Mullett Lake Shoreline Survey 2016

By Tip of the Mitt Watershed Council

Report written by:

Dave D. Edwards & Matt L. Claucherty

Watershed Protection Team

December, 2017

Table of Contents

List of Figures

Page

List of Tables

Page

SUMMARY

During the summer of 2016, the Tip of the Mitt Watershed Council conducted a shoreline survey of Mullett Lake. Surveys were designed to replicate a 2008 shoreline survey, documenting conditions that can impact water quality, including the three biggest threats to inland lakes: nutrient pollution, habitat loss, and shoreline erosion. With funding from the Mullett Lake Area Preservation Society (MAPS), this assessment was conducted on a parcel by parcel basis. Within the Mullett Lake Watershed, shoreline properties have the greatest potential to impact Mullett Lake water quality. Survey results indicate that human activity along Mullett Lake shoreline is likely impacting the lake ecosystem and water quality.

Development and Shoreline Vegetation

Of all shoreline properties, 86% were considered developed. Over half (59%) of all shoreline properties contained little to no vegetation (beyond manicured lawn) growing at water's edge. These 2016 results are similar to results from 2008, where 86% of all parcels were considered developed and 64% of shoreline properties showed little to no vegetation at water's edge. These data suggest Greenbelt status along the Mullett Lake shoreline has increased slightly since the 2008 survey. Lack of vegetation on shoreline property is variable around the lake, however poor greenbelts are highlighted along the northern and southeastern shoreline. Healthy greenbelts are also variable around the lake, and are partially concentrated along the southwestern shoreline.

Erosion and Shoreline Alterations

Erosion was documented along the shoreline of 471 properties (36%), which was increased from the 2008 survey (158 properties, 12%). A majority of these erosion areas (329 out of 471 shoreline properties) were identified as "minor" erosion. Meaning, exposed soils were present or contained a gully up to 1" deep. Shoreline alterations were also more prevalent in 2016 (984 shorelines, 76%) than in 2008 (754 shorelines, 58%). A majority of identified shoreline alterations (808 of 984 shorelines, 82%) were identified as cobble and boulder riprap.

Nutrients and *Cladophora*

The number of shoreline areas with signs of nutrient pollution has decreased, relative to the 2008 survey. *Cladophora*, an algal indicator of nutrient pollution, was documented at 44% of all properties, down from 59% in 2008. Fifty-nine tributaries were documented in 2016, increased from 49 tributaries identified in 2008.

In conclusion, data collected during 2016 indicate slight shoreline improvements. However, considerable human activity along the shores of Mullett Lake is impacting the lake ecosystem. Steps can be taken to improve the habitat and water quality of Mullett Lake. Erosion sites can be repaired, greenbelts can be enhanced by allowing vegetation to regrow on the shoreline, providing improved nutrient filtration and erosion resistance. Outreach to shoreline property owners regarding lake-friendly shoreline management practices can help to improve conditions. Educating residents on lake-friendly shoreline management is often all that is needed to bring about change.

INTRODUCTION

Background

During the late spring and early summer of 2016, a shoreline survey was conducted on Mullett Lake by the Tip of the Mitt Watershed Council (Watershed Council) to document shoreline conditions that potentially impact water quality. The entire shoreline was surveyed to document the following: algae (*Cladophora*) as a nutrient pollution indicator, erosion, shoreline alterations, greenbelts, and tributary inlets and outlets.

According to Watershed Council records, Mullett Lake has had two shoreline surveys conducted prior to 2016. During the first survey, in 1989, Watershed Council staff identified nutrient pollution problems through the use of increased algae presence and a septic leachate detector

in densely populated areas of Mullett Lake. Additionally, the entire shoreline was surveyed to document adjacent wetlands. This original survey was funded by the Michigan Department of Natural Resources and the United States Environmental Protection Agency. In 2008, Maullett Lake Area Preservation Society and National Fish and Wildlife Foundation funded a more detailed and comprehensive shoreline survey. This survey was the first comprehensive report that provided data to help understand specific shoreline conditions on Mullett Lake. The 2008 survey included identification of specific shoreline areas with erosion and algae concerns that can be attributed to shoreline alterations and nutrient inputs. In 2016, another comprehensive shoreline survey was conducted through funding provided by the Mullett Lake Area Preservation Society (MAPS).

The following 2016 survey results provide a comprehensive data set documenting shoreline conditions on Mullett Lake; A valuable dataset that can be used as a lake management tool. Where possible, the Watershed Council has compared 2016 survey results with 2008 survey results. Combined with follow-up activities, such as questionnaires and site visits, problems in shoreline areas that threaten the lake's water quality can be identified and corrected. These solutions are often simple and low cost, such as regular septic system maintenance, proper lawn care practices, and wise land use along the shoreline. In addition, outreach and education, particularly associated with this survey, is critical to protecting water quality. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends of near-shore nutrient inputs and shoreline alterations associated with land-use changes, and for assessing the success of remedial actions.

Shoreline Development Impacts

Lake shorelines are an important interface linking the landscape to water within a watershed. This area is a transitional zone that does not necessarily have an exact line between the landscape and water and is the area in which a transfer of water and nutrients occurs from land to water. Lake shorelines are shape, size, and vegetation dependent. Accordingly, human

activities along shorelines have high potential for degrading water quality within Mullett Lake. Development of shoreline properties for residential, commercial, or other use have an impact on Mullett Lake in a variety of ways and in various degrees. For example, as more vegetation is removed from the shoreline, the potential for nutrients and pollutants to run off the landscape and enter Mullett Lake increases. Moreover, as the Mullett Lake Watershed terrain is altered, structures are built, and areas paved, pollutants from cars, roads, and soils from eroded areas can often end up in Mullett Lake.

Nutrient pollution can have adverse impacts on aquatic ecosystems and pose a danger to human health. While nutrients are necessary to sustain a healthy aquatic ecosystem, excess nutrients will stimulate nuisance aquatic plant 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. blue green algae) produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Excess plant and algae growth can also degrade water quality by depleting the ecosystem's dissolved oxygen stores. During nighttime respiration, plants compete with other organisms for a limited oxygen supply. Furthermore, the decomposition of algae and plants has the potential to deplete dissolved oxygen supplies due to the aerobic activity of decomposers, particularly in the deeper waters of stratified lakes.

In general, deep, large lakes such as Mullett are less sensitive to nutrient pollution. With the increased volume, large lakes tend to have greater dissolved oxygen stores and increased dilution of nutrients. By contrast, small lakes generally have smaller stores of dissolved oxygen and a lesser ability to dilute nutrients. Nutrient pollution can be more problematic in small lakes due to extensive shallow areas that can support more aquatic plant growth. However even large lakes can develop problematic nutrient levels and algae issues if left unchecked.

Mullett Lake is one of the largest and deepest inland lakes in the State of Michigan (17,200

acres, maximum depth = 144 feet). As a result, Mullett is relatively resilient to nutrient pollution when compared to surrounding smaller lakes. Mullett Lake is a drainage lake with important inflows and outflows, providing a mechanism to flush excess nutrients out of the system. However, unnaturally high nutrient concentrations can occur and cause localized problems for landowners, particularly near shoreline areas.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from riparian (shoreline) areas, and atmospheric deposition. Springs 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 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 results in soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, 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 (a.k.a., bio-indicators). Although chemical analyses of water samples to check for nutrient pollution can be effective, they are oftentimes more labor intensive and costlier than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituents, such as chloride, can be measured. Physical measurements, such as water temperature and conductivity (i.e., the water's ability to conduct an electric current), are primarily used to detect malfunctioning septic systems. Biologically, nutrient pollution can be detected along the lake shore by noting the presence of *Cladophora* algae, a bio-indicator.

Cladophora is a branched, filamentous green algal species that occurs naturally in small amounts in Northern Michigan lakes. *Cladophora* occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. This algae bio-indicator is found most commonly in the wave splash zone and shallow shoreline areas of lakes, as well as streams and grows best on stable substrates such as rocks and logs. Artificial substrates such as concrete or wood seawalls are also suitable. *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 from mid-May to early July, and September to October.

The nutrients required for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in the lakes of Northern Michigan. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. Although the growth features of *Cladophora* can be influenced by factors such as current patterns, shoreline topography, substrate composition, and wave action, the presence or absence of any significant growth is a powerful lake-wide screening tool. The existence of chronic nutrient loading problems can be revealed and *Cladophora* presence can assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient inputs due to changing land use.

Erosion along the shoreline has the potential to degrade the lake's water quality. Stormwater runoff carries sediments into the lake and impacts the lake ecosystem in a variety of ways. Sediments reduce organism respiration by clogging the gills of fish, insects, and other aquatic organisms. Excessive sediments smother fish spawning beds and fill interstitial spaces 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 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. They also help to stabilize shorelines against wave and ice action with their extensive network of deep, fibrous roots. Greenbelts also provide shade to nearshore areas, which is particularly important for lakes with cold water fisheries. In addition, greenbelts provide a mechanism to filter pollutants carried by stormwater from rain events and snowmelt. Another pollutant and nutrient delivery mechanism is a tributary.

The primary function of a tributary is to drain the landscape. Therefore, tributaries have a significant potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake from its watershed. Inlet streams may provide exceptionally high quality waters that benefit the lake ecosystem; 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 the means to remove contaminants that have accumulated in the lake ecosystem. With regard to shore surveys, noting the location of inlet tributaries is very helpful when evaluating shoreline algae conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to naturally heavier *Cladophora* and other algal growth in nearby shoreline areas.

