Lake Charlevoix Shoreline Survey 2018

By Tip of the Mitt Watershed Council

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SUMMARY

During the fall of 2018, Lake Charlevoix Association partnered with Tip of the Mitt Watershed Council and ZeroGravity Aerial to conduct a shoreline survey of Lake Charlevoix. The survey was designed to document conditions that can impact water quality, including the three biggest threats to inland lakes: nutrient pollution, habitat loss, and shoreline erosion. The shoreline assessment was conducted on a parcel by parcel basis around the entirety of Lake Charlevoix. Survey results indicate that large portions of Lake Charlevoix shoreline contain natural and native vegetation growth. However, human activity around Lake Charlevoix shoreline may be impacting the lake ecosystem and water quality. Improving areas with poor greenbelts will help the character and quality of Lake Charlevoix by reducing nutrient pollution and sediment input from erosion along the shoreline.

INTRODUCTION

Background

During the fall of 2018, a shoreline survey was conducted on Lake Charlevoix by ZeroGravity Aerial and Tip of the Mitt Watershed Council to document shoreline conditions that impact water quality. The entire shoreline was surveyed to document the following: algal (*Cladophora*) growth as an indicator of nutrient pollution, erosion, shoreline alterations (including drain pipes), and greenbelts. The following 2018 survey results provide documentation for shoreline conditions on Lake Charlevoix that can be used as a lake management tool.

Shoreline Development Impacts

Lake shorelines are an important interface linking the landscape to water within a watershed. A shoreline is the area in which a transfer of water and nutrients occurs from land to water. This transitional zone does not necessarily have an exact line between the landscape and water as lake shorelines vary based on shape, size, water level, and vegetation. Accordingly, human activities along the shoreline have a varying potential for degrading the water quality of Lake Charlevoix. Development of shoreline properties for residential, commercial, or other use have an impact on Lake Charlevoix in a variety of ways and in various degrees. For example, as more shoreline vegetation is removed, the potential for nutrients and pollutants to run off the landscape and enter Lake Charlevoix increases. Additionally, as the Lake Charlevoix Watershed terrain is altered, sediments and nutrients from eroded areas can often end up in Lake Charlevoix.

While nutrients are necessary to sustain a healthy aquatic ecosystem, excess nutrients will stimulate nuisance growth of both macrophytes (aquatic plants that grow in or near water and are either emergent, submergent, or floating) and algae. Additionally, algal blooms pose a public health risk as some species (i.e. Cyanobacteria - blue green algae) produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Excess plant and algal growth can degrade water quality by depleting the ecosystem's dissolved oxygen. As algal and plant growth increases and individuals begin to die, the aerobic activity of decomposers deplete dissolved oxygen, particularly in the deeper waters of stratified lakes. In general, small lakes are more prone to nutrient pollution than large lakes. With the increased volume, large lakes tend to have greater stores of dissolved oxygen and increased dilution of nutrients. By contrast, small lakes generally have a lesser ability to dilute nutrients and extensive shallow areas that can support aquatic plant growth. Excess nutrients enter surface waters through a variety of natural and cultural (human) sources.

Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from riparian (shoreline) areas, and atmospheric deposition. Springs and seeps, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter. Nearby wetland seepages may also discharge nutrients at certain times of the year. Cultural (human) sources include septic systems, fertilizers, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural and forestry practices, which oftentimes result in soil erosion, and wetland destruction also contribute to nutrient pollution. Moreover, some cultural sources (e.g., malfunctioning septic systems) pose a potential health risk due to bacterial and viral contamination. Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators.

Although chemical analyses of water samples to check for nutrient pollution can be effective, they are oftentimes more labor intensive and cost prohibitive than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually the forms of phosphorus and nitrogen), but other chemical constituents, such as chloride, can be measured. Physical measurements, such as water temperature and conductivity (the ability for water to conduct an electrical current), are primarily used to detect excess nutrients entering a water body. Biologically, nutrient pollution can be detected along the lake shore by noting and observing the presence of *Cladophora* algae, a biological indicator. Observed increases of *Cladophora* presence can be an indicator of elevated nutrients along the shoreline.

Cladophora is a branched, filamentous green algal species that occurs naturally in relatively small amounts in Northern Michigan lakes. *Cladophora* occurrence is governed by specific environmental requirements for temperature, substrate, sunlight, and nutrients. This algal bio-indicator is found most commonly in the wave splash zone and shallow shoreline areas of lakes and grows best on stable substrates such as rocks and logs. Artificial substrates such as concrete or wooden seawalls are also suitable growth areas. *Cladophora* prefers water temperatures in a range of 50 to 70 degrees Fahrenheit, which means that the optimal time for growth and detection in Northern Michigan lakes is usually from middle of May to early July, and again in early to middle of September. The nutrient availability in Northern Michigan lakes is typically less than what is needed for *Cladophora* to achieve large, dense growth. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*.

Although the growth of *Cladophora* can be influenced by factors such as water current patterns, shoreline topography, substrate composition, and wave action, the presence or absence of any significant growth can be a powerful lake-wide screening tool. The existence of chronic nutrient availability along the shoreline can be revealed and chronic observance of dense *Cladophora* presence can assess the effectiveness of any remedial actions. Comparing the total number of algal growth areas along the shoreline over time can reveal trends in nutrient inputs to a lake. One factor contributing to nutrient input is bank erosion.

Erosion along the shoreline can degrade the lake's water quality. Stormwater runoff carries sediments into the lake that can reduce organism respiration by clogging the gills of fish, insects, and other aquatic organisms. Excessive sediments can smother fish spawning beds and fill interstitial spaces along the lake bottom that provide habitat for a variety of aquatic organisms. Suspended sediments absorb sunlight energy and increase water temperatures. In addition, nutrients (particularly phosphorus) adhere to sediments that wash in from eroded areas, which can lead to nuisance aquatic plant growth and algal blooms. To help prevent erosion and runoff of sediments and nutrients, healthy shoreline greenbelts are essential.

