Walloon Lake Shoreline Survey 2016

By Tip of the Mitt Watershed Council

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SUMMARY

During the late spring of 2016, the Tip of the Mitt Watershed Council conducted a comprehensive shoreline survey on Walloon Lake as part of an update of the Little Traverse Bay Watershed Protection Plan. Watershed Council staff and interns surveyed the entire shoreline in May and June to document conditions that can potentially impact water quality. The parameters of the survey are designed to assess the three biggest threats to lakes: nutrient pollution, habitat loss, and shoreline erosion.

Survey results indicate that human activity along the Walloon Lake shoreline is likely impacting the lake ecosystem and water quality. Well over half (60%) of all shoreline properties lack adequate shoreline vegetation, and approximately 80% have altered shorelines. Properties with poor greenbelts, altered shorelines, and signs of nutrient pollution occur throughout the Lake, with clusters of problematic conditions more concentrated in the North Arm and Foot Basin. On a positive note, the number of properties showing signs of nutrient pollution has decreased, relative to previous surveys.

To achieve the full value of this survey, the Walloon Lake Association and other stakeholders should engage in follow-up activities, including: 1) Educate riparian property owners about how to protect the water quality of Walloon Lake through shoreline property best management practices; 2) Disseminate a shore survey results summary to all shoreline residents; and 3) Provide assistance to property owners whose shorelines have been identified through the survey as potentially impacting water quality (e.g. nutrient pollution, lack of greenbelt, erosion, etc.) to improve conditions. The shoreline survey should be repeated every 3-5 years as shoreline ownership, management, and conditions continually change.

INTRODUCTION

Background:

During the late spring of 2016, a shoreline survey was conducted on Walloon 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 as a nutrient pollution indicator, erosion, shoreline alterations, greenbelts, and tributary inlets and outlets. This survey was funded by the Petoskey-Harbor Springs Area Community Foundation as part of the Little Traverse Bay Watershed Protection Plan Update.

Eleven shoreline surveys have been performed on Walloon Lake during the last 35 years, the most recent complete survey carried out in 2010 with funding by the Walloon Lake Association (WLA).

The 2016 survey provides a comprehensive data set documenting shoreline conditions on Walloon Lake; a valuable data set that can be used as a lake management tool. Combined with follow-up activities, such as questionnaires and on-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. Prevention of problem situations can also be achieved through the publicity and education associated with the survey. 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 the critical interface between land and water; where human activity has the greatest potential for degrading water quality. Traditional development of shoreline properties for residential, commercial or other uses invariably leads to negative impacts on the lake ecosystem. During the development process, the natural landscape is altered in a variety of ways: vegetation is removed; the terrain is graded; utilities are installed; structures are built; and areas are paved. These changes to the landscape and subsequent human activity in the shoreline area have consequences on the aquatic ecosystem. Nutrients from organic wastes, contaminants from cars and roads, and soils from eroded areas are among some of the pollutants that end up in and negatively impact the lake following shoreline development.

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, large, deep lakes, such as Walloon Lake, are less sensitive to nutrient pollution. Because larger lakes have a greater water volume and dissolved oxygen stores, they tend to be less susceptible to nutrient pollution. By contrast, small lakes generally have smaller stores of dissolved oxygen and a lesser ability to dilute nutrients; therefore, they are more susceptible to the indirect impacts of nutrient pollution. Furthermore, nutrient pollution can be more problematic in small lakes due to extensive shallow areas that can support more aquatic macrophyte growth.

Walloon Lake has a naturally high buffering capacity that helps mitigate negative impacts from nutrient pollution due to its large surface area and depth (4,600 acres, maximum depth= 100').

Additionally, it is a drainage lake with inflows and an outflow, which provides a mechanism to flush excess nutrients through the system. Regardless of Walloon Lake's attributes, unnaturally high nutrient concentrations can occur and cause problems in localized areas, particularly near nutrient sources in 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. Its occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. It is found most commonly in the wave splash zone and shallow shoreline areas of lakes, as well as streams. It grows best on stable substrates such as rocks and logs, though artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures in a range of 50 to 70 degrees Fahrenheit, which means that the optimal time for its 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. It can reveal the existence of chronic nutrient loading problems and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient inputs due to changing land use.

Erosion along the shoreline has the potential to degrade the lake's water quality. Stormwater runoff through eroded areas carries sediments into the lake and impacts the lake ecosystem in a variety of ways. Sediments clog the gills of fish, aquatic insects and other aquatic organisms. Excessive sediments smother fish spawning beds and fill interstitial spaces that provide habitat for a variety of aquatic organisms. Suspended sediments absorb sunlight energy and increase water temperatures. In addition, nutrients adhere to sediments that wash in from eroded areas, which can lead to nuisance aquatic plant growth and algal blooms.

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.

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. 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:

Walloon Lake is located in Bear Creek and Resort Townships of Emmet County, and Bay, Evangeline, and Melrose Townships of Charlevoix County of the northwest Lower Peninsula of Michigan. Based on digitization of 2012 aerial orthophotography from Emmet and Charlevoix County Equalization/GIS departments, the shoreline of Walloon Lake measures 30.5 miles and has a surface area of 4,586 acres. Walloon Lake extends approximately 9.5 miles in a southeast to northwest direction and is generally less than one mile wide throughout its length. A number of prominent land points project into the Lake and define the boundaries of the Lake's five distinct basins. The five basins in Walloon Lake include (from northwest to southeast): Mud Basin, the West Arm, the Wildwood Basin, the Foot Basin, and the North Arm (Figure 1). Bathymetry maps show the deepest location to be near the center of the West Arm, with a maximum depth of 100 feet (MI DNR, 2011). Maximum depths in the other basins are as follows: 94’ in the Foot Basin, 80’ in the Wildwood Basin, 52’ in the North Arm, and 14’ in Mud Basin. Broad shallow areas are found between the various basins and throughout the Mud Basin.

