland restoration project by year 10											Obtain Funding	ACD, CCD, CRA, TOMWC	PF, SG, FG, PO, CS	6.1, 6.3
			WL Total	$5,000															
Category 11	Aquatic Invasive Species																		
AIS.A	Develop volunteer-based aquatic invasive species monitoring program	H	NA	$50,000	Develop program and begin implementation by year 5	Create Internet-based data reporting for volunteers to upload AIS information by year 6						Develop Program					ACD,CCD, FOB, FOJ, LCA,TOMWC	PF, SG, FG, LG, PO	6.1, 6.2, 6.3, 6.4, 6.5
			AIS Total	$50,000															
Category 12	Wastewater and Septics																		
WS.A	Develop septic system awareness campaign including incentives such as: sponsor free or discounted septic evaluations or septic pumping for Lake Charlevoix riparians	M	NA	$20,000	Develop program and begin implementation by year 5						Develop Program						LCA, local governments, NWMCOG, TOMWC, WATCH	PF, LG, PO, CS	6.1, 6.3, 6.5
			WS Total	$20,000															

Table 46: Information and Education Strategy Recommended Tasks and Actions Cost Summary

I/E Strategy Recommended Tasks and Actions Cost Summary		
	Category	**Cost**
G	General	$233,000
SP	Shoreline and Streambank Protection	$90,000
SW	Stormwater	$93,000
PZ	Planning, Zoning, and Land Use	$212,000
RSX	Road/stream Crossings	$10,000
LP	Land Protection and Management	$8,500
HFW	Habitat, Fish and Wildlife	$45,000
RSH	Recreation, Safety and Human Health	$62,500
HG	Hydrology and Groundwater	$50,000
WQ	Water Quality Monitoring	$15,000
WL	Wetlands	$5,000
AIS	Aquatic Invasive Species	$50,000
WS	Waste Water and Septics	$20,000
	Total	**$894,000**

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APPENDIX A: ESTIMATING STORMWATER POLLUTANT EXPORT AND LOAD REDUCTIONS

Stormwater

A simple, empirical method developed by the Metropolitan Washington Council of Governments was used to estimate pollutant loadings for sediment and phosphorus from stormwater inputs (MWCOG, 1987). Although very general in nature, this method is considered precise enough to make to make reasonable and reliable nonpoint source pollution management decisions at the site-planning level.

Stormwater export for an area can be estimated by using the equation:

$$L= [(P)(Pj)(Rv)/12](C)(A)(2.72)$$

where:

L = Pollutant export in pounds.

P = Rainfall amount in inches over the desired time interval. 32 was used for this study, which has been determined to be the average annual rainfall at Pellston, Michigan.

Pj = A factor that corrects P for storms that produce no runoff. A value of 0.90, determined from a study in the metropolitan Washington D.C area, was used for this study.

Rv = A runoff coefficient that expresses the fraction of rainfall that is converted to runoff, based on percent watershed imperviousness. This was determined from a figure depicting the relationship between watershed imperviousness and the runoff coefficient developed during a nationwide urban runoff study in the 1980's.

C = Flow-weighted mean concentration of the selected pollutant in urban runoff. Values for Total Suspended Sediments (54.500 mg/l) and Total Phosphorus (0.260 mg/l) were taken from nation-wide averages (Smullen and Cave, 1998) presented in the New York State Stormwater Management Design Manual.

A = Area of the study site in acres. Area determinations were determined using a geographic information system.

12 and 2.72 are unit conversion factors.

Streambank erosion and road/stream crossings

Streambank erosion pollutant load reductions were estimated using the Channel Erosion Equation (CEE) as outlined in the Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual (MDEQ, 1999). Reduction in sediments and nutrients (phosphorus and nitrogen) were estimated using this method.

The CEE is used to calculate the annual average sediment reduction using the direct volume method:

CEE= Length (ft) x Height (ft) x LRR (ft/yr) x Soil weight (ton/ft^3)

where:

LRR= Lateral Recession Rate, or the thickness of the soil eroded from a bank surface (perpendicular to the face) in an average year. A LRR of 0.4 ft/yr was used for the severe site; 0.05 ft/yr was used for the minor sites.