Lake-friendly shoreline property management is paramount for protecting water quality and sustaining a healthy, thriving lake ecosystem. Healthy greenbelts, septic system maintenance, stormwater management, erosion control, and the elimination of fertilizers, herbicides, and pesticides are among the many low-cost best management practices that minimize the impact

of shoreline properties on water quality.

Study Area

Mullett Lake is located at the northeastern tip of the Lower Peninsula of Michigan; in Aloha, Benton, Inverness, Koehler, Mullett, and Tuscarora Townships of north-central Cheboygan County. Based upon digitization of aerial orthophotography provided by Cheboygan County Equalization (2004), the shoreline of Mullett Lake proper measures 30.48 miles and lake surface area totals 16,512 acres, while the Indian River spreads connecting at the south of Mullett Lake includes an additional 692 acres. Mullett Lake is approximately 9 miles long, gradually widening from the southwest to northeast. Pigeon River and Scott Bays are located in the southern part of the lake and prominent points are interspersed along the shoreline including Dodge, Long, Needle, Parrott, Red, Pine, Round, Stony, and Veery Points (Figure 1).

Bathymetry maps from the state of Michigan as well as the Sportsman's Connection Fishing Map Guide show the deepest area located directly out from Red Pine Point with a maximum depth of 120 feet. However, a deeper hole not appearing on these maps is known to exist in front of Long Point where sampling by Watershed Council staff has documented a depth in excess of 140 feet. According to digitized bathymetry maps acquired from the Michigan Geographic Data Library, approximately 62% of the lake (including Indian River Spreads) exceeds 20 feet of depth. Relatively shallow areas are found in the southwest in the Indian River Spreads and Pigeon River Bay and in the northeast where there is a broad shallow plateau. Mullett Lake contains both inlets and outlets.

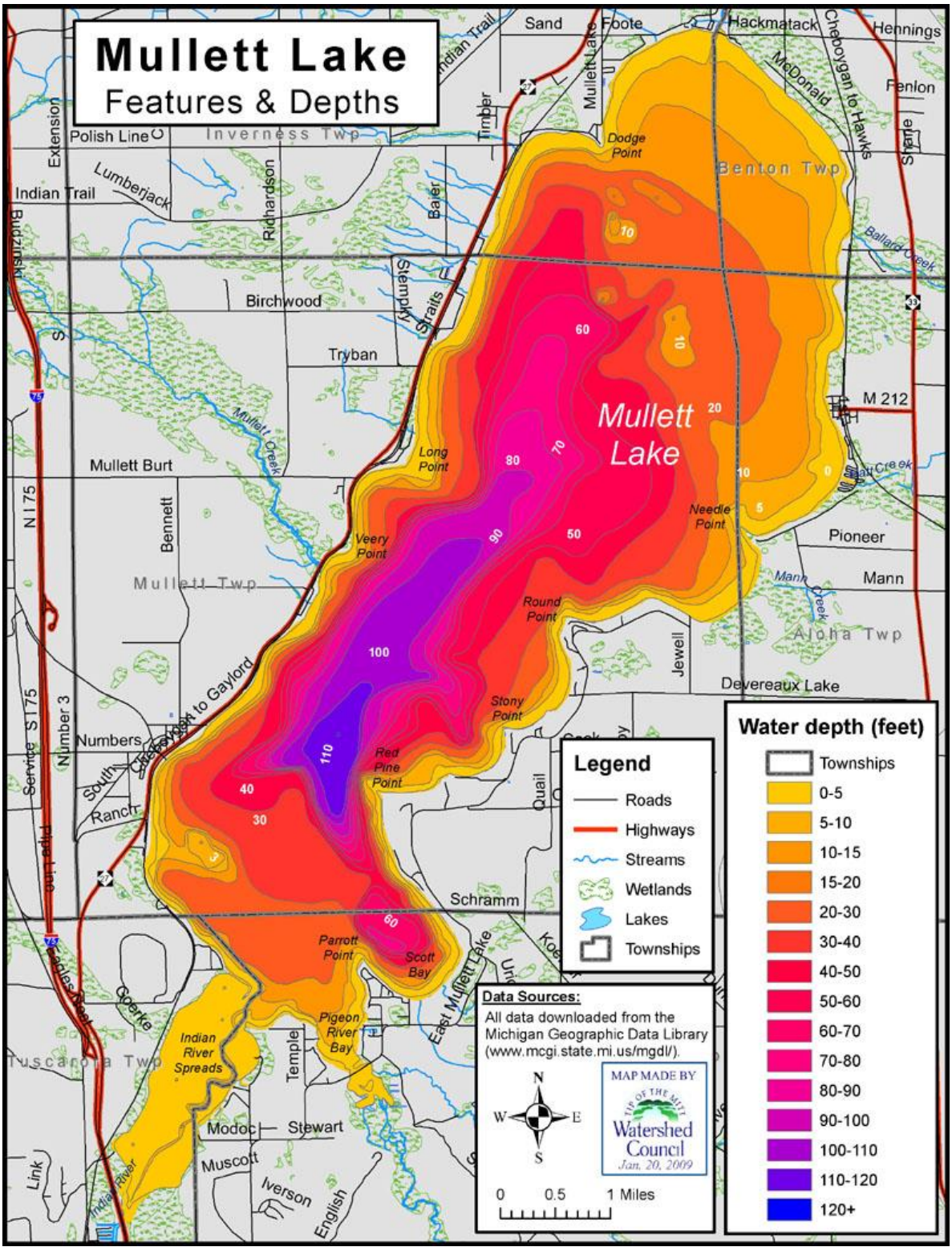


Figure 1. Map of Mullet Lake: Features and Depths

Mullett Lake is a part of the Inland Waterway. The Inland waterway consists of three large lakes (Mullett, Burt, Crooked) all connected by three rivers (Crooked, Indian, Cheboygan). Mullett is a drainage lake with primary inlets including the Indian and Pigeon Rivers in the southwest end of the lake. The only outlet from Mullett Lake is the Cheboygan River in the northeast end. As a part of the inland waterway, Mullett Lake is the final lake water passes through on the way to Lake Huron. A number of smaller tributaries enter into the lake throughout the length of the Lake, including Ballard, Hatt, Mullett, and Scott Creeks (USGS, 1990).

According to GIS (Geographical Information System) files developed by the Watershed Council using watershed boundary and elevation data acquired from the State of Michigan, the Mullett Lake Watershed encompasses approximately 560,000 acres of land and water. The Watershed stretches from the City of Gaylord in the south, to the Cheboygan River to the north and contains a number of the other regionally important water bodies including Burt Lake, Douglas Lake, Crooked Lake, the Maple River, the Sturgeon River, and the Pigeon River (Figure 2). Therefore, understanding the health of Mullett Lake holistically provides water body health information about a significant portion of Michigan's Northern Lower Peninsula.

To put the importance of understanding Mullett Lake ecosystem health in perspective, a watershed ratio of 32.55 was calculated by dividing the lake surface area into the watershed area (not including the lake). This value indicates there are over 32 acres of watershed area for each acre of Mullett Lake water surface. A watershed ratio provides a statistic for gauging susceptibility of lake water quality to changes across the landscape. Relative to other lakes in Northern Michigan, Mullett Lake has a high watershed ratio. Therefore, recognizing major watershed attributes is important in order to detect any potential changes in the watershed.

Land cover statistics were generated for the Watershed using data from the Coastal Great Lakes Land Cover Project (Table 1). Based on 2006 data, the majority of the Watershed's land cover is natural; consisting primarily of forest, wetlands, and grassland. There is little agricultural land

cover within the Watershed (~9%) and even less urban (~3.5%), though both of these land-cover types increased by roughly one percent between 2000 and 2006. As of 2010, land cover has remained consistent within the Mullett Lake Watershed.