Shoreline greenbelts are essential for maintaining a healthy aquatic ecosystem. A greenbelt consisting of a variety of native woody and herbaceous plant species provides habitat for near-shore aquatic organisms as well as other shoreline-dependent wildlife. Natural greenbelts can help deter geese as these shoreline guests tend to prefer well-manicured lawns with easy access to the water. Greenbelts also help stabilize shorelines against wave and ice action with their extensive network of deep, fibrous roots. Overhanging vegetation provides shade to nearshore areas, which is particularly important for many fisheries and insects the fish consume. Lastly, and perhaps most importantly, greenbelts provide a mechanism to filter pollutants carried by stormwater from rain events and snowmelt. Vegetation will utilize nutrients (nitrogen and phosphorus) for growth and filter them out of runoff before entering a lake. Another pollutant and nutrient delivery mechanism to a lake is a tributary.

The primary function of a tributary is to drain the landscape (lake watershed). Therefore, tributaries have a very high potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake within a watershed. Inlet streams may provide exceptionally high-quality waters that benefit the lake ecosystem. Conversely, they have the potential to deliver polluted waters that degrade the lake's water quality. Outlet streams flush water out of the lake, providing a way to remove contaminants in the lake ecosystem. While conducting shore surveys, noting inlet tributary locations is very helpful when evaluating shoreline algal conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to heavier *Cladophora* and other algal growth in nearby shoreline areas.

Background of Study Area

Located in the northwestern area of the Lower Peninsula, Lake Charlevoix resides in Charlevoix County. Lake Charlevoix has a surface area of 17,200 acres and a shoreline length of 60 miles. The primary inflows are the Boyne River and Jordan River. Other inflows include Loeb, Monroe, Horton, and Stover Creeks (Figure 1). The primary outflow is to the northwest and flows directly into Lake Michigan via the Pine River. According to digitized bathymetry maps acquired from the Michigan Geographic Data Library, the deepest area of Lake Charlevoix reaches 122 feet in depth (Figure 2).