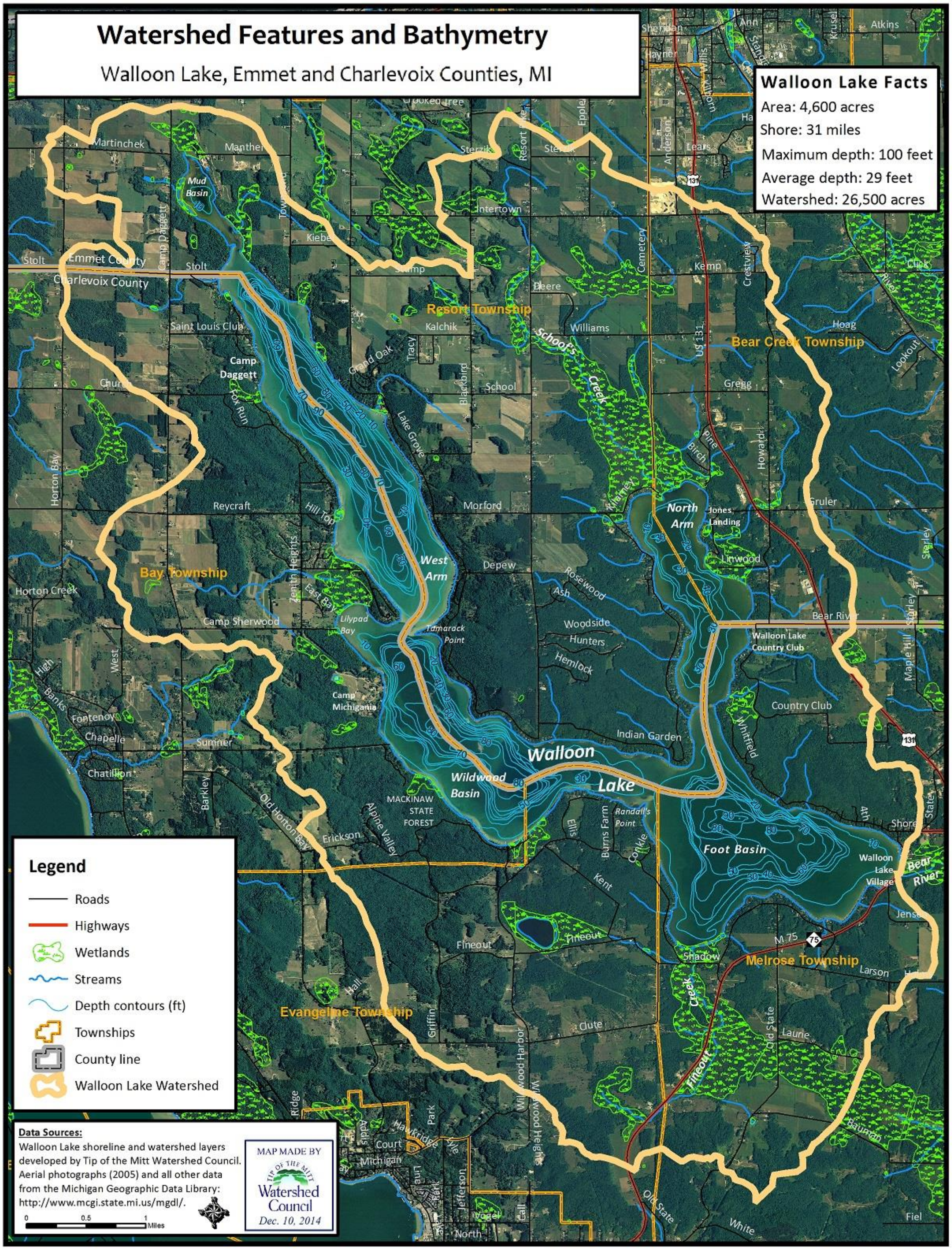

Figure 1. Map of Walloon Lake and its Watershed.

Walloon Lake is a drainage lake with water flowing into and out of the Lake. The primary inlets include Schoof's Creek in the north end of the North Arm and South Arm Creek (AKA, Fineout Creek) in the south end of the Foot Basin. The only outlet is the Bear River, which flows out the east end of the Foot Basin at Walloon Lake Village. Extensive wetland areas are found in the lower Schoof's and South Arm Creeks' Watersheds, as well as the perimeter of the Mud Basin.

Using elevation data acquired from the State of Michigan, Watershed Council staff developed watershed boundary files for Walloon Lake in a GIS (Geographical Information System). Based on these data, the Walloon Lake Watershed encompasses approximately 26,500 acres of land and water (Figure 1). A watershed ratio of 4.75 was calculated by dividing the Lake surface area into the watershed area (not including the lake), indicating that there are under five acres of land in the Watershed for each acre of Walloon Lake's water surface. This ratio provides a statistic for gauging susceptibility of lake water quality to changes in watershed land cover. Relative to other lakes in Northern Michigan, Walloon Lake has a low watershed ratio and therefore, a smaller buffer to protect the lake from impacts associated with watershed development.

Land cover statistics were generated for the Watershed using remote sensing data from the Coastal Great Lakes Land Cover project (Table 1). Based on 2010 data, the majority of the Watershed's landcover is natural, consisting primarily of forest, wetlands, and grassland. There is a moderate amount of agricultural landcover (~22%), but little urban (~3.5%). Both agricultural and urban landcover increased by roughly one percent between 2000 and 2010.

Table 1. Walloon Lake Watershed land-cover statistics.