Soil Weight = The dry density soil weight for a soil textural class. Dry density soil weights are given in Exhibit 1 (MDEQ, 1999). A soil weight of 0.045 tons/ft^3 was determined using the soil textural class of sandy clay.

A related equation was used to calculate annual average nutrient (P and N) reduction:

Nutrient reduced (lb/yr) =
Sediment reduced (T/yr) x Nutrient conc. (lb/lb soil) x 2000 lb/T x correction factor

where:

Sediment reduced: The value determined from previous CEE calculations.

Nutrient concentration: A concentration of 0.005 lbP/lb of soil was used for phosphorus; 0.001 lbN/lb of soil was used for nitrogen.

Correction factor: A correction factor is used to correct for soil texture. Sandy clay is categorized as Sand, with a correction factor of 0.85. Correction factors are presented in Exhibit 2 (MDEQ, 1999).

APPENDIX B: DESIGNATED TROUT STREAMS

FO-210.08

Under the authority of Section 48701(o), as amended, being Sections 324.48701(o) of the Michigan
Compiled Laws, the Director of the Department of Natural Resources on November 8, 2007, ordered that for a period of five years the streams and portions of streams in the list which follows are hereby designated as trout streams:

Key to Designation List:
Unless otherwise described, the location description listed after the stream name indicates the downstream limit of the trout designation. All of the stream and its tributaries, unless excepted, from that point upstream are designated trout waters. Exceptions are italicized.

The list below includes the official designated trout streams for the Watershed, as determined under the authority of the Michigan Department of Natural Resources:

Lake Charlevoix Area	**County**
Woods Creek (T34N, R7W, S32)	Charlevoix
Horton Creek (T33N, R6W, S6)	Charlevoix
Dyer Creek (T33N, R6W, S8)	Charlevoix
Porter Creek (T33N, R6W, S32)	Charlevoix
Loeb Creek (T33N, R8W, S1)	Charlevoix
Stover Creek (T34N, R8W, S35)	Charlevoix
Tributaries of South Arm Lake	Charlevoix
Olstrom Creek (T32N, R7W, S3)	Charlevoix
Brown Creek (T32N, R7W, S23)	Charlevoix
Monroe Creek (T32N, R7W, S9)	Charlevoix
Boyne River Basin	
Boyne River (T33N, R6W, S35)	Charlevoix
Schoolhouse Creek (T32N, R5W, S10)	Charlevoix
North Branch Boyne River (T32N, R5W, S10)	Charlevoix
South Branch Boyne River (T32N, R5W, S9)	Charlevoix, Antrim
Moyer Creek (T32N, R5W, S21)	Charlevoix
Jordan River Basin	
Jordan River (T32N, R7W, S23)	Charlevoix, Antrim
Lanway Creek (T32N, R7W, S26)	Charlevoix
Deer Creek (T32N, R7W, S26)	Charlevoix
Bartholemew Creek (T31N, R7W, S1)	Antrim
Severence Creek (T31N, R6W, S7)	Antrim
Webster Creek (T31N, R6W, S7)	Antrim

Gook Creek (T31N, R6W, S17)	Antrim
Lilak Creek (T31N, R6W, S17)	Antrim
Martin Creek (T31N, R6W, S20)	Antrim
Cokirs Creek (T31N, R6W, S20)	Antrim
Mill Creek (T31N, R6W, S20)	Antrim
Kocher Creek (T31N, R6W, S29)	Antrim
Scotts Creek (T31N, R6W, S29)	Antrim
Tutstone Creek (T31N, R6W, S29)	Antrim
Green River (T30N, R6W, S5)	Antrim
Stevens Creek (T30N, R6W, S9)	Antrim
Todd Creek (T31N, R7W, S1)	Antrim
Landslide Creek (T30N, R6W, S10)	Antrim
Section 13 Creek (T30N, R6W, S11)	Antrim
Six Tile Creek (T30N, R5W, S6)	Antrim
Unnamed Creek (T31N, R5W, S30)	Antrim
Unnamed Creek (T31N, R7W, S12)	Antrim
Unnamed Creek (T31N, R6W, S32)	Antrim
Two Unnamed Creeks (T31N, R6W, S7)	Antrim
Unnamed Creek (T31N, R6W, S20)	Antrim
Unnamed Creek (T30N, R6W, S5)	Antrim
Two Unnamed Creeks (T30N, R6W, S4)	Antrim
Unnamed Creek (T30N, R6W, S2)	*Antrim*