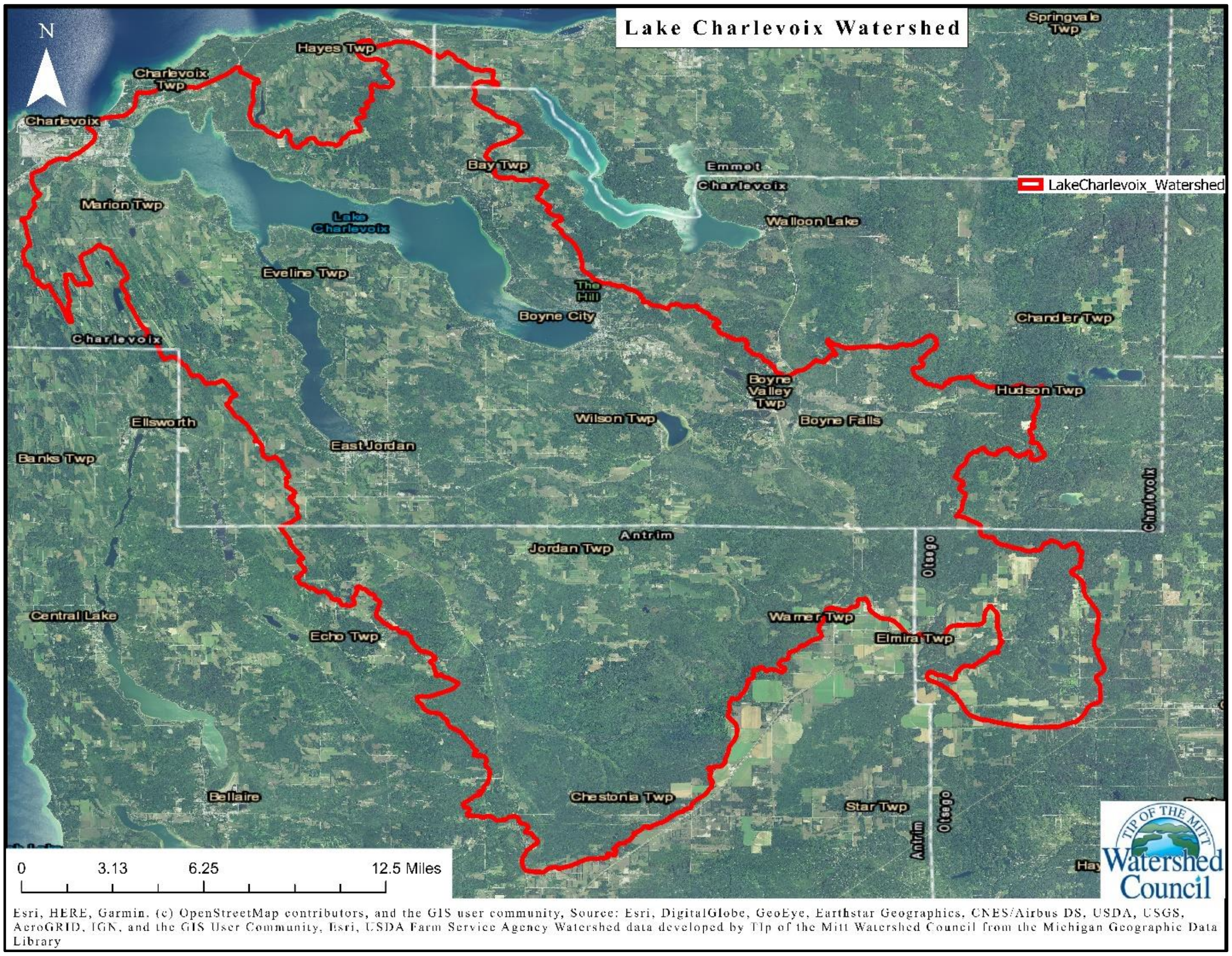

Figure 1 Lake Charlevoix Watershed

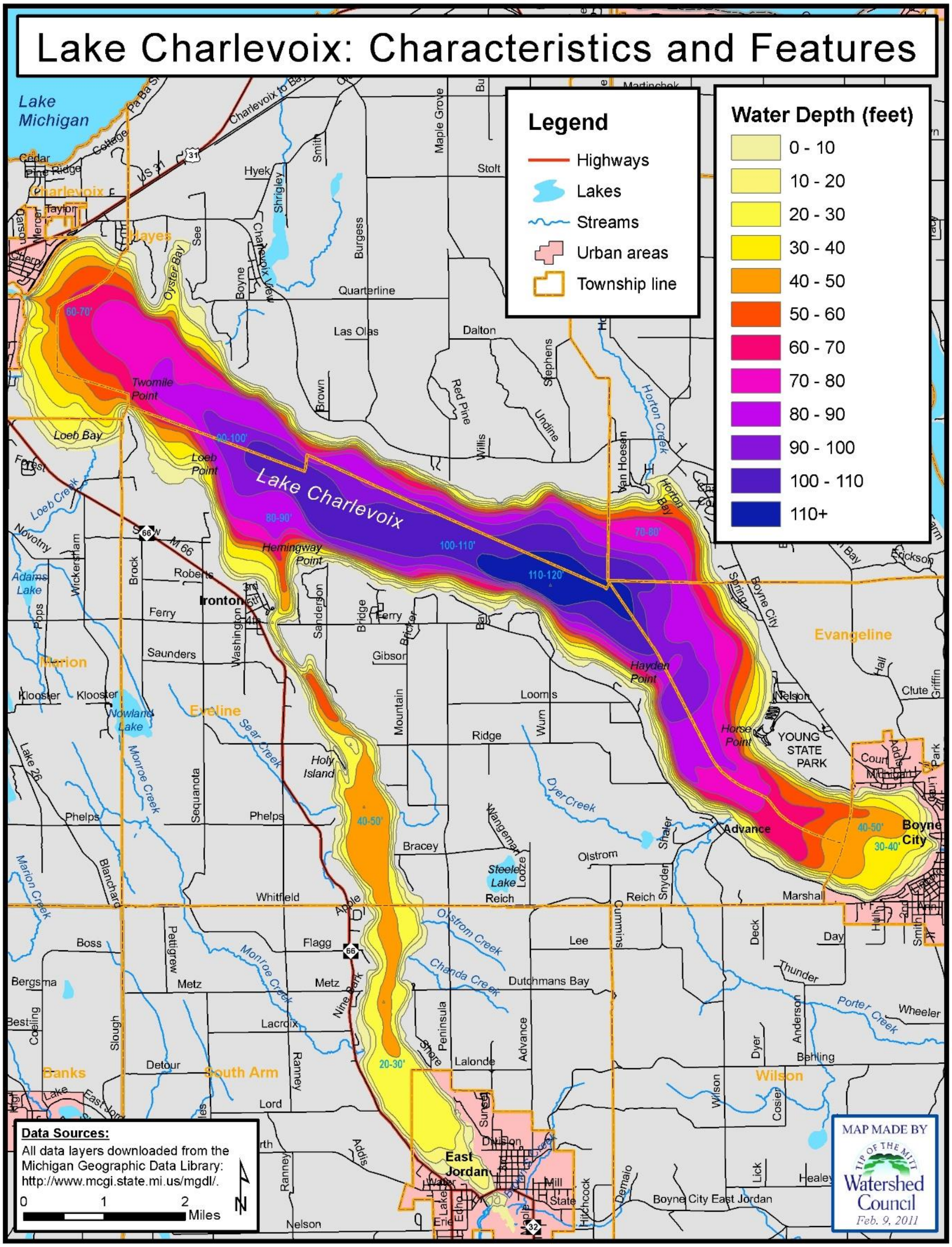

Figure 2 Map of Lake Charlevoix Depths (bathymetry)

Land cover statistics generated for the surface watershed using data from the NOAA Coastal Great Lakes Land Cover Project reveal much of Lake Charlevoix's Watershed land cover is forest (45.97%), wetland (14.13%), grassland/herbaceous (7.34%) and agriculture (13.86%) (Table 1).

Table 1 Lake Charlevoix Surface Watershed Land Cover 2016

Land Cover Type	**2016 (% of watershed)**
Agriculture	13.86
Bare Land	1.53
Developed	3.24
Forest	45.97
Grassland/Herbaceous	7.34
Open Water	8.70
Pasture/Hay	2.37
Scrub/Shrub	2.85
Wetland	14.13

SHORELINE SURVEY METHODS

Lake Charlevoix was surveyed via drone during September of 2018 and observations were recorded with video to document shoreline conditions. Shoreline conditions were noted with visual observations as possible from the video included *Cladophora* growth, erosion conditions, greenbelt length, greenbelt depth, shoreline alterations, and tributaries. All information was digitally recorded on a tablet connected to ArcGIS, compiled into a database, and used for map creation showing observations.

Parameters

Developed parcels were noted as a separate column in the database. Properties described as developed indicate the presence of buildings or other permanent structures, including roadways, boat launching sites, and recreational properties (i.e.- parks with pavilions and parking lots) as seen from video. The length and area of developed versus undeveloped shoreline was not possible to calculate. After noting development status, *Cladophora* was identified in the area.

Many species of filamentous green algae are commonly found growing in the nearshore regions of lakes. Positive identification at the species level usually requires the aid of a microscope. However, *Cladophora* genus usually has a unique appearance and texture that is quite distinct to a trained surveyor. Other species of filamentous green algae can respond to an external nutrient source in much the same way as *Cladophora*, though their value as an indicator species is not thought to be as reliable. When other species occurred in especially noticeable, large, dense growths, they were recorded and described the same as those of *Cladophora*.