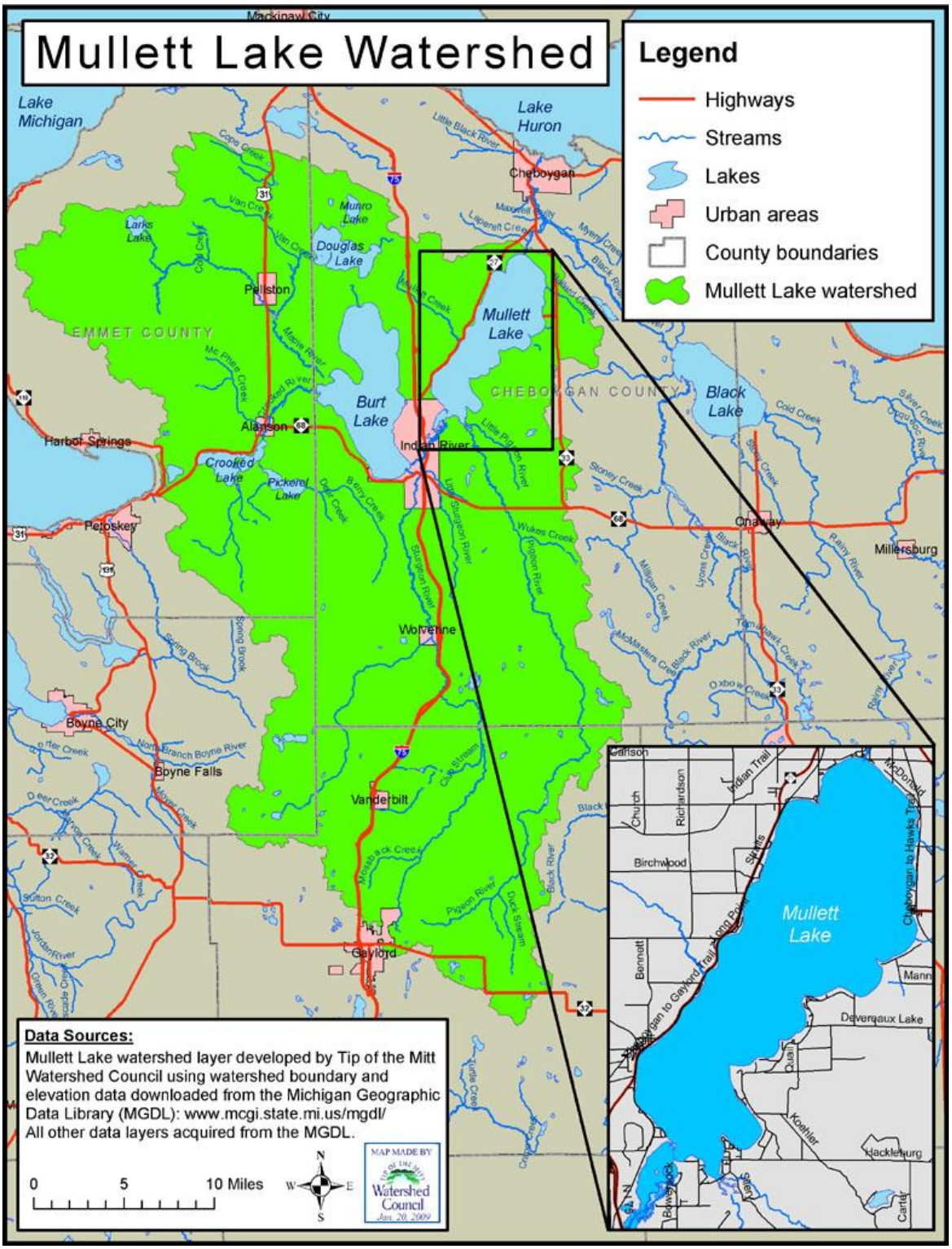


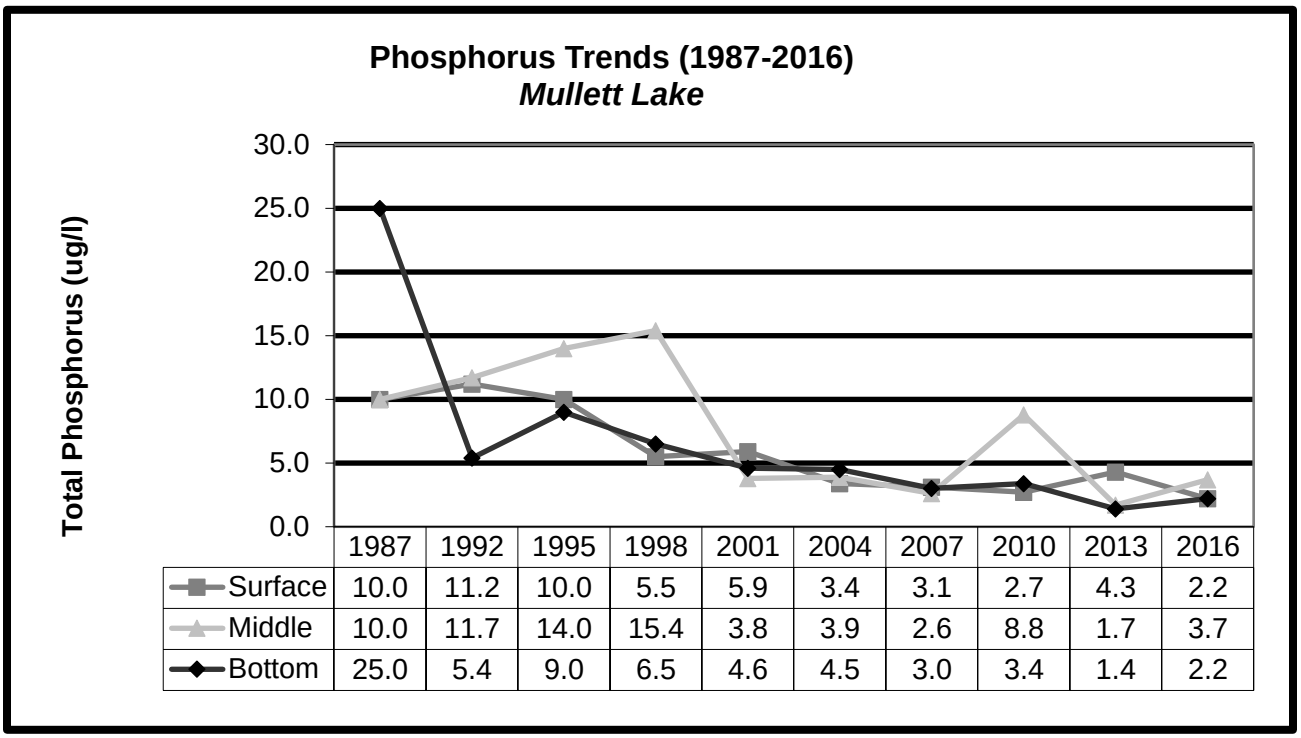
Figure 2. Map of Mullett Lake and its Watershed

Table 1. Mullett Lake Watershed land cover, 2000, 2006, 2010, and change 2000 – 2010

Land Cover Type	2000 Percent	2006 Percent	2010 Percent	2000 – 2010 Change (%)
Agriculture	8.06	8.76	8.72	-0.66
Barren	0.22	0.16	0.18	-0.04
Forested	49.36	51.18	49.47	0.11
Grassland	14.81	9.28	8.59	-6.22
Scrub/shrub	3.27	4.01	5.51	2.24
Urban	2.35	3.35	3.41	1.06
Water	8.32	8.21	8.22	-0.10
Wetland	13.59	15.04	15.89	2.30
TOTAL	100.00	100.00	100.00	NA

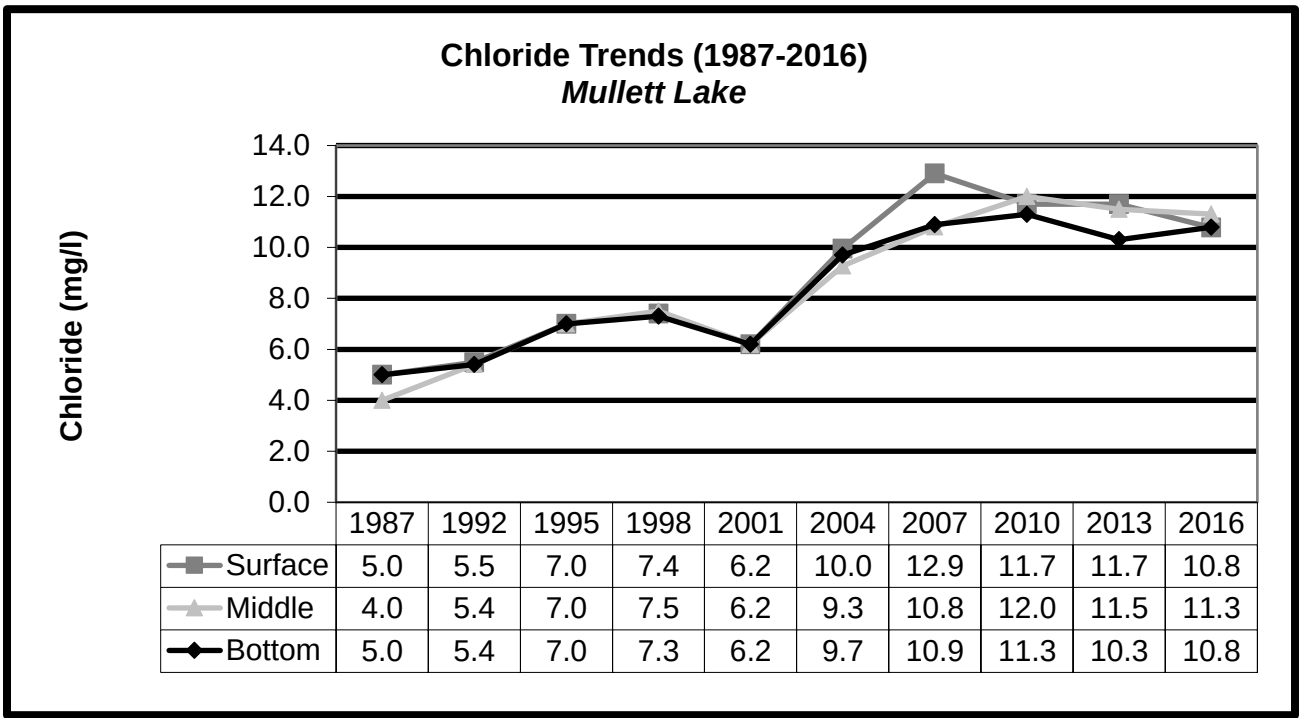
The Mullett Lake Area Preservation Society (MAPS) has actively supported water quality monitoring programs on Mullett Lake. Volunteers have engaged with water quality monitoring programs coordinated by Tip of the Mitt Watershed Council. In addition, Watershed Council staff monitor Mullett Lake water quality as part of the Comprehensive Water Quality Monitoring Program (CWQM). Watershed Council databases contain Volunteer Lake Monitoring and CWQM data that date back to 1986 and 1987 respectively.