APPENDIX C: FISHERIES

MDNR Lake Charlevoix Fish Stockings, 1990-2010					
Year	**Species**	**Number**	**Age**	**Strain**	**Fin clip**
1990	Brown trout	30,000	Fall fingerlings	Plymouth Rock	
	Brown trout	71,250	Yearlings	Plymouth Rock	
	Brown trout	3,746	Yearlings	Soda Lake	
	Lake trout	100,000	Yearlings	Marquette	Ad-CWT
1991	Brown trout	39,805	Yearlings	Plymouth Rock	
	Brown trout	39,608	Yearlings	Seeforellen	
	Lake trout	100,000	Yearlings	Lake Superior	Ad-CWT
	Walleye	80,000	Spring fingerlings	Bay De Noc	
1992	Brown trout	19,497	Yearlings	Seeforellen	RV
	Brown trout	46,413	Yearlings	Wild Rose	LV
	Lake trout	100,000	Yearlings	Lake Superior	Ad-CWT
	Walleye	92,000	Spring fingerlings	Bay De Noc	
1993	Brown trout	39,992	Yearlings	Plymouth Rock	RV
	Brown trout	33,786	Yearlings	Wild Rose	LV
	Lake trout	96,000	Yearlings	Marquette	RPLV
	Rainbow trout	500	Adv. yearlings	Eagle Lake	
	Walleye	150,000	Spring fingerlings	Bay De Noc	
1994	Brown trout	45,135	Yearlings	Seeforellen	RV
	Brown trout	45,100	Yearlings	Wild Rose	LV
	Lake trout	100,000	Yearlings	Marquette	Ad-CWT
	Walleye	73,400	Spring fingerlings	Bay De Noc	
1995	Brown trout	39,988	Yearlings	Seeforellen	RV
	Brown trout	39,980	Yearlings	Wild Rose	LV
	Lake trout	77,250	Fall fingerlings	Marquette	
	Walleye	92,200	Spring fingerlings	Bay De Noc	
1996	Brown trout	35,975	Yearlings	Seeforellen	
	Brown trout	37,173	Yearlings	Wild Rose	
1997	Brown trout	56,355	Yearlings	Seeforellen	
	Lake trout	80,879	Yearlings	Marquette	
	Walleye	90,000	Spring fingerlings	Bay De Noc	
	Walleye	40,000	Spring fingerlings	Tittabawassee	
1998	Brown trout	48,800	Yearlings	Seeforellen	
	Rainbow trout	9,770	Yearlings	Eagle Lake	
1999	Lake trout	134,296	Yearlings	Marquette	RVLP
	Brown trout	24,800	Adv. yearlings	Wild Rose	LP
	Walleye	96,000	Spring fingerlings	Bay De Noc	
	Walleye	3,200,000	Fry	Bay De Noc	