When *Cladophora* was observed, it was described in terms of the length of shoreline with growth, the relative growth density, and any observed shoreline features potentially contributing to the growth. Both shoreline length and growth density are subjective estimates. Growth density is determined by estimating the percentage of substrate covered with *Cladophora* using the following categorization system:

Table 2 Categorization system for Cladophora density

Density Category	**Field Notation**	**Substrate Coverage (%)**
Very Light	(VL)	0 *
Light	(L)	1- 20
Light to Moderate	(LM)	21-40
Moderate	(M)	41-60
Moderate to Heavy	(MH)	61-80
Heavy	(H)	81-99
Very Heavy	(VH)	90-100 *

**Very Light is noted when a green shimmer is noticed on hard substrate, but no filamentous growth present. Very Heavy overlaps with heavy and is distinguished by high percentage of substrate coverage and long filamentous growth.*

Among other things, the distribution and size of each *Cladophora* growth is dependent on the amount of suitable substrate present. The extent of suitable substrate should therefore be taken into account when interpreting the occurrence of individual growths, and assessing the overall distribution of *Cladophora* along a particular stretch of shoreline. Substrate types were noted during the survey, using the following abbreviations: m = soft muck or marl, s = sand, g = gravel (0.1” to 2.5” diameter), r = rock (2.5” to 10” diameter), b = boulder (>10” diameter), and w = woody debris. Substrate suitable for *Cladophora* growth include the g, r, b, and w types.

However, the extent of suitable substrate along a shoreline parcel in terms of distance was not documented. Erosion conditions were similarly noted along each shoreline.

Erosion was noted based on shoreline areas that exhibited: areas of bare soil, leaning or downed trees, exposed tree roots, undercut banks, slumping hunks of sod, excessive deposits of sediments, or muddy water. Similar to *Cladophora*, shoreline erosion was recorded with extent and relative severity estimates (light, moderate, or heavy/severe). For example “Mx20” indicated 20 feet of shoreline with moderate erosion. Additional information about the nature of the erosion, such as potential causes, were also noted.

Minor: exposed soils, gullies up to 1” deep.

Moderate: exposed soils, gullies > 1” & < 6”, banks undercut by <6”, minor slumping.

Severe: exposed soils, gullies > 6”, banks undercut by > 6”, severe slumping, tree fall

Greenbelts were rated based on the relative length of shoreline with a greenbelt and the average depth of the greenbelt from the shoreline into the property. Ratings ranged from zero to four and were based on the following.

Length	0: None, 1: 1-10%, 2: 10-25%, 3: 25-75%, 4:>75%
Depth	0: None, 1: <10 ft, 2: 10-40 ft, 3: >40 ft

Greenbelt ratings for length and depth were summed to produce an overall greenbelt score.

Tributaries were noted and included in a separate column in the database. Additional information was included in the database in a “comments” column. The comments column also included notes about shoreline alterations. The following shoreline alterations (structures) were noted:

Steel seawall	Concrete seawall	Wood seawall	Rock rip-rap	Boulder rip-rap
Mixed rip-rap	Boathouse	Discharge pipe	Artificial beach	

Data Processing

Upon completion of surveying the entire Lake Charlevoix shoreline, all data were transferred to a Microsoft Excel® workbook. Digital photographs and GPS data were uploaded to a computer and processed for use. Linking field and equalization data allows shoreline conditions documented during the survey to be referenced by parcel identification number or parcel owner name. Data were linked to Charlevoix County parcel data in a Geographic Information System (GIS) with the aid of GPS and photographs.

In order to display survey results without pinpointing specific parcels, a new map layer was developed using the parcel map data layer acquired from the county equalization department and a Lake Charlevoix shoreline layer. The new map layer consists of a narrow band following the shoreline, split into polygons that contain field and equalization data. This data layer was overlaid with other GIS data from the State of Michigan (http://gis-michigan.opendata.arcgis.com/) to produce the maps contained in this report.

RESULTS

Following are results of the 2018 survey documenting shoreline conditions at 2,199 parcels on Lake Charlevoix. Approximately 90% (1,983) of shoreline properties on Lake Charlevoix were considered developed.

Cladophora

Noticeable growths of *Cladophora* or other filamentous green algae were observed along the shoreline at 624 parcels (36.8% of total parcels surveyed; Table 3). At properties where *Cladophora* growth was observed, 396 parcels consisted of light or very light growth, while 78 parcels had heavy to very heavy growth (Figure 10). Clusters of parcels near East Jordan and Boyne City showed relatively dense patches of *Cladophora*. These areas also receive input from nearby tributaries.

Table 3 Cladophora density results

***Cladophora* Density**	**Parcels**	**Percent of total parcels (%)**
Very light	259	15.3
Light	137	8.1
Light to Moderate	6	0.35
Moderate	139	8.2
Moderate to Heavy	5	0.30
Heavy	63	3.72
Very Heavy	15	0.89
Total	624	36.8