Land Cover Type	Acres (2000)	Percent (2000)	Acres (2010)	Percent (2010)	Change, Acres (2000-2010)	Change, Percent (2000-2010)
Agriculture	5499.14	20.74	5806.79	21.90	307.65	1.16
Barren	34.71	0.13	26.4473	0.10	-8.26	-0.03
Forested	10101	38.1	10233.1	38.60	132.17	0.50
Grassland	3162.54	11.93	2016.33	7.60	-1146.21	-4.33
Scrub/Shrub	521.03	1.97	712.77	2.69	191.74	0.72
Urban/residential	691.33	2.61	968.49	3.65	277.16	1.04
Wetland	1788.91	6.75	2041.35	7.70	252.44	0.95
Water	4711.44	17.77	4707.99	17.76	-3.45	-0.01
TOTAL	26510.1	100	26513.3	100	NA	NA

The water quality of Walloon Lake has been monitored consistently for more than two decades. WLA has actively supported water quality monitoring programs by providing volunteers for monitoring programs coordinated by the Watershed Council. In addition, Walloon Lake is monitored by Watershed Council staff as part of the Comprehensive Water Quality Monitoring program (CWQM). Watershed Council databases contain Volunteer Lake Monitoring and CWQM data that date back to 1989 and 1992, respectively.

Data collected through these programs indicate that water quality has been consistently high. Total phosphorus data collected in the CWQM program show that levels have dropped considerably throughout the last 25 years and are generally found below 10 parts per billion (PPB), which is typical for high quality lakes of Northern Michigan (Figure 2). Volunteer Lake Monitoring data indicate that biological productivity has decreased in Walloon Lake, which is likely a result of the introduction of invasive zebra mussels (*Dreissena polymorpha*). Trophic status index scores for three of the four basins monitored by volunteers now generally fall into the oligotrophic category, which indicates low biological productivity (Figure 3). Oligotrophic lakes are characteristically large, deep, and nutrient poor, but have ample stores of dissolved oxygen and, in general, high water quality.

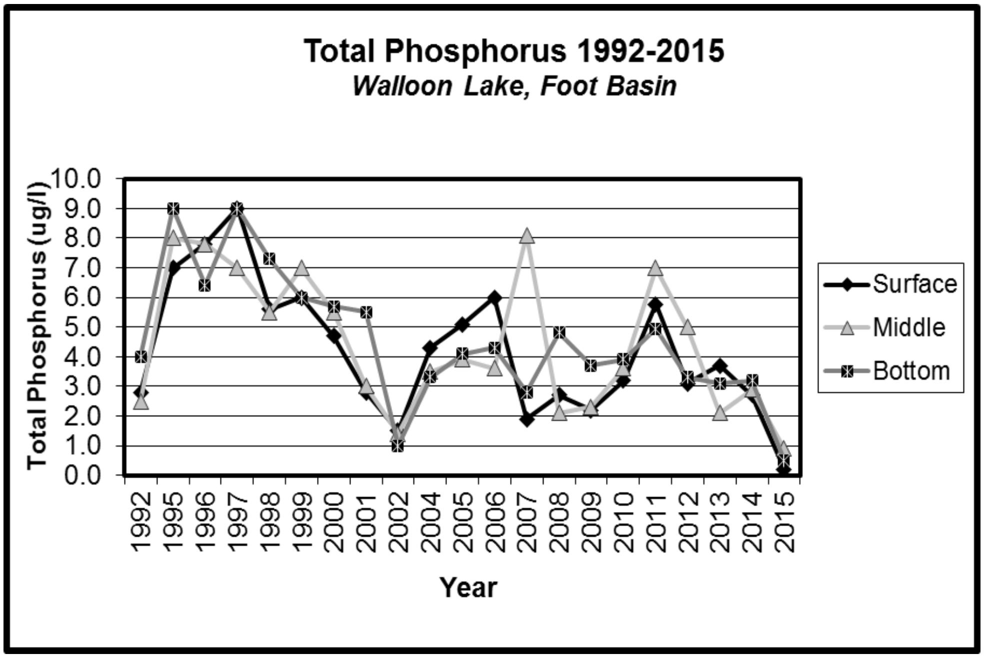

Figure 2. Chart of phosphorus data from Walloon Lake.
**Total phosphorus measured in ug/l, which is milligrams per liter or parts per billion.*

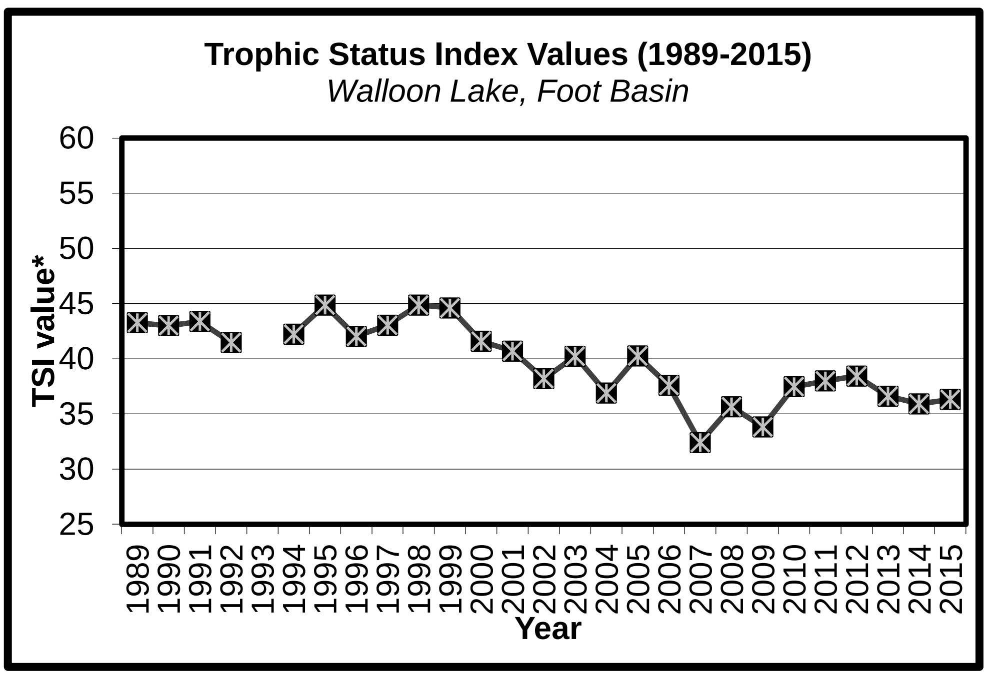

Figure 3. Chart of trophic status index data from Walloon Lake.
**Trophic Status Index values based on annual averaged Secchi disc depth data and represent the trophic status (biological productivity) of the lake: 0-38 = oligotrophic (low productive system), 39-49 = mesotrophic (moderately productive system), and 50+ = eutrophic (highly productive system).*