MDNR Lake Charlevoix Fish Stockings, 1990-2010					
Year	**Species**	**Number**	**Age**	**Strain**	**Fin clip**
2000	Brown trout	25,000	Adv. yearlings	Wild Rose	
	Lake trout	100,140	Yearlings	Marquette	RP
2001	Brown trout	19,024	Adv. yearlings	Wild Rose	RP
	Lake trout	100,040	Yearlings	Marquette	RV
	Walleye	20,000	Spring fingerlings	Tittabawassee	OTC
	Walleye	86,155	Spring fingerlings	Bay De Noc	OTC
2002	Brown trout	25,000	Adv. yearlings	Wild Rose	
	Lake trout	133,256	Yearlings	Marquette	RPLV
	Rainbow trout	10,000	Yearlings	Eagle Lake	
2003	Brown trout	25,000	Adv. yearlings	Wild Rose	
	Lake trout	111,543	Yearlings	Marquette	RP
	Walleye	101,478	Spring fingerlings	Muskegon	
2004	Brown trout	25,000	Adv. yearlings	Wild Rose	
	Lake trout	101,092	Yearlings	Marquette	RVLP
	Rainbow trout	3,593	Yearlings	Eagle Lake	
	Walleye	3,000	Spring fingerlings	Bay De Noc	
2005	Lake trout	100,000	Yearlings	Marquette	LV
	Rainbow trout	6,160	Yearlings	Eagle Lake	
	Walleye	9,900	Spring fingerlings	Bay De Noc	
2006	Lake trout	87,300	Yearlings	Marquette	LP
	Lake trout	13,697	Yearlings	Seneca Lake	LP
	Walleye	106,274	Spring fingerlings	Bay De Noc	
2007	Lake trout	46,694	Yearlings	Marquette	RVLP
	Lake trout	42,952	Yearlings	Seneca Lake	RVLP
2008	Lake trout	50,358	Yearlings	Lewis Lake	RV
	Lake trout	33,218	Yearlings	Seneca Lake	RV
	Walleye	90,800	Spring fingerlings	Muskegon	
2009	Walleye	180,432	Spring fingerlings	Muskegon	

MDNR Fisheries Survey on Lake Charlevoix 1947-2011

Year	Survey Type
1947	Hook and Line Survey- Collected cisco and smelt
1950	Hook and Line Survey- parasite investigation in rainbow smelt
1952	Sea lamprey investigation
1955	Special Study- Deep water trawls for plankton and fry, gill netting, limnology
1959	Special Study- Netting and seining to look for the presence of walleye, some limnology
1962	General Study- Gill netting
1966	General Study- Hook and line survey
1967	Special Study- Bottom trawling
1967	General Study- Hook and line survey
1968	General Study- Gill netting
1969	Special Study- Looked to determine is steelhead were migrating from Lake Charlevoix to Lake Michigan.
1970	Special Study- Looked at coho salmon off of Porter Creek, examined for lamprey wounds and BKD.
1972	Special Study- Looked to collect rainbow trout and determine their diet
1975	Special Study- Looked to determine if trap nets could be used to catch Atlantic salmon.
1976	General Survey- Gill netting
1978	Special Study- Looked for returning Chinook salmon.
1979	General Survey- First extensive netting survey conducted
1984	Special Study- Looked at fish community near a proposed marina.
1990	Special Study- Looked at fish community near a proposed marina.
1990	Stocking Evaluation- Looking at survival of stocked lake trout and brown trout.
1992	Stocking Evaluation- Looking at survival of stocked brown trout.
1996	Special Study- Looked at predation on stocked brown trout by walleye.
1996	Recruitment Evaluation- Looked for natural reproduction of walleye.
1998	Recruitment Evaluation- Looked for natural reproduction of walleye.
2006	Population Estimate- Large Lake Survey protocol.
2006	Status & Trends- Netting and seining to accompany Large Lake Survey.
2006	Stocking evaluation- Looked at survival of walleye fingerlings stocked in the spring of 2006 (Two-part, shocked in two locations).
2009	Stocking evaluation- Looked at survival of walleye fingerlings stocked in the spring of 2009.

APPENDIX D: INTERVIEW QUESTIONS FOR ADVISORY COMMITTEE MEMBERS

(As part of Watershed Management Plan evaluation strategy)

1. Have you participated actively in Advisory Committee meetings during the implementation of the Plan?
    - If so, have Advisory Committee meetings and other activities been useful? How could they be more beneficial?
    - If not, why not? What might motivate you to participate?
    - Have you filled out the questionnaire on Survey Monkey about future meetings of the Advisory Committee?
2. Has Watershed Management Plan been helpful in carrying out your organization's activities related to water quality in the watershed? Has it informed your work planning, helped you identify priority activities, helped you find partners, and/or helped to raise funding for your work?
3. What do you think are the three most important actions (by anyone, not just your organization) that should be taken in the next five years to achieve the goals and objectives of the Plan?
4. What is the status of the recommendations in the Plan for which your organization was listed as having a role (see attached spreadsheet)?
    - Which recommendations have been completed?
    - Which ones are currently underway?
    - Are there other actions that your organization has taken to achieve the Plan's goals and objectives that were not specifically recommended in the Plan?
5. Given developments over the five years since the Plan was approved, do you think the outstanding recommendations "assigned" to your organization remain as important and urgent?
6. Are there other actions needed today that were not included in the Plan but that are important to carry out to achieve the Plan's goals and objectives?
7. Do you have ideas for partnerships, projects, and fundraising (including grant requests) opportunities to help achieve the Plan's goals and objectives? If so, what type of support (from other Advisory Committee members) would be helpful in making them happen?
8. Do you think you have received enough information on the implementation of the Plan, the activities carried out by others on recommendation actions, and/or partnership opportunities? How do you like to receive information about the Plan and related topics (for example, via email, newsletters, in group or one-on-one meetings)?