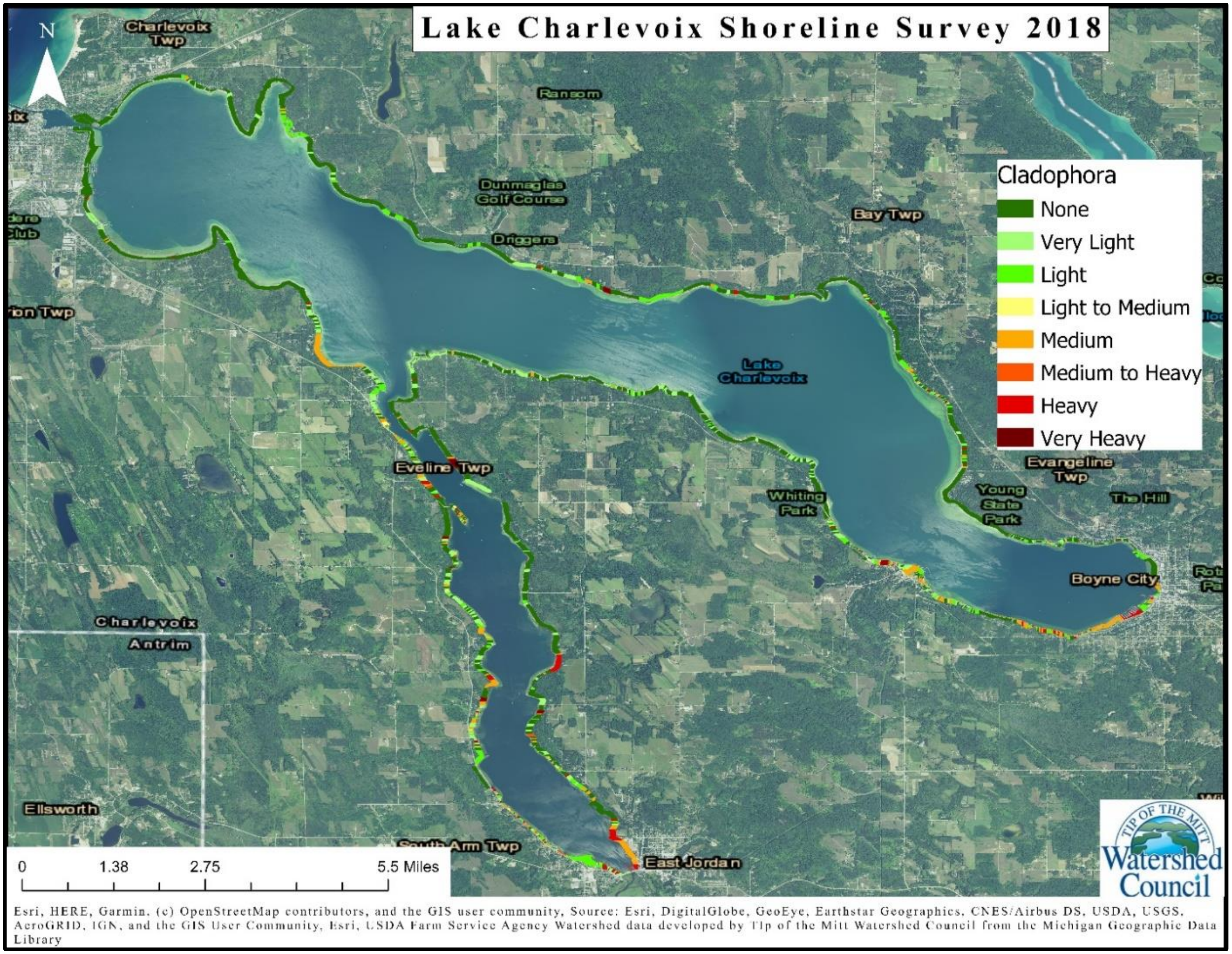

Figure 3 Cladophora density around Lake Charlevoix Shoreline

Greenbelt Scores

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Lake Charlevoix greenbelts were generally observed to be in moderate to excellent condition. Of 1,692 parcels, 1,051 (62%) received a greenbelt rating in the moderate, good, or excellent categories (Table 4).

Table 4 Greenbelt rating results

Greenbelt Rating		Number of Parcels	Percent (%)
0	Very Poor (absent)	191	11
1-2	Poor	439	26
3-4	Moderate	488	29
5-6	Good	436	26
7	Excellent	127	8

Clusters of properties along the South Arm and near Boyne City were ranked in the very poor (absent) to poor categories (Figure 4). Large parcels along the eastern shoreline showed excellent, healthy greenbelts. These areas also appeared to be largely undeveloped parcels of land.