From these programs, data clearly indicate water quality remains high. Total phosphorous measurements collected as part of the CWQM program show decreasing concentrations throughout the last 20 years (Figure 3). Total phosphorus readings are now consistently below 10 parts per billion (PPB). This value is typical for high quality lakes of Northern Michigan. However, chloride measurements have been on the rise in recent years, which could be a result of winter roadside salt application and other nonpoint source pollution within the Watershed (Figure 4).



	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016
Surface	10.0	11.2	10.0	5.5	5.9	3.4	3.1	2.7	4.3	2.2
Middle	10.0	11.7	14.0	15.4	3.8	3.9	2.6	8.8	1.7	3.7
Bottom	25.0	5.4	9.0	6.5	4.6	4.5	3.0	3.4	1.4	2.2

Figure 3. Mullett Lake Phosphorus trends



	1987	1992	1995	1998	2001	2004	2007	2010	2013	2016
Surface	5.0	5.5	7.0	7.4	6.2	10.0	12.9	11.7	11.7	10.8
Middle	4.0	5.4	7.0	7.5	6.2	9.3	10.8	12.0	11.5	11.3
Bottom	5.0	5.4	7.0	7.3	6.2	9.7	10.9	11.3	10.3	10.8

Figure 4. Mullett Lake Chloride trends

METHODS

Mullett Lake was surveyed in kayak during June and July of 2016 to document shoreline conditions. Tip of The Mitt Watershed Council performed the survey, noting and photographing property features on all shoreline parcels. Shoreline conditions were surveyed by traveling as close to the shoreline as possible (usually within 20 feet) and noting *Cladophora* growth, substrate type, erosion conditions, greenbelt length, greenbelt depth, shoreline alterations, and tributaries. All information was recorded on field data sheets, subsequently compiled into a database, and used in conjunction with GPS data to link field data and photographs with property owner (equalization) data.

Field Survey Parameters

Shoreline property features were documented by photographing and noting physical features on a data sheet, such as building descriptions, public access sites, and county road endings. Due to data sheet space limits, building descriptions were recorded in an abbreviated cryptic style. For example, *Red 2 sty, brn rf, wht trm, fldstn chim, lg pine* means that the property has a red two-story house with a brown roof, white trim, fieldstone chimney, and a large pine tree in the yard. Whenever possible, names of property owners and addresses were included.

Developed parcels were noted on field data sheets and included as a separate column in the database. Properties described as developed indicate the presence of buildings or other significant permanent structures, including roadways, boat launching sites, and recreational properties (such as parks with pavilions and parking lots). Properties with only mowed or cleared areas, seasonal structures (such as docks or travel trailers), or unpaved pathways were not considered developed. Additionally, large parcels that had structures in an area far from the water's edge were not considered developed. The length and area of developed versus undeveloped shoreline was not calculated. 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 of these species usually requires the aid of a microscope. However, *Cladophora* usually has an appearance and texture that is quite distinct to a trained surveyor, and these were the sole criteria upon which identification was based. 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 on the data sheets 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. For example, "MHx30 – seeps" denotes a moderate to heavy growth that covered 30' of the shoreline and with groundwater seeps in the area that may have been 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 on field data sheets 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 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: <25%, 2: 25-75%, 3: >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 on the field data sheets and included in a separate column in the

database. Additional information regarding shoreline property features or shoreline conditions written on field data sheets was included in the database in a "comments" column. The comments column also included notes about shoreline alterations. Shoreline alterations (structures) were noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)
CB = concrete bulkhead
WB = wood bulkhead
BB = boulder bulkhead
RR = rock rip-rap
BH = permanent boathouse
DP = discharge pipe

Sometimes abbreviations were mixed or vary from what is listed above.

Data Processing

Upon completion of surveying the entire Mullett Lake shoreline, all field data were transferred to computer. Information recorded on field data sheets was placed into a Microsoft Excel® workbook. Digital photographs and GPS data were uploaded to a computer at the Watershed Council office 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. Field data were linked to Cheboygan County parcel data in a GIS with the aid of GPS and photographs. Errors can occur wherein field data are not linked to the appropriate parcel.

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 Mullett Lake 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 to produce the maps contained in this report.

Final products include a comprehensive database, a complete set of digital photographs, and a GIS data layer representing shoreline parcels including both county equalization and shore survey data. The shoreline survey database contains a sequential listing of properties beginning at the Mullett Township boat launch in Topinabee on the southeast side of the Lake and traveling counter-clockwise around the entire perimeter of the Lake. The database contains all data collected in the field and identification numbers in the database correspond to those in the GIS data layer and on the hard-copy map. Digital photographs were named using the same identification numbers and are linked to the GIS data layer.

RESULTS

Following are results of the 2016 survey documenting shoreline conditions at 1,293 parcels on Mullett Lake. Approximately 86% (1,113) of shoreline properties on Mullett Lake were considered developed.

Cladophora

Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 564 parcels (44% of total parcels surveyed) (Table 43. At properties where *Cladophora* growth was observed, 71% (400 parcels) consisted of light or very light growth, whereas only 13% (164 parcels) parcels had growth in the moderate to heavy categories.

Table 3. Cladophora density results

***Cladophora* Density**	**Parcels**	**Percent (%)**
Very light	198	15
Light	202	16
Light to Moderate	67	5
Moderate	33	3
Moderate to Heavy	32	2
Heavy	28	2
Very Heavy	4	< 1
TOTAL	564	44

Most of the moderate – heavy to heavy patches of *Cladophora* growth were located along the northern shores of Mullett Lake (Figure 5). A few parcels along the eastern shoreline contained moderate *Cladophora* growth. Properties with little to no *Cladophora* growth were concentrated along the southwestern and southern shore.

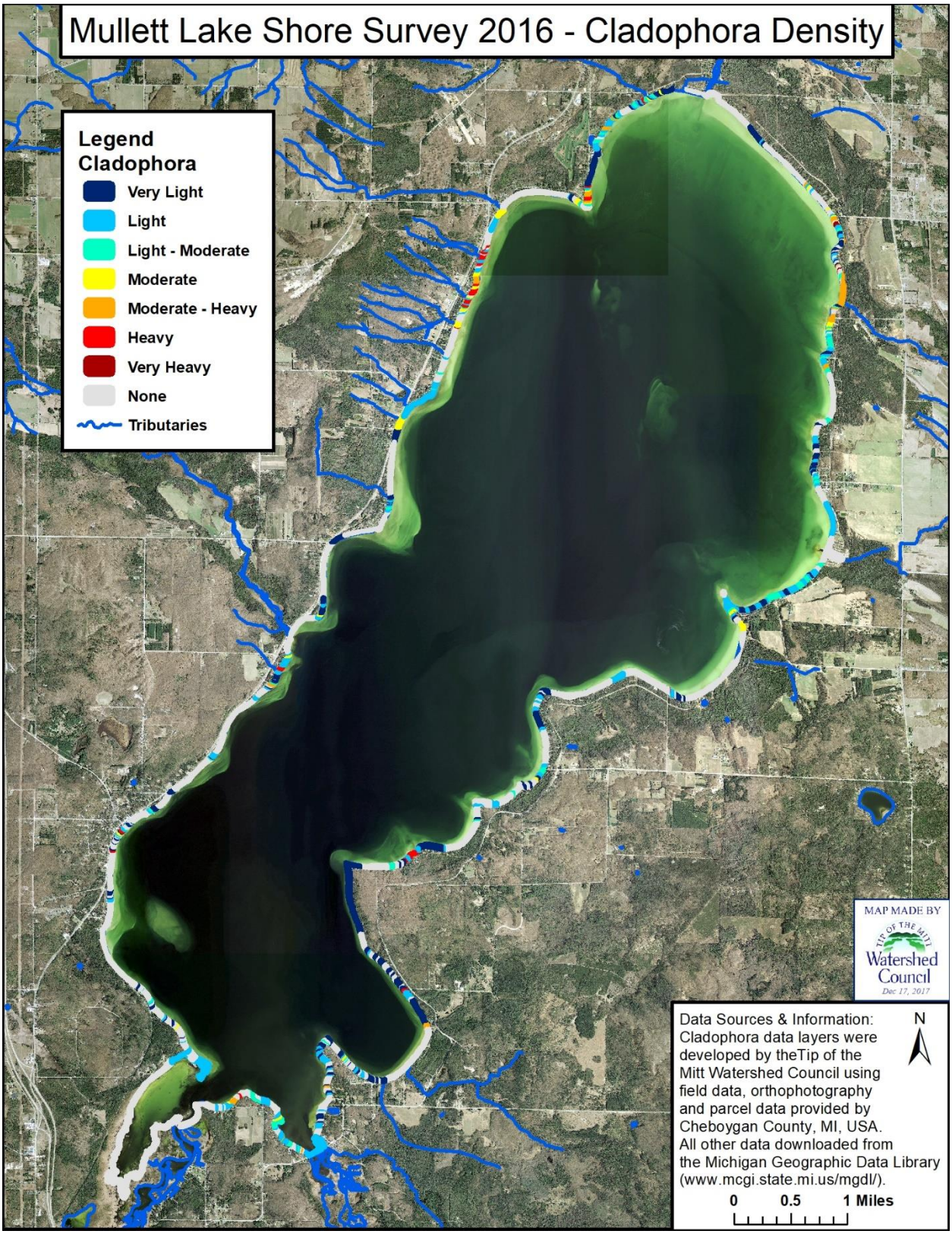


Figure 5. *Cladophora* algae density results Mullett Lake

Greenbelt Scores

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Only 20% of shoreline greenbelts along Mullett Lake were found to be in good or excellent condition (Table 4). A majority of parcels (59%) received a greenbelt rating in the poor or very poor categories.