9. Do you have any other comments or suggestions?

APPENDIX E: PROCEDURE FOR PRIORITIZATION OF PARCELS FOR PERMANENT LAND PROTECTION

Tip of the Mitt Watershed Council, October 2011

Conservation Drivers and Scoring:

1.	Parcel Size (acreage)	
1)	Acres >= 10 AND acres < 40	1 pts
2)	Acres >= 40 AND acres < 80	2 pts
3)	Acres >= 80 AND acres < 120	3 pts
4)	Acres >= 120	4 pts
2.	Groundwater Recharge Potential	
1)	Groundwater Recharge Acres >= 1 AND < 10	1 pts
2)	Groundwater Recharge Acres >= 10 AND < 20	2 pts
3)	Groundwater Recharge Acres >= 20 AND < 50	3 pts
4)	Groundwater Recharge Acres >= 50+	4 pts
3.	Wetland Preservation	
1)	Wetland Acres > 0 AND < 10	1 pts
2)	Wetland Acres >= 10 AND < 20	2 pts
3)	Wetland Acres >= 20 AND < 40	3 pts
4)	Wetland Acres >= 40+	4 pts
4.	Lake Shoreline/Riparian Protection	
1)	Lake Shore Distance >= 100’ AND < 200’	1 pts
2)	Lake Shore Distance >= 200’ AND < 500’	2 pts
3)	Lake Shore Distance >= 500’ AND < 1000’	3 pts
4)	Lake Shore Distance >= 1000’	4 pts
5.	River and Stream Shoreline/Riparian Protection	
1)	Stream Distance >= 200’ AND < 500’	1 pts
2)	Stream Distance >= 500’ AND < 1000’	2 pts
3)	Stream Distance >= 1000’ AND < 2000’	3 pts
4)	Stream Distance >= 2000’	4 pts
6.	Steep Slopes for Erosion Prevention	
1)	Slopes >= 20 and < 30%	1 pts
2)	Slopes >= 30 and < 35%	2 pts
3)	Slopes >= 35 and < 40%	3 pts
4)	Slopes > 40%	4 pts
7.	Adjacency to Protected Lands (Wildlife Corridors)	
1)	Adjacent to one protected parcel	1 pts
2)	Adjacent to two or more protected parcels	4 pts
8.	Threatened/Endangered Species (using MNFI model)	
1)	Probability = 'High' AND "RI" >=4 AND "RI" <5	1 pts
2)	Probability = 'High' AND "RI" >=5 AND "RI" <10	2 pts
3)	Probability = 'High' AND "RI" >=10 AND "RI" <20	3 pts
4)	Probability = 'High' AND "RI" >=20	4 pts

APPENDIX F: STORMWATER MONITORING RESULTS

Sample site	Date	Time	Water Temperature (°C)	Dissolved Oxygen (mg/l)	Specific Conductivity (µS/cm)	pH	E. coli Bacteria (#/100ml)	Total Coliform Bacteria (#/100ml)
East Jordan, Tourist Park, MDOT outfall	8/2/2011	1:01:36 PM	24.24	7.72	211.0	8.14	no data	no data
East Jordan, Tourist Park, MDOT outfall	10/14/2011	1:13:11 AM	16.00	7.02	327.9	8.07	no data	0
East Jordan, Downtown, Next to Pier	8/2/2011	1:30:55 PM	22.09	2.74	821.6	7.91	no data	no data
East Jordan, Downtown, Next to Pier	10/14/2011	1:36:28 AM	16.17	9.22	66.1	8.36	no data	2800
Boyne City, Lower Lake Street	8/9/2011	12:00:21 PM	24.24	1.20	1366.5	7.80	>2419.6	no data
Boyne City, Lower Lake Street	10/14/2011	2:15:33 AM	13.90	9.96	548.9	8.13	no data	199986
Boyne City, Boyne River by Lake St.	8/9/2011	11:28:59 AM	21.42	5.93	68.7	8.04	613.1	no data
Boyne City, Tannery Park	10/14/2011	2:07:06 AM	15.26	9.38	172.6	8.10	no data	72382