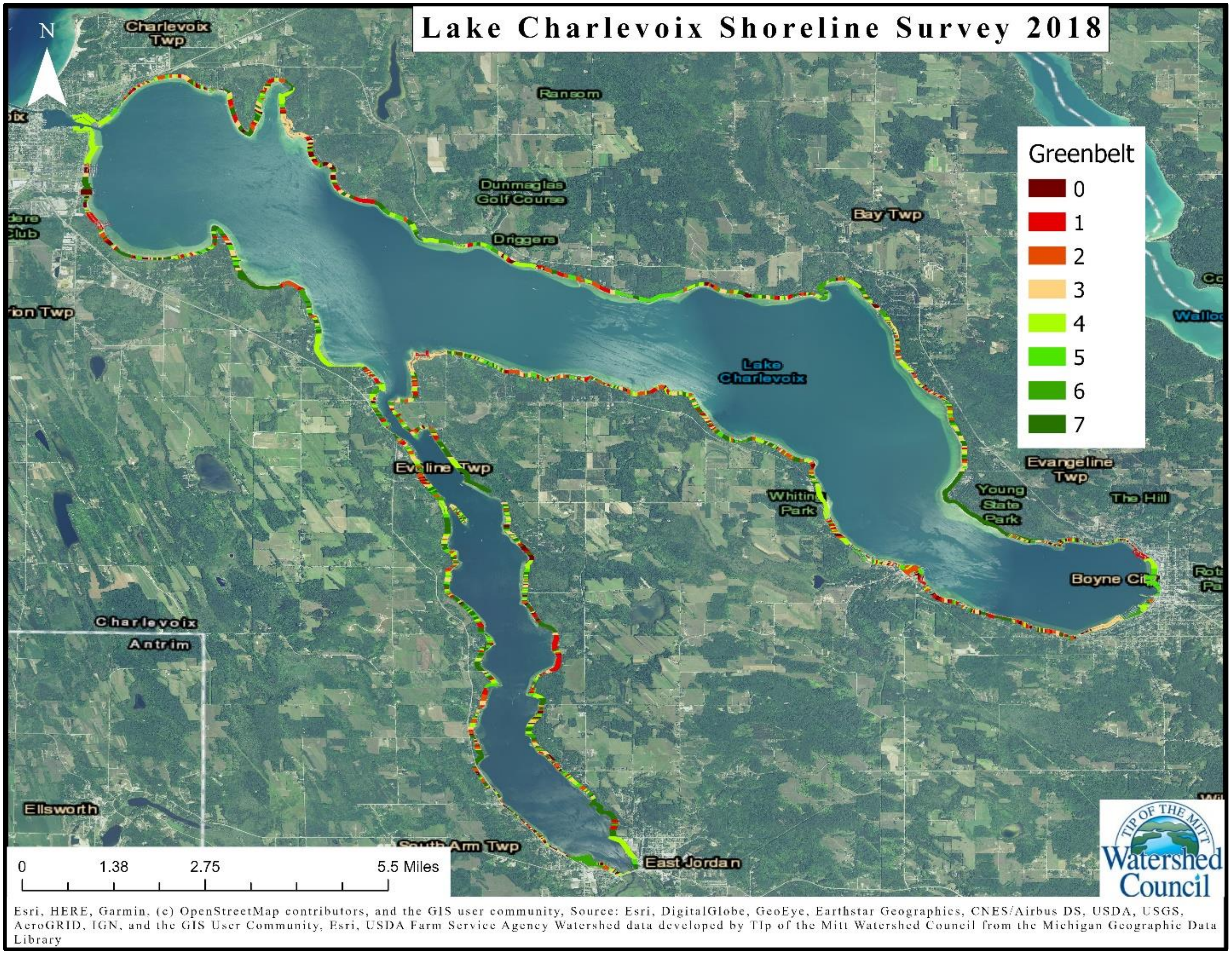

Figure 4 Greenbelt Scores around Lake Charlevoix shoreline

Erosion

Erosion was noted at 578 parcels (34%) on the Lake Charlevoix shoreline (Table 5). Of all erosion observed, 57% was classified as light in severity, while 7% of properties observed with erosion were considered heavy, severe erosion (Figure 5). Parcels with moderate to heavy erosion were observed sporadically around the lake. Clusters along the South Arm, near East Jordan, along the northern main basin and southeast of Whiting Park toward Boyne City also exhibited erosion.

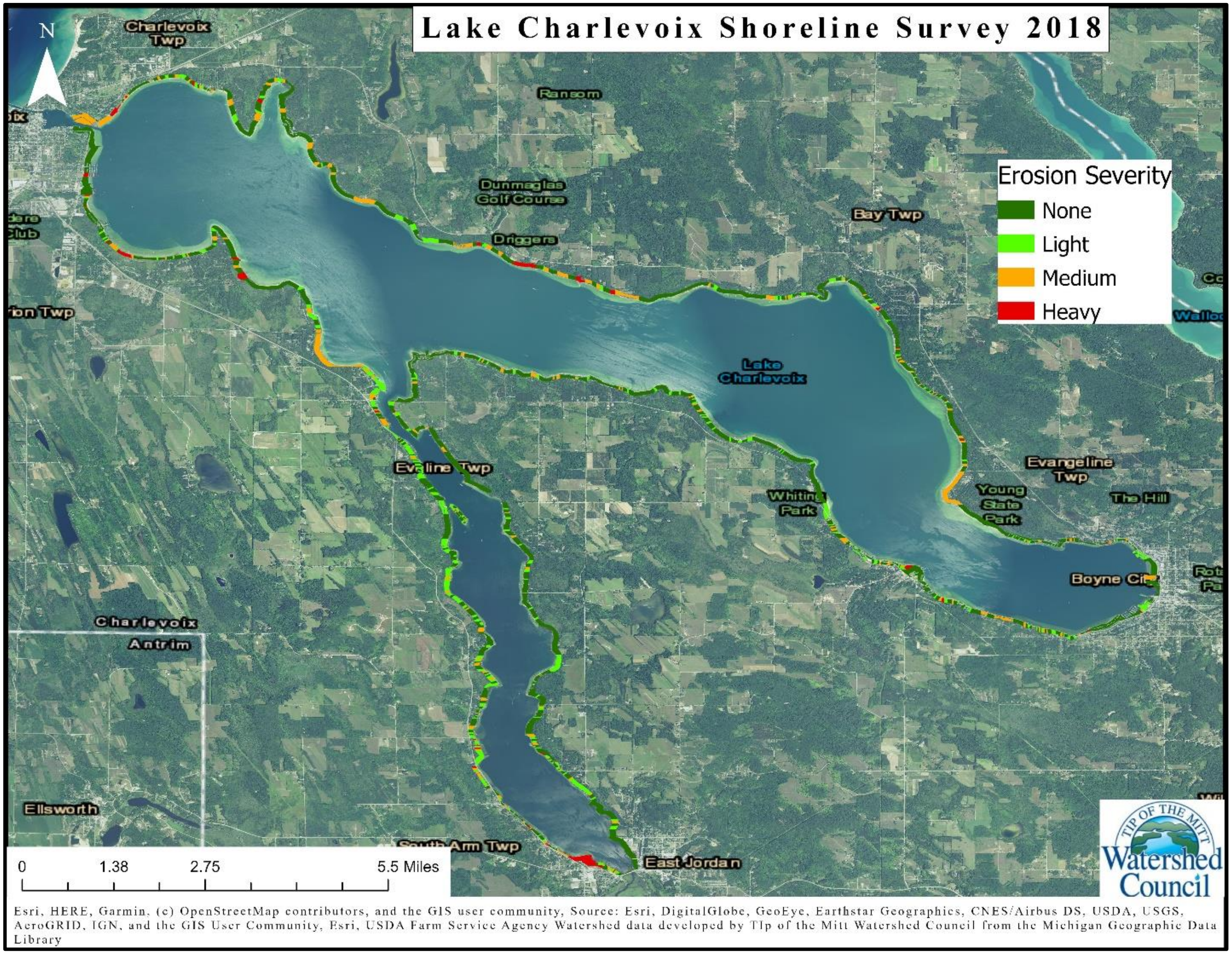

Figure 5 Lake Charlevoix Shoreline Erosion Severity

Table 5 Shoreline erosion severity results

Erosion Category	Number of Properties	Percent of total Properties (%)
Light	330	20
Medium	206	12
Heavy	42	2