Table 4. Greenbelt rating results

Greenbelt Rating		Number of Parcels	Percent (%)
0	Very Poor (absent)	444	34
1-2	Poor	325	25
3-4	Moderate	261	20
5-6	Good	160	12
7	Excellent	103	8

Greenbelt status varied throughout Mullett Lake. However, many clusters of properties along the northern shoreline were ranked very poor (absent) to poor (Figure 6). Clusters along the western and southern shoreline were in the moderate to excellent rating.

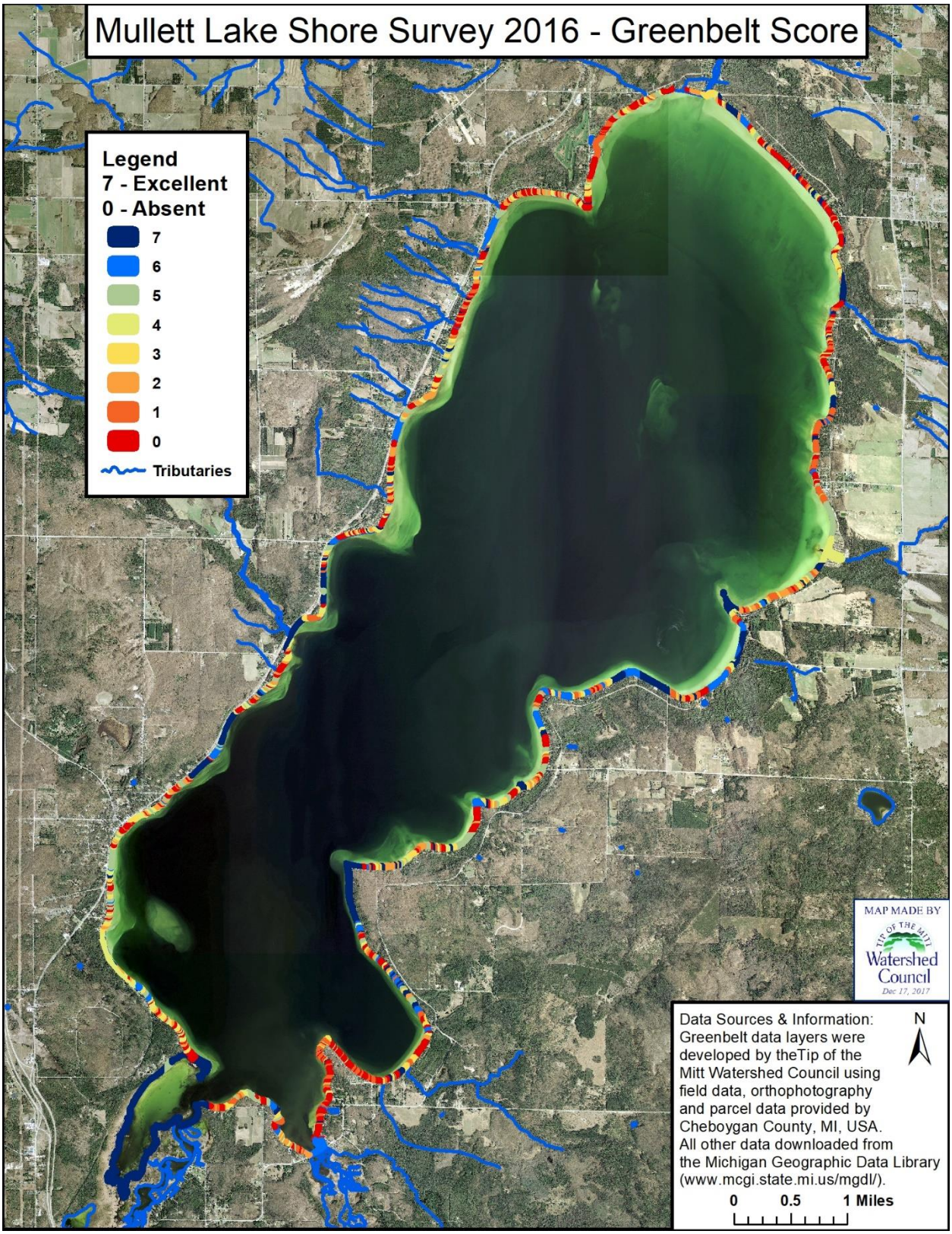


Figure 6. Greenbelt score totals results for Mullett Lake

Shorline alterations

Some form of shoreline alteration was noted at 76% of shoreline properties (Table 6). The majority of alterations consisted of riprap (62%), while seawalls (wooden, concrete, or metal), account for approximately 7% of all shoreline alterations.

Table 5. Shoreline alteration results

Alteration Type	Number of Parcels*	Percent With Alteration (%)*
Riprap (small)	221	17
Riprap (boulder)	98	8
Mixed riprap	489	38
Seawalls	90	7
Beach Sand	120	9
Discharge Pipes	186	14
Unaltered	309	24

**Numbers and percentages quantify alteration type, many parcels had multiple alterations*

Erosion

Erosion was noted at 108 parcels (36%) on the Mullett Lake shoreline (Table 7). Twenty-four percent of shoreline properties with erosion were classified as minor in terms of severity, while less than 1% of properties were considered severe. Pockets of shoreline erosion were identified along the northern and southern most shoreline of Mullett Lake (Figure 7).

Table 6. Shoreline erosion results

Erosion Category	Number of Properties	Percent of Properties (%)
Minor	71	24
Moderate	33	11
Severe	4	< 1
TOTAL	108	36

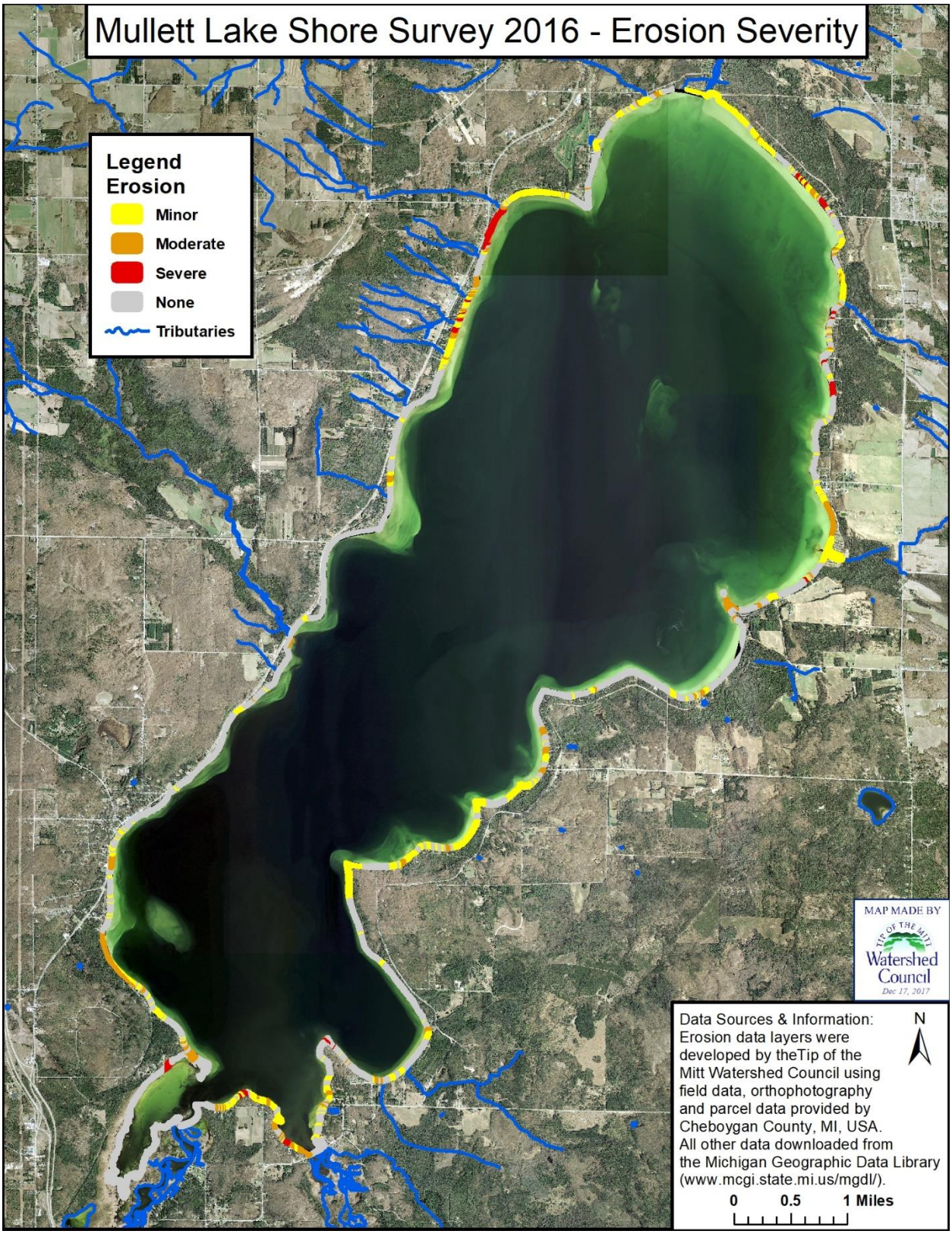


Figure 7. Shoreline erosion severity results for Mullett Lake

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 are: 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, and 3) waste and byproducts of human activity such as septic leachate, fertilizers and decomposing yard waste that potentially reach and contaminate the lake water. Clearly, there are many problems associated with development, but there are also many solutions for reducing or even entirely eliminating impacts.