METHODS

The Walloon Lake shoreline was comprehensively surveyed in late May and early June of 2016 to document shoreline conditions that can potentially impact water quality. Shoreline conditions were surveyed by traveling in kayak as close to the shoreline as possible (usually within 20 feet) and noting *Cladophora* growth, substrate type, erosion, greenbelt health, shoreline alterations, and tributaries. A GPS camera was used to photograph all shoreline properties. Information for each property was recorded on field data sheets, subsequently inputted into a database, and used in conjunction with GPS data to link field data and photographs with property owner data from county equalization records.

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 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.

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 both 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. The extent of suitable substrate along a shoreline parcel in terms of distance was not documented.

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, or excessive deposits of sediments. Similar to *Cladophora*, shoreline erosion was recorded on field data sheets with estimates of its extent and relative severity (minor, moderate, or severe). For example “Mx20” indicated 20 feet of shoreline with moderate erosion. Additional information about the nature of the erosion, such as potential causes, was also noted.

Greenbelts (i.e., shoreline vegetation) were rated based on the length of shoreline with a greenbelt and the average depth of the greenbelt from the water’s edge landward. Ratings for length ranged from 0 to 4, while ratings for depth ranged from 0 to 3. Ratings 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. Greenbelt scores ranged from 0 to 7, representing the greenbelt status or health. Scores of 0 were considered very poor, 1-2=poor, 3-4=moderate, 5-6=good, and 7=excellent.

Shoreline alterations were surveyed and noted with the following abbreviated descriptions: SB = steel bulkhead (i.e., seawall), BB = boulder bulkhead, CB = concrete bulkhead, RR = rock rip-rap, WB = wood bulkhead, BS = beach sand, BH = permanent boathouse, DP = discharge pipe.

Abbreviations were sometimes mixed or vary from what is listed above.

Tributaries (i.e., rivers and streams) 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 recorded on field data sheets was included in the database in a “comments” column.

Data Processing

Upon completing fieldwork, all field data were transferred to computer. Information from field data sheets was inputted 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 Emmet and Charlevoix County parcel data in a GIS with the aid of GPS and photographs. Occasionally, errors 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 departments and a Walloon 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 a poster-size map to display survey results.

Final products include a comprehensive database, a complete set of GPS digital photographs, GIS data layers of shoreline parcels that include both county equalization and shore survey data, and a map displaying results. The shoreline survey database contains a sequential listing of properties beginning at the Gruler Road end boat launch 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 hard-copy maps. GPS photographs were renamed using the same identification numbers and are linked to a GIS data layer.

RESULTS

This survey documented shoreline conditions at 1031 parcels on Walloon Lake. The length of shoreline per parcel varied from less than 20 feet to more than a mile. Approximately 89% (913) of shoreline properties on Walloon Lake were considered to be developed.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 903 properties (88%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 636 parcels (62% of the total or 70% of properties with suitable habitat). At properties where *Cladophora* growth was observed, nearly 50% consisted of light or very light growth, whereas only 1.6% of parcels had growth in the moderate-heavy to heavy categories (Table 3).

Table 3. *Cladophora* density results.

***Cladophora* Density**	**Parcels**	**Percent**
Very light	233	22.6
Light	263	25.5
Light to Moderate	71	6.9
Moderate	53	5.1
Moderate to Heavy	13	1.3
Heavy	2	0.2
Very Heavy	1	0.1
TOTAL	636	100.00

Moderate to moderate heavy *Cladophora* growth was observed to occur in pockets intermittently in all basins except Mud Basin (Figure 4). Low density *Cladophora* was a common occurrence throughout Walloon Lake. Accordingly, baseline *Cladophora* conditions (those not directly indicative of nutrient pollution) range from none to light.