Sample site	Soluble Reactive Phosphorus (µg/l)	Total Phosphorus (µg/l)	Nitrate Nitrogen (µg/l)	Ammonium Nitrogen (µg/l)	Total Nitrogen (µg/l)	Chloride (mg/l)	Total Suspended Solids (mg/l)	Dissolved Organic Carbon (mg/l)
East Jordan, Tourist Park, MDOT outfall	60.2	83.0	824.8	865.5	1688	129.9	27.6	4.9
East Jordan, Tourist Park, MDOT outfall	10.4	19.6	1144.9	29.7	2296	46.5	131.0	30.0
East Jordan, Downtown, Next to Pier	7.4	72.5	1487.9	39.0	1726	20.0	65.2	27.1
East Jordan, Downtown, Next to Pier	64.6	65.5	303.1	30.2	724	3.0	10.0	12.5
Boyne City, Lower Lake Street	9.9	35.7	14.2	2065.5	3496	400.0	1707.5	70.2
Boyne City, Lower Lake Street	55.6	52.7	213.3	10.8	553	61.9	128.7	9.9
Boyne City, Boyne River by Lake St.	104.0	59.1	513.5	243.4	1347	9.3	42.5	15.6
Boyne City, Tannery Park	26.6	1.0	410.5	32.4	819	22.5	15.0	14.0

Sample site	Arsenic (mg/l)	Cadmium (mg/l)	Chromium (mg/l)	Lead (mg/l)	Mercury (mg/l)	Zinc (mg/l)	OilGrease (mg/l)
East Jordan, Tourist Park, MDOT outfall	ND	ND	ND	0.005	ND	0.08	ND
East Jordan, Tourist Park, MDOT outfall	ND	ND	ND	0.018	0.0007	0.20	no data
East Jordan, Downtown, Next to Pier	ND	ND	ND	0.011	ND	0.09	ND
East Jordan, Downtown, Next to Pier	ND	ND	ND	0.006	ND	0.09	no data
Boyne City, Lower Lake Street	0.008	0.001	0.016	0.051	ND	0.18	ND
Boyne City, Lower Lake Street	ND	ND	ND	0.006	ND	0.05	ND
Boyne City, Boyne River by Lake St.	ND	ND	ND	0.004	ND	0.15	ND
Boyne City, Tannery Park	ND	ND	ND	0.002	ND	0.06	ND

APPENDIX G: WATER QUALITY PARAMETERS MONITORED

1	Alkalinity	23	Nitrogen, organic
2	Arsenic	24	Nitrogen, total
3	Calcium	25	Oil and grease
4	Chlordane	26	Oxygen, dissolved
5	Chlorophyll-a	27	PCB
6	Color	28	pH
7	Conductance, specific	29	Phosphorus, orthophosphate
8	Copper	30	Phosphorus, total
9	DDT	31	Potassium
10	Dieldrin	32	Residue
11	Hardness	33	Secchi disk depth
12	Heptachlor epoxide	34	Selenium
13	Hexachlorobenzene	35	Silicate
14	Ice cover	36	Sodium
15	Iron	37	Solids, dissolved
16	Lead	38	Solids, suspended
17	Magnesium	39	Sulfate
18	Manganese	40	Temperature, water
19	Mercury	41	Total Chloride
20	Nitrogen, ammonia	42	Turbidity
21	Nitrogen, nitrate	43	Zinc
22	Nitrogen, nitrite		

APPENDIX H: ROAD/STREAM CROSSING INVENTORY FIELD FORM

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