Numerous best management practices have been developed that help minimize negative impacts to water quality and which can be utilized during, or retroactively after, the development of shoreline parcels. A buffer of diverse, native plants can be 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 2016 shoreline survey indicate that some of the aforementioned issues may pose a threat to the water quality and overall health of Mullett Lake. Widespread removal of shoreline vegetation is the paramount concern. Over half (59%) of all shorelines exhibited greenbelts that were in poor condition. Erosion is also a concern, with light to moderate erosion commonly occurring throughout the same areas most heavily impacted by vegetation removal. Algal indicators of nutrient pollution are far less extensive than the above issues. Comparisons with prior shoreline surveys show changes in these measurements over time. The

total number of properties with documented *Cladophora* growth decreased by 15% since 2008 (Table 8). This indicates that the trend of increasing near-shore nutrient pollution, identified in the 2008 report, is abating. Outreach regarding septic system maintenance, phasing out of old systems, and properly siting new systems may be playing a role in reduction in nutrient pollution related to septic systems. A few problem areas still exist, which warrant further investigation. Where human-caused nutrient pollution is occurring, the source has to be identified in order to address the problem. Although impeded by factors such as wind, wave action, currents, and groundwater paths, efforts by trained personnel to identify specific nutrient input sources on individual properties are often successful.

Table 7. Critical shoreline survey parameter comparisons: 2008 to 2016

Survey Parameter	**2008 Survey Results**		**2016 Survey Results**	
	Properties	%	Properties	%
Cladophora Algae Presence	758	59%	564	44%
Poor Greenbelts (score 0-2)	822	64%	769	59%
Erosion	158	12%	471	36%
Shoreline Alterations	754	58%	984	76%

Average greenbelt conditions have improved, albeit slightly, around Mullett Lake. Further improvements would benefit the lake's ecosystem and reduce impacts associated with increasing lakeshore development. 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 leads to greater amounts of shoreline erosion and less filtration of pollutants. Although a substantial number of greenbelts are in poor condition, 7% of properties received a perfect 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, Mullett Lake has a relatively high number of parcels exhibiting *Cladophora* growth (Table 9).

Table 8. Shore survey statistics from Northern Michigan lakes

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Beals Lake	2016	0%	0%	0%	17%	0%
Black Lake	2005	20%	21%	ND	ND	ND
Burt Lake	2009	47%	29%	4%	36%	46%
Charlevoix, Lake	2012	22%	19%	14%	34%	79%
Crooked Lake	2012	29%	26%	14%	51%	65%
Douglas Lake	2015	27%	6%	17%	53%	60%
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%
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%
Six Mile Lake	2016	10%	24%	13%	41%	37%
Thumb Lake	2007	4%	0%	ND	ND	39%
Walloon Lake	2016	62%	2%	17%	39%	80%
Wildwood Lake	2014	5%	0%	22%	45%	50%
AVERAGE	NA	23%	11%	18%	41%	52%

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

Although many properties on Mullett Lake are experiencing some form of erosion, the majority (70% of all erosion sites) are considered minor and less than 1% of all erosion is considered to be severe. 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 Mullett Lake. To prevent changes to the lake ecosystem, changes need to 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.
2. Send a general summary of the survey results to all shoreline residents, along with a packet of informational brochures produced by the Watershed Council and other organizations to provide information about threats to the Lake's ecosystem and public health as a result of poor shoreline property management practices as well as practical, feasible, and effective actions to protect water quality.
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. Following the questionnaire survey, property owners have the option to have the Watershed Council perform site visits and conduct groundwater testing in an effort to

gain more insight into the nature of the findings. Again, it should be stressed that all information regarding names, specific locations, and findings be kept confidential to encourage property owner participation in this project.

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 (e.g., brochures) 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 have the Watershed Council perform site assessments and carry out projects 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 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. MAPS is 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 a new 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 Mullett Lake residents to visit www.mishorelandstewards.org to take the survey.

LITERATURE AND DATA REFERENCED

Cheboygan County GIS Office. 2012. Cheboygan County Digital Orthophotography. Cheboygan, MI.

Cheboygan County GIS Office . 2016. Cheboygan County GIS Parcel Data. Cheboygan, MI. http://www.charlevoixcounty.org/

National Oceanic and Atmospheric Administration (NOAA). 2003. Coastal Great Lakes Land Cover Project. NOAA Coastal Services Center. Charleston, SC. http://www.csc.noaa.gov/crs/lca/greatlakes.html

Michigan Department of Natural Resources. 2008. Lake Maps by County. Lansing, MI. http://www.michigan.gov/cgi/0,1607,7-153-30301_31431_32340---,00.html

National Oceanic and Atmospheric Administration (NOAA). 2011. Coastal Great Lakes Land Cover Project. NOAA Coastal Services Center. Charleston, SC. http://www.csc.noaa.gov/crs/lca/greatlakes.html

Tip of the Mitt Watershed Council. 2016. Comprehensive Water Quality Monitoring Program Data. Tip of the Mitt Watershed Council. Petoskey, MI. http://www.watershedcouncil.org/Protect/

Tip of the Mitt Watershed Council. 2016. Volunteer Lake Monitoring Program Data. Tip of the Mitt Watershed Council. Petoskey, MI. http://www.watershedcouncil.org/Protect/

Tip of the Mitt Watershed Council. 2008. A Shoreline Survey of Mullett Lake. Tip of the Mitt Watershed Council. Petoskey, MI. http://www.watershedcouncil.org/