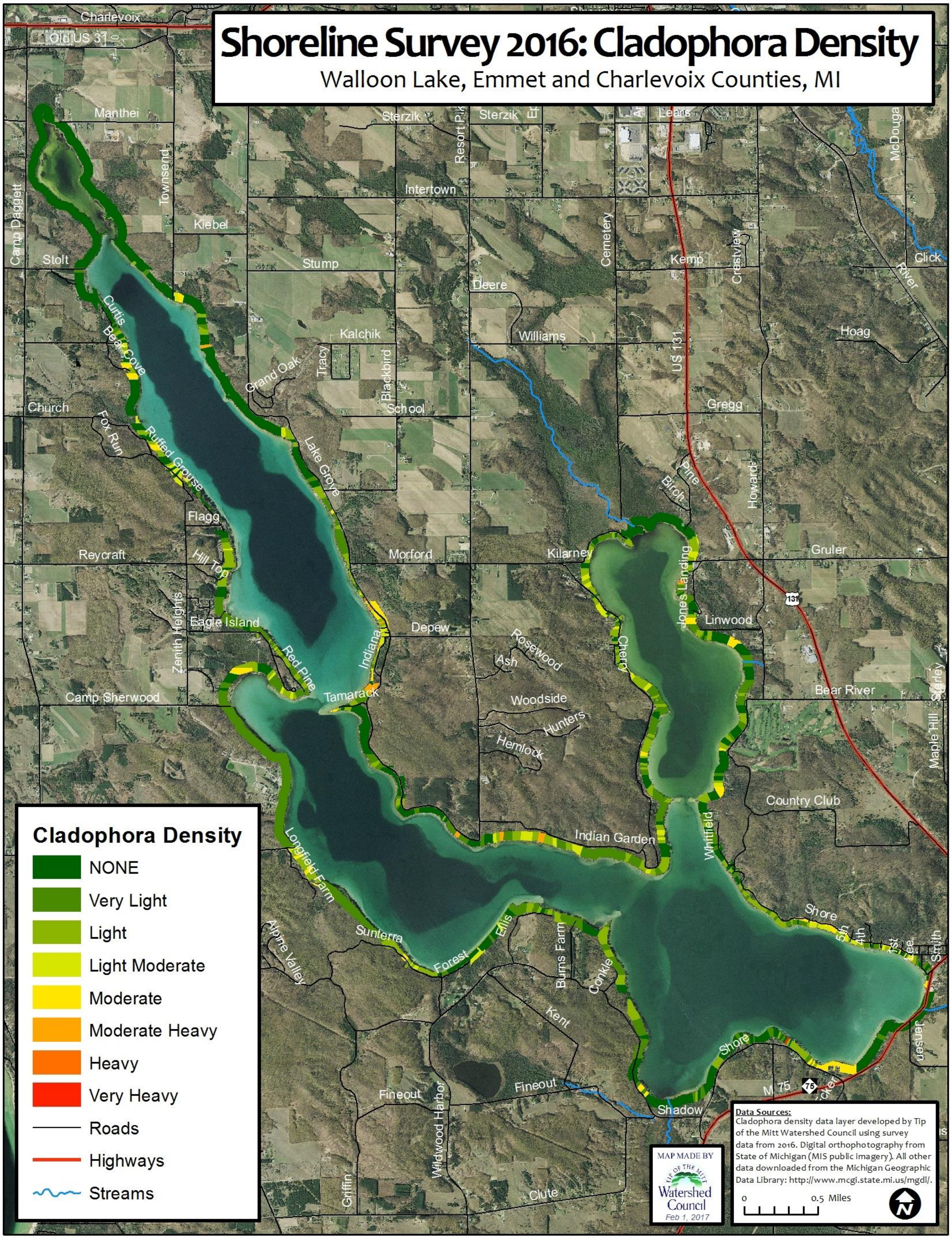

Figure 4. *Cladophora* algae density results for Walloon Lake.

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Less than half of greenbelts (40%) along the Walloon Lake shoreline were found to be in good or excellent condition (Table 4). Nearly an equal amount of parcels (39%) received a greenbelt rating in the poor or very poor categories.

Table 4. Greenbelt rating results.

Greenbelt Rating		Number of Parcels	Percent of Parcels
0	Very Poor (absent)	151	14.6%
1-2	Poor	250	24.2%
3-4	Moderate	212	20.6%
5-6	Good	249	24.2%
7	Excellent	169	16.4%

Greenbelt status ranged, in general, from poor in the eastern portions of Walloon Lake to moderate in the western portions of Walloon Lake (Figure 5). Although clusters of properties with poor greenbelts occurred throughout the lake, they are more prevalent in the North Arm and Foot Basin. The North Arm had the poorest average greenbelt score, 2.32 (Table 5). Mud Basin was the only basin to achieve an average greenbelt score falling within the "good" category.

Table 5. Greenbelt rating results by Basin.

Basin	Greenbelt Depth (Average)	Greenbelt Length (Average)	Overall Score (Average)
Foot Basin	1.13	2.1	3.23
North Arm	0.87	1.45	2.32
Wildwood Basin	1.37	2.58	3.95
West Arm	1.65	2.82	4.47
Mud Basin	2.85	4	6.85