Shoreline alterations

Some form of shoreline alteration was noted at 62.3% (1,371 parcels) of shoreline properties (Table 6). Most of the alterations were observed to be rock/cobble and boulder rip rap as well as artificial beach sand. There were also 191 seawalls observed along the shoreline.

Table 6 Shoreline alteration results

Alteration Type	Number of Parcels*	Percent With Alteration (%)*
Riprap (rock)	576	34
Riprap (boulder)	200	11.8
Mixed riprap	192	11.3
Seawalls	191	11.3
'Artificial' Beach Sand	258	15.2
Discharge Pipes	66	4.1
Unaltered	321	18.9

**Numbers and percentages quantify alteration type, some parcels could have multiple alterations*

DISCUSSION

In general, development of shoreline parcels can negatively impact a lake's water quality due to a multitude of factors. Among the most serious impacts to water quality include:

1) Loss of vegetation that would otherwise absorb and filter pollutants in stormwater runoff as well as stabilize shoreline areas and prevent erosion.
2) Increased impervious surface area such as roofs, driveways and roads, which leads to greater inputs of stormwater runoff and associated pollutants.
3) Waste and byproducts of human activity such as septic leachate, fertilizers and decomposing yard waste that potentially reach and contaminate the lake water.

There can be many problems associated with development, but there are also many solutions for reducing or even eliminating impacts. Numerous best management practices have been developed that help minimize negative impacts to water quality and can be utilized during or after the development of shoreline parcels. A buffer of diverse, native plants can be planted/maintained along the shoreline to filter pollutants and reduce erosion. Impacts from stormwater generated from roofs, roads, and driveways can be reduced using rain barrels, rain gardens, grassy swales, and many other techniques. Leachate reaching the lake from septic systems can be minimized by pumping the septic tank regularly, having all components of the septic system inspected regularly and replacing the septic system when necessary. Mulch can be composted far from the shoreline and fertilizers applied sparingly, if at all.

Results from the 2018 shoreline survey indicate that some of the aforementioned issues may pose a threat to the water quality and overall health of Lake Charlevoix. The lack of native vegetation at water's edge with potential septic leakage from parcels might be the greatest threat to Lake Charlevoix. Removal of shoreline vegetation and erosion are highlights of the main concerns. *Cladophora* presence was less of a concern around the entire Lake.

When compared to previous Lake Charlevoix shoreline surveys, the percentage of development along the shoreline and *Cladophora* presence was slightly higher in 2018, while erosion was similar to the 2012 survey (Appendix A). The percentage of development along Lake Charlevoix increased from around 85% in 2007 and 2012, to around 90% in 2018. Although a greater number of parcels exhibited *Cladophora* growth, the number of parcels with heavy growth was lower than 2012, but still greater than 2007. The percent of parcels with noticeable patches of *Cladophora* increased from 17% in 2007, 22% of the shoreline in 2012, up to 37% in 2018. Of the parcels with some presence of *Cladophora* in 2018, 23% was categorized as "light". Erosion was observed along 35% of the shoreline in 2012 and 34% of the shoreline in 2018.

The easiest, and perhaps most beneficial way to improve Lake Charlevoix shoreline to defend water quality would be to improve greenbelts along the shoreline. A lack of vegetation on the Lake's shoreline, which provides habitat and acts as a food source, can impact the abundance and diversity of aquatic organisms, ranging from minute crustaceans to top tier predator fish.

Furthermore, the absence of vegetation can lead to increased shoreline erosion and less filtration of pollutants. Although 30% of greenbelts are in poor condition, 33% of properties received a good to excellent score, indicating exemplary greenbelt health. Properties with healthy, intact greenbelts provide a model for improvement for other shoreline properties. Compared to other lakes in the region, Lake Charlevoix has a relatively low number of parcels exhibiting *Cladophora*, poor greenbelts, and above average number of shoreline alterations (Table 7).

Table 7 Shore survey statistics from Northern Michigan lakes

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

Many properties with patches of lawn at water's edge experience a minor undercutting caused by waves and ice shove. Properties with artificial beach sand usually experience some loss of sand into the Lake, evidenced by small erosional rills leading into the Lake. Although not catastrophic, these types of minor erosion do have the ability to degrade the water and habitat quality of Lake Charlevoix. To prevent changes to the lake ecosystem, changes should be made in shoreline property management. Mismanagement of shoreline properties can degrade the lake's water quality, diminish fisheries, and even create an environment that poses threats to human health. Therefore, Tip of the Mitt Watershed Council offers a number of recommendations.

RECOMMENDATIONS

The full value of a shoreline survey is only achieved when the information is used to educate riparian property owners about preserving water quality, and to help them rectify any problem situations. The following are recommended follow-up actions:

1. Keep the specific results of the survey confidential (e.g., do not publish a list of sites where *Cladophora* algae were found) as some property owners may be sensitive to publicizing information regarding their property.