APPENDIX A

Mullett Lake survey results displayed by northern and southern shoreline

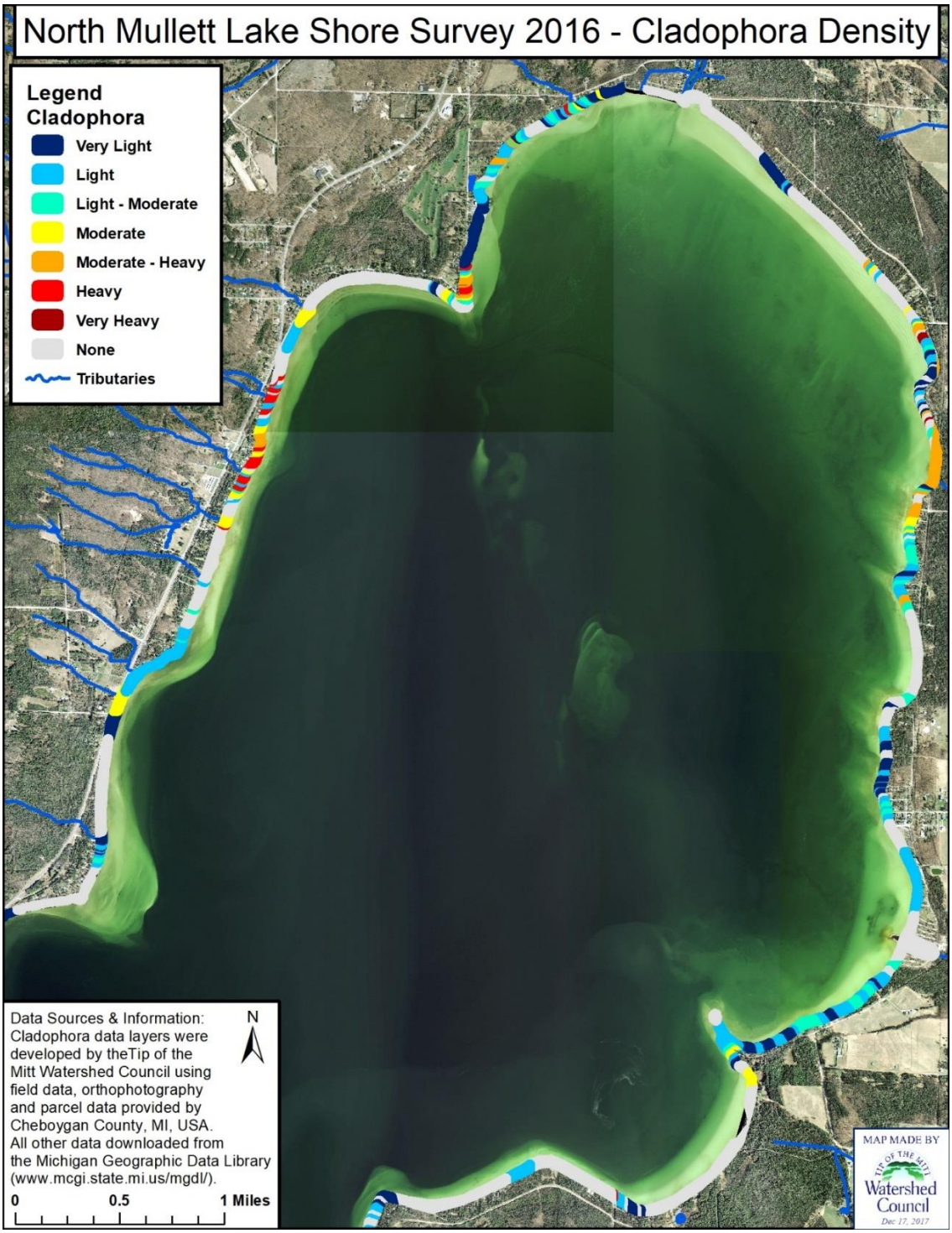


Figure 8. Northern shore Mullett lake *Cladophora* density

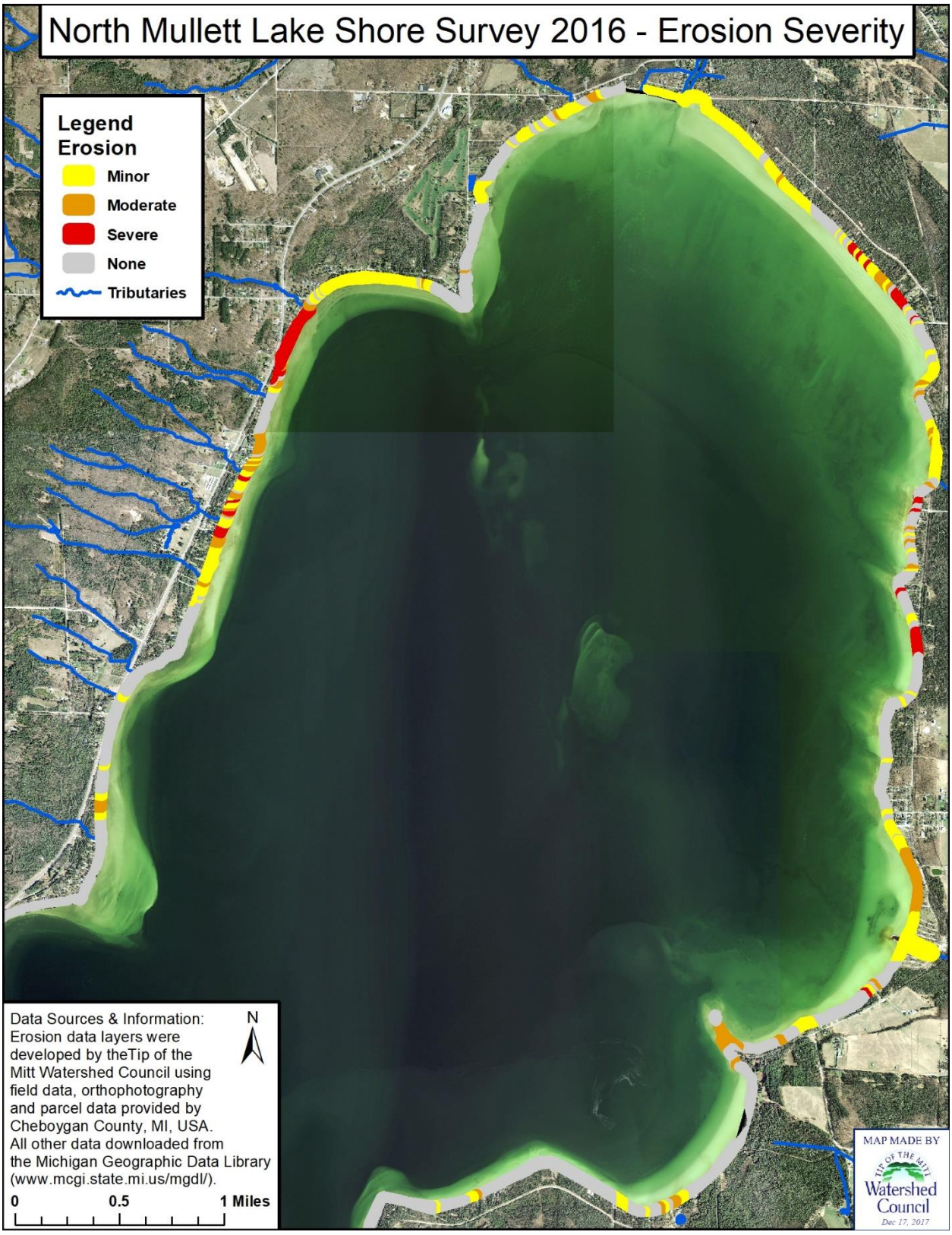


Figure 9. Northern shore Mullett Lake erosion severity

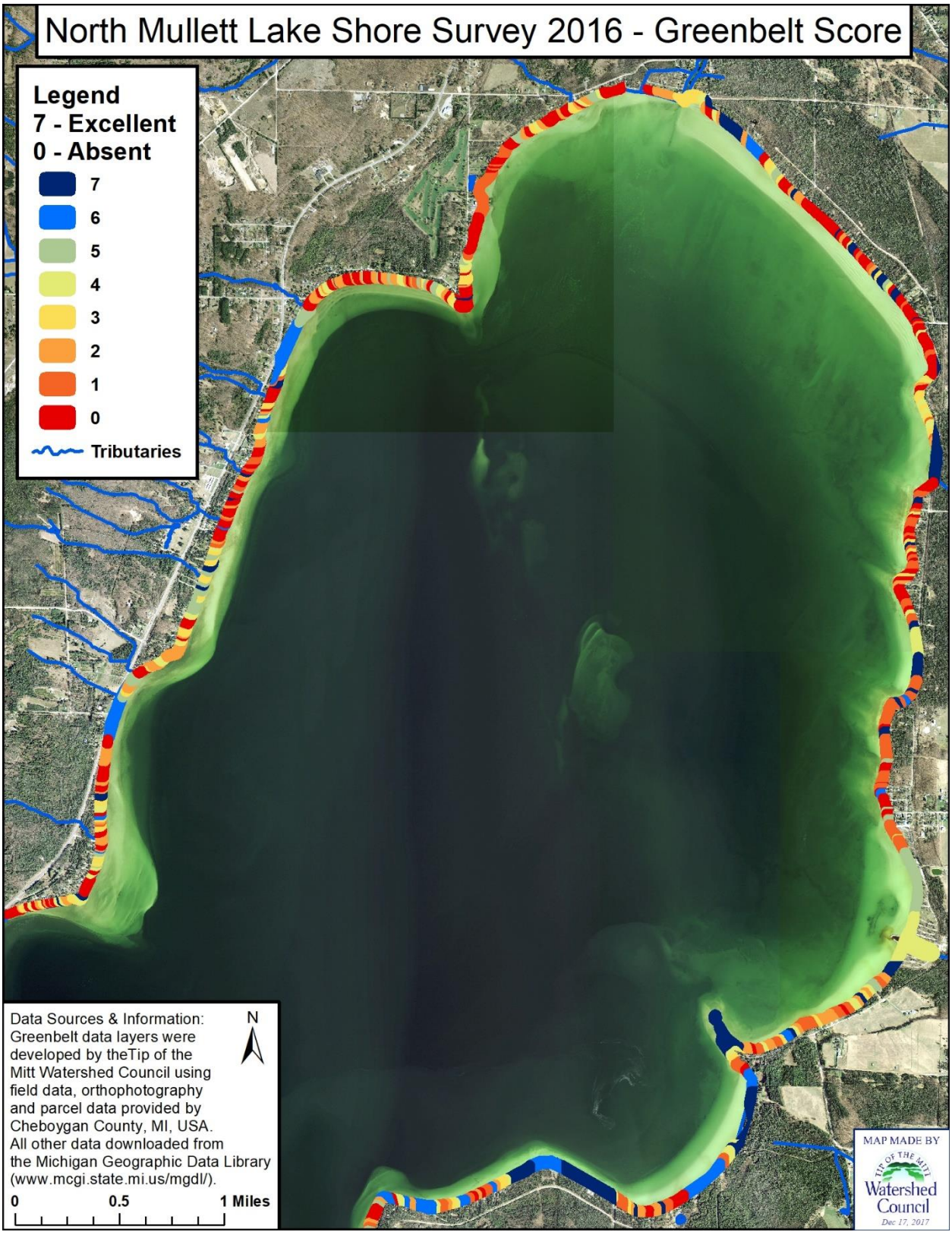