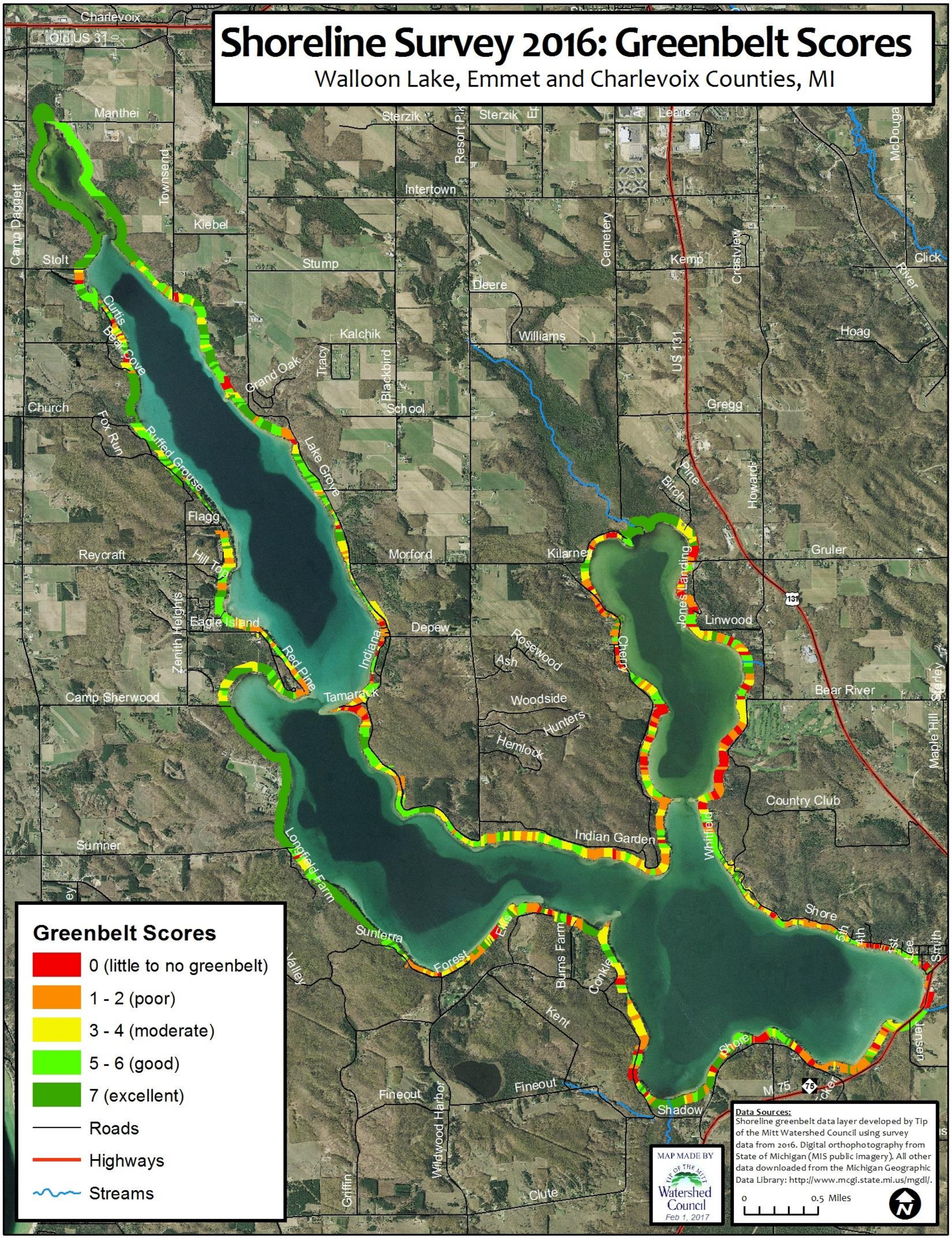

Figure 5. Greenbelt score totals results for Walloon Lake.

Some form of shoreline alteration was noted at 80% of shoreline properties (Table 6). The majority of alterations consisted of boulders (70%), while seawalls (both concrete and metal), account for approximately 5% of altered shorelines.

Table 6. Shoreline alteration results.

Alteration Type	Number of Parcels*	Percent of Parcels With Alteration*
Riprap (small)	212	20.6
Riprap (boulder)	718	69.7
Seawalls	52	5.0
Beach Sand	86	8.3
Unaltered	203	19.7

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

Erosion was noted at 459 parcels (~45%) on the Walloon Lake shoreline (Table 7). Over 60% of shoreline properties with erosion were classified as minor in terms of severity, while roughly 4% of properties were considered severe.

Table 7. Shoreline erosion results.

Erosion Category	Number of Properties	Percent of Properties*
Minor	288	62.7
Moderate	154	33.6
Severe	17	3.7
TOTAL	459	100.0