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Beals Lake	2016	0%	0%	0%	17%	0%
Ben-Way Lake	2016	3%	0%	84%	47%	40%
Burt Lake	2009	47%	29%	4%	36%	46%
Bellaire Lake	2017	35%	1%	27%	30%	55%
Charlevoix, Lake	2018	37%	4%	34%	37%	62%
Clam Lake	2017	48%	5%	30%	51%	55%
Crooked Lake	2012	29%	26%	14%	51%	65%
Douglas Lake	2015	27%	6%	17%	53%	60%
Lake Charlevoix	2017	84%	2%	52%	30%	87%
Ellsworth Lake	2016	40%	14%	38%	24%	23%
Hanley Lake	2016	11%	0%	33%	19%	23%
Huffman Lake	2015	14%	0%	7%	57%	70%
Huron, Duncan Bay	2013	41%	2%	19%	45%	63%
Huron, Grass Bay	2013	0%	0%	4%	0%	8%
Intermediate Lake	2016	19%	9%	53%	63%	77%
Lance Lake	2014	19%	0%	12%	35%	31%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2016	44%	6%	36%	59%	76%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Scotts Lake	2016	0%	0%	2%	18%	7%
Silver Lake	2014	3%	0%	70%	53%	65%
Skegemog Lake	2017	52%	5%	40%	46%	76%
St. Clair Lake	2016	4%	0%	13%	34%	21%
Six Mile Lake	2016	10%	24%	13%	41%	37%
Thayer Lake	2017	11%	1%	32%	16%	22%
Thumb Lake	2007	4%	0%	ND	ND	39%
Torch Lake	2017	39%	5%	26%	20%	ND
Walloon Lake	2016	62%	2%	17%	39%	80%
Wildwood Lake	2014	5%	0%	22%	45%	50%
Wilson	2016	27%	5%	29%	11%	14%
AVERAGE	NA	24%	6%	27%	36%	46%

2. Send a general summary of the survey results to all shoreline residents.
3. Organize and sponsor an informational session to present findings of the survey to shoreline residents and provide ideas and options for improving shoreline management practices that would help protect and improve the Lake's water quality.
4. Inform owners of properties with heavy *Cladophora* growths of specific results for their

property, ask them to fill out a questionnaire in an attempt to interpret causes of the growth, and offer individualized recommendations for water quality protection.

5. Inform owners of properties with poor greenbelt scores and those with severely eroded shorelines of specific results for their property. Supply these property owners with information regarding the benefits of greenbelts and/or the problems associated with erosion. Encourage property owners to improve greenbelts using a mix of native plants and to correct erosion problems. Property owners can contact the Watershed Council for more information on how to improve greenbelts and/or correct erosion problems.
6. Utilize the Internet and other organizations' websites to share survey information. A general summary report and this detailed report can be posted on websites because they do not contain any property-specific information. Property-specific information can be shared by randomizing and encrypting the shoreline survey database and providing property owners with a code number that refers specifically to survey results from their property. The Watershed Council is available to assist with this approach.
7. Continue to support the Tip of the Mitt Watershed Council Volunteer Lake and Stream Monitoring programs by providing volunteer support. The information collected by volunteers is extremely valuable for evaluating water quality and determining trends. These data are also provided to State agencies (DEQ, EPA). Lake residents are encouraged to continue supplying volunteer help and volunteers should attend training sessions held by the Watershed Council to ensure that a complete set of quality data is being collected each year.
8. Repeat some version of the survey periodically (ideally every 5 - 10 years), coupled with the follow-up activities described previously, in order to promote water quality awareness and good management practices on an ongoing basis. During each subsequent survey, more details about shoreline features are added to the database, which can be utilized for other water resource management applications.
9. The Michigan Natural Shoreline Partnership has developed an educational tool called the Michigan Shoreland Stewards Program, which is a voluntary web-based survey designed to educate shoreline property owners on the importance of lake-friendly

management practices. The survey asks questions related to management practices in each of the four sections of a shoreland property: upland, buffer, shoreline and lake. Responses to the questions are rated to determine the shoreland steward recognition level. A gold, silver, bronze or starter level rating can be achieved. Encourage Lake Charlevoix residents to visit www.mishorelandstewards.org to take the survey.

APPENDIX A

Documentation	2007	2012	2018
Total Parcels	1,694	1,718	1,692
Developed	1,442	1,464	1,530
Undeveloped	252	254	162
Percent Developed	85.1%	85.2%	90.4%

	2007		2012		2018	
Cladophora **Density**	**Parcels**	**Percent**	**Parcels**	**Percent**	**Parcels**	**Percent**
Light	114	6.7%	119	6.9%	396	23%
Moderate	114	6.7%	83	4.8%	145	9%
Heavy	60	3.5%	168	9.8%	85	5%
TOTAL	288	17%	370	22%	624	37%

		2007		2012		2018	
Greenbelt Rating		**Number of Parcels**	**Percent of Parcels**	**Number of Parcels**	**Percent of Parcels**	**Number of Parcels**	**Percent of Parcels**
0	Very Poor (absent)	388	23%	357	21%	191	11%
1-2	Poor	369	22%	429	25%	439	26%
3-4	Moderate	937	55%	330	19%	488	29%
5-6	Good	--	--	315	18%	436	26%
7	Excellent	--	--	287	17%	127	8%

	2007		2012		2018	
Alteration Type	**Number***	**Percent of Total**	**Number***	**Percent of Total**	**Number***	**Percent of Total**
Riprap (small rock)	396	23%	511	30%	576	34%

Riprap (boulder and rock)	61	4%	287	17%	192	11%
Seawalls	223	13%	100	6%	191	11%
Beach sand®	295	17%	259	15%	258	15%

	2007		2012		2018	
Erosion Category	**Number of Properties**	**Percent of Properties***	**Number of Properties**	**Percent of Properties***	**Number of Properties**	**Percent of Properties***
Light	--	--	263	15%	330	20%
Moderate	--	--	253	15%	206	12%
Severe	--	--	77	4%	42	2%
TOTAL	154	100%	593	35%	578	34%