Figure 10. Northern shore Mullett Lake total greenbelt scores

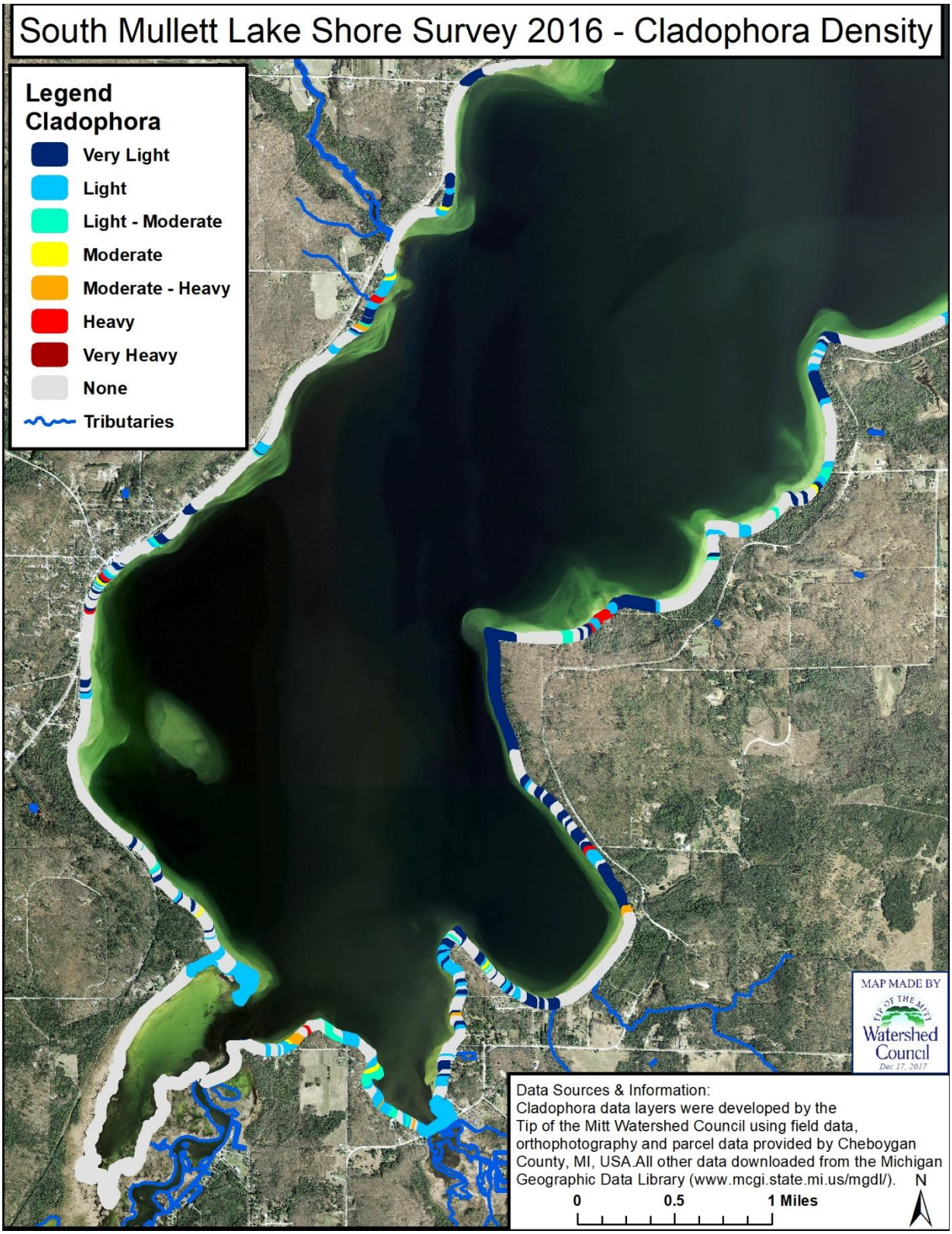


Figure 11. Southern shore Mullett Lake *Cladophora* density

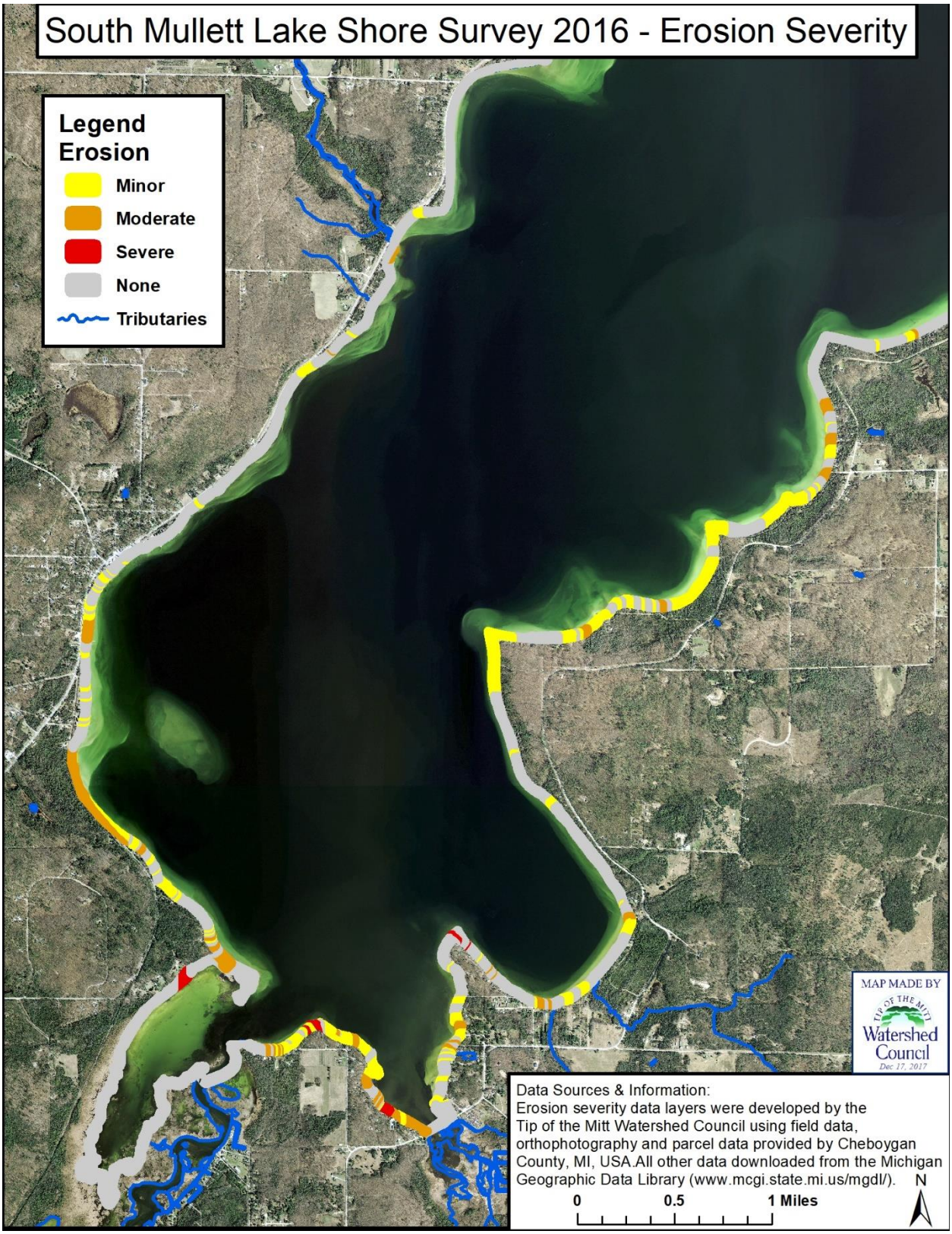


Figure 12. Southern shore Mullett Lake erosion severity

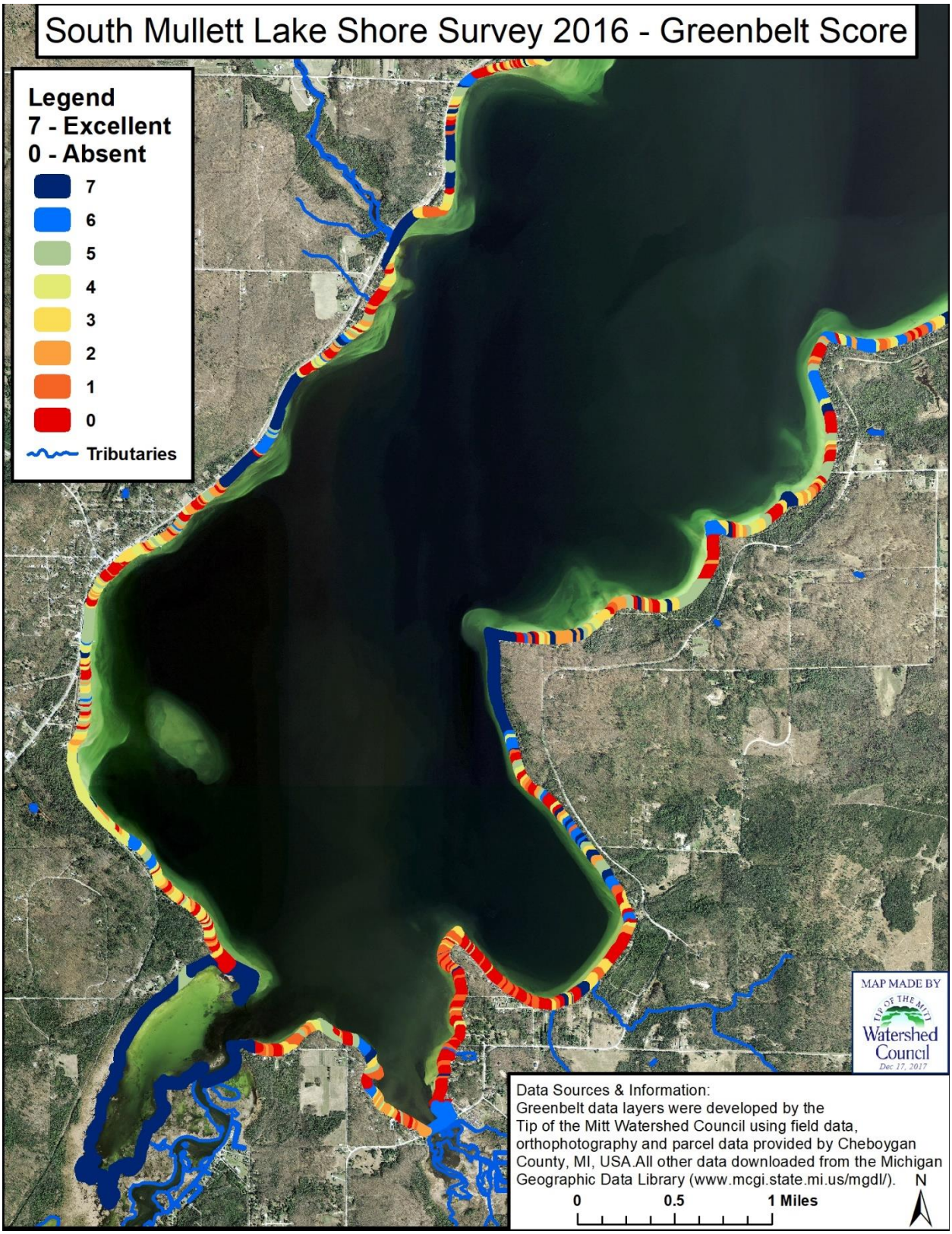


Figure 13. Southern shore Mullett Lake total greenbelt scores