**Refers to percentage of properties with documented erosion*

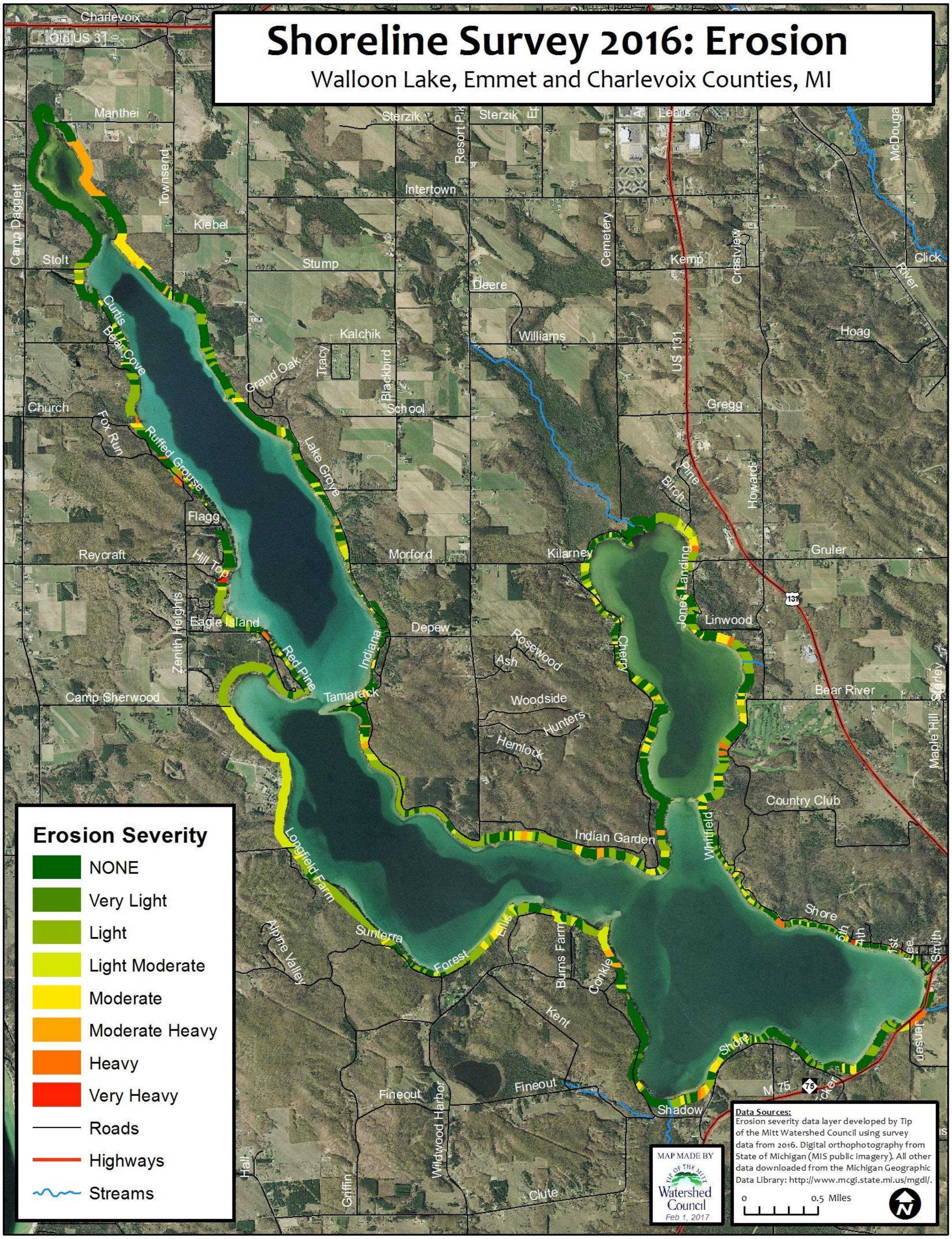

Figure 6. Shoreline erosion severity results for Walloon Lake.

DISCUSSION

Development of shoreline parcels negatively impacts 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 nutrient pollution, poor greenbelts, and shoreline alterations continue to pose a threat to the water quality and overall health of Walloon Lake. Nutrient pollution indicators were documented at numerous properties, nearly 40% of all shorelines exhibited greenbelts that were in poor condition, and 80% of all lakeshore properties had altered shorelines. Although less extensive, the amount of light shoreline erosion on the Walloon Lake shoreline is high relative to other lakes.

Comparisons with prior shoreline surveys show that there has been a considerable increase in light *Cladophora* growth. The total number of properties with documented *Cladophora* growth increased by over 26% between 2001 and 2016 (Table 8). With regards to heavy-density *Cladophora*, there was a decrease in the number of properties where heavy growth was observed. The data indicate that overall, algae has become more prolific throughout Walloon Lake, but the occurrence of localized heavy *Cadophora* blooms is becoming less common.

Table 8. *Cladophora* density comparisons: 2001 to 2016.

Cladophora* Growth	**2001 Survey Results**		**2005 Survey Results**		**2010 Survey Results**		**2016 Survey Results**	
	Properties	%	Properties	%	Properties	%	Properties	%
Light	270	26	177	17	228	22	496	48
Moderate	83	8	82	8	127	12	124	12
Heavy	22	2	45	4	111	11	16	2
TOTAL[ƚ]	375	36	304	29	466	45	636	62

** Note that the light growth includes "very light", moderate includes "light to moderate", and that heavy growth includes "moderate to heavy" and "very heavy".*

ƚ Percentage in the total is of all properties on the lake.

With 62% of all properties having some form *Cladophora* growth, the presence of benthic algae is now the norm for Walloon Lake. Zebra mussels have altered the lake ecosystem; disrupting natural nutrient cycling, as well as increasing water clarity. Redistribution of nutrients from the water column to the lake bottom via zebra mussels is the likely explanation for the recent increase in light benthic algae.

Of the shoreline areas showing evidence of potential nutrient pollution, some of the heavier algae growth is undoubtedly associated with septic system leachate or other factors associated with development and human activities. There are numerous streams, springs, and seeps flowing into Walloon Lake at different points along the shoreline that may be delivering nutrients that naturally promote algal growth. 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.

Contrary to what one might expect based on shoreline survey results, water quality monitoring data from Walloon Lake do not show an increase in nutrient concentrations. Phosphorus and nitrogen levels have remained relatively stable in recent decades (Tip of the Mitt Watershed Council 2016). Water clarity actually appears to be increasing in Walloon Lake, which may be the result of a decrease in the amount of algae in the water column (Tip of the Mitt Watershed Council 2016). The amount of algae is influenced, among other things, by the availability of nutrients and therefore, a reduction in algae indicates a possible reduction in nutrients. Zebra mussels also filter-feed algae from the water column, thereby reducing algae and phosphorus concentrations.

While these data suggest a decrease in nutrient pollution, there are numerous factors to consider when interpreting such data. One is that all water quality data referenced above have been collected in open water, far removed from shoreline areas where the majority of nutrient pollution tends to occur.

Results from the greenbelt assessment portion of the survey show a different trend on Walloon Lake. Between 2001 and 2016, the number of properties with poor greenbelts decreased by 14% while properties with good greenbelts increased by 20% (Table 9). It is important to note that the field methodologies were revised between 2001 and 2016. They now include additional parameters that factor into greenbelt ratings. Therefore, any direct comparisons between data sets should consider this aspect.

Table 9. Greenbelt rating comparisons: 2001 to 2016*.

Greenbelt Rating	2001 (%)	2010 (%)	2016 (%)
Poor	52	28	38
Moderate	27	17	21
Good	21	55	41

**Greenbelts were not assessed for all properties in 2005.*

Shoreline survey greenbelt results fluctuate from year to year, based on a number of factors. Development of new parcels often times correlates with a decrease in good greenbelt conditions. As parcels are cleared of vegetation for houses and other infrastructure, so too are the shorelines. Accordingly, survey results between 2010 and 2016 show an increase in the number of developed parcels and a decrease in "good" greenbelts. Although many newly established, ornamental greenbelts were observed on Walloon Lake in 2016 (Figure 7), they are oftentimes lacking in vegetation types, species diversity, density and area. While these greenbelts may indicate a greater awareness of the importance of shoreline vegetation, more education and outreach is needed to convey the importance of greenbelt quality.

The Lake ecosystem would benefit from further improvements. Greenbelts continue to be in poor to moderate condition throughout much of the Lake. The lack of vegetation on the Lake shoreline, which provides habitat and acts as a food source, impacts aquatic fauna ranging from minute crustaceans to top 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, over 16% of properties received a perfect score, indicating exemplary greenbelt health. Properties with healthy, intact greenbelts provide a model for improvement for other shoreline properties. Further improvement of the quality of greenbelts throughout the shoreline would invariably have positive impacts on the Lake's water quality and ecosystem in general.

Figure 7. A typical ornamental greenbelt located on Walloon Lake.

Compared to other lakes in the region, Walloon Lake has the highest percentage of properties with *Cladophora* growth, but is low in terms of heavy *Cladophora* growth (Table 10). Burt and Mullett Lakes are similar to Walloon Lake, although slightly lower, in in terms of benthic algae growth. Baseline benthic algae conditions in many lakes are thought to be driven by zebra mussel infestation, and subsequent future surveys of other lakes will likely show increases in the presence of light *Cladophora* algae. Properties on Walloon Lake with erosion are near the overall average for lakes within Northern Michigan. The percent of properties with altered shoreline was high on Walloon Lake relative to other lakes in the region, but very similar to Lake Charlevoix.

Table 10. Shore survey statistics from Northern Michigan lakes.

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
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	2008	59%	50%	7%	64%	58%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Silver Lake	2014	3%	0%	70%	53%	65%
Six Mile Lake	2008	14%	5%	5%	34%	30%
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 Walloon Lake are experiencing some form of erosion, the majority (63%) of occurrences are considered minor and only 17% had moderate to severe erosion (Table 7). 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 Walloon Lake. While wind-generated waves can cause erosion, it is believed that the large powerful boats common to Walloon Lake are responsible for exacerbating erosion.

With regards to altered shorelines, 80% of all shoreline properties had some form of alteration. Large rocks or boulders were by far the most common type of alteration, found at almost 70% of all parcels. In general, rocks of this size are not native to Walloon Lake. Oversized boulders can have negative impacts including lakebed scour, shoreline erosion, and reduced habitat value. Seawalls are the most damaging type of shoreline alteration due to negative impacts that include loss of near-shore habitat, lakebed scour, and wave flanking. Seawalls were only found at 5% of properties.

Throughout the past two decades, shoreline surveys on Walloon Lake have documented development trends, both on land and at water's edge. The percentage of developed lakeshore properties (i.e. those with permanent structures or pavement installed) has increased from 83% in 2001 to 89% in 2016. The percentage of lakeshore properties with alterations has increased at a more rapid pace, from 66% in 2001 to 80% in 2016 (Figure 8).

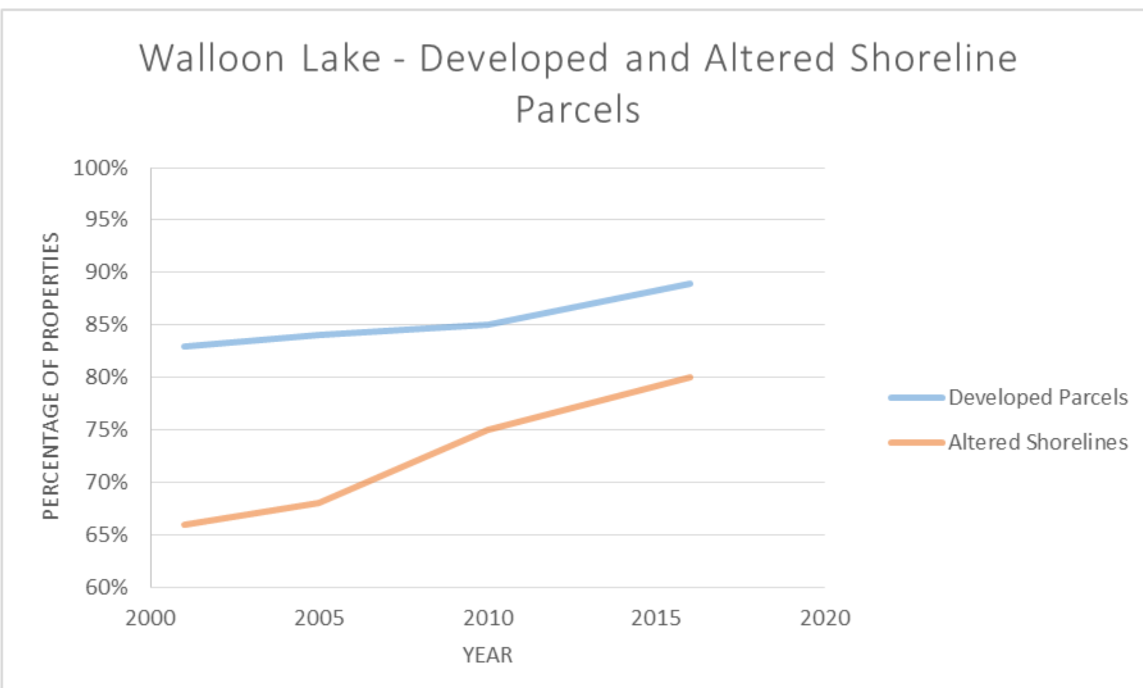

Figure 8. Increases in developed and altered shorelines on Walloon Lake

In spite of the problems exposed by this survey, the water quality of Walloon Lake remains high. Due to its oligotrophic nature and the volume of water flushing through it as a drainage lake, Walloon Lake is somewhat resilient to nutrient pollution. However, such resiliency is not without limits. To prevent potentially serious and irreversible 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.

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 the WLA's website to share survey information. A general summary report and this detailed report can be posted on WLA's website because they do not contain any property-specific information. Property-specific information can be shared via the WLA's website 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. Verify links made between shore survey results and land parcel data to ensure that information is being properly reported. Shoreline residents can assist the Watershed Council in determining if house descriptions in survey database match correctly with county landowner information. By doing so, property owners will receive the correct information regarding their parcel. This information is also useful for empowering the WLA to monitor shoreline activities, recruit new members, and compile and manage other water resource information.
8. Repeat some version of the survey periodically (ideally every 3-5 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. 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. WLA 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.

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