Walloon Lake Shoreline Survey 2010

By Tip of the Mitt Watershed Council

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SUMMARY

Shoreline property management practices have the potential to negatively impact water quality in many ways. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess can adversely impact an aquatic ecosystem, and indirectly poses a danger to human health. Greenbelts provide many benefits to the lake ecosystem, which are lost when shoreline vegetation is removed. Erosion and shoreline alterations (seawalls, rip-rap, etc.) both have the potential to degrade water quality.

During the late spring of 2010, the Tip of the Mitt Watershed Council conducted a comprehensive shoreline survey on Walloon Lake that was sponsored by the Walloon Lake Association. Watershed Council staff surveyed the entire shoreline in May and June to document conditions that potentially impact water quality. The parameters surveyed include: algae as a bio-indicator of nutrient pollution, greenbelt status, shoreline erosion, shoreline alterations, nearshore substrate types, and stream inlets and outlets.

Survey results indicate that human activity along the Walloon Lake shoreline is likely impacting the lake ecosystem and water quality. Signs of nutrient pollution were noted at nearly half of shoreline properties, over 25% had greenbelts in poor condition, approximately 75% had altered shorelines, and erosion was documented at 16%. Relative to other lakes, Walloon Lake had an average percentage of properties with *Cladophora* algae growth and poor greenbelts, but a high percentage of properties with erosion and altered shorelines. Clusters of properties with strong signs of nutrient pollution and those with poor greenbelts were scattered throughout the lake, but more prevalent in the North Arm and Foot Basin.

Although survey results indicate that nutrient pollution is occurring along the shoreline, water quality data from Walloon Lake do not show increases in nutrient concentrations. The water quality data does not necessarily reflect what is occurring in nearshore areas because it is collected in open water, far from the shoreline. Furthermore, interpreting such data is confounded by the alteration of the lake's nutrient cycling caused by invasive zebra mussels. Regardless, changes should be made in shoreline property management to prevent degradation of lake water quality and to protect the lake ecosystem.

To achieve the full value of this survey, the association should engage in follow-up activities, including: 1) Educate riparian property owners about preserving water quality and provide tips on what they can do to protect water quality; 2) Send a survey summary to all shoreline residents along with information about what each person can do to help; 3) Contact property owners confidentially to encourage them to participate in identifying and rectifying any problems that exist on their property; and 4) Organize an informational session to present survey results and best management practices that help protect and improve lake water quality. 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 2010, a shoreline survey was conducted on Walloon Lake by the Tip of the Mitt 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 Walloon Lake Association.

A total of nine shoreline surveys have been performed on Walloon Lake during the last 30 years, the most recent carried out in 2005. Based on the 2005 shoreline survey report, indicators of nutrient pollution were found at 30% of the 1002 properties surveyed (TOWMC 2005). There was a decline in the number of properties that had indications of nutrient pollution from 2001 to 2005, though the percent or properties with strong indications of nutrient pollution increased during the same time period.

The 2010 survey provides another 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. Developing shoreline properties for residential, commercial or other uses invariably has 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 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 indirectly poses a danger to human health. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess will stimulate unnatural plant growth. Increased abundance of aquatic macrophytes (higher or vascular plants) can become a nuisance to recreation in shallow areas (typically less than 20 feet of depth). An increase in algal blooms also has the potential to become a recreational nuisance when algal mats and scum are formed on the lake's surface. Additionally, algal blooms pose a public health risk as some species produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system).

Excess growth of both macrophytes and algae has the potential to 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 dead algae and plant material 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 are less sensitive to nutrient pollution. Large lakes with greater water volume have a bigger buffer and thus, greater resistance to nutrient pollution. The large lakes tend to have greater dissolved oxygen stores and the greater volume allows for greater dilution of nutrients. By contrast, small lakes generally have smaller stores of dissolved oxygen, a lesser ability to dilute nutrients and therefore, are more susceptible to the indirect impacts of nutrient pollution. Furthermore, nutrient pollution can be problematic in small lakes due to extensive shallow areas that support excessive aquatic macrophyte growth.

Walloon Lake has a naturally high buffering capacity that helps reduce negative impacts from nutrient pollution due to its large size and deep waters (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 out of the system. In spite of Walloon Lake’s resilience to nutrient pollution, unnaturally high nutrient concentrations can occur and cause problems in localized areas, particularly near 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 the riparian (shoreline) area, and atmospheric deposition. Springs, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter and wetland seepages may discharge nutrients at certain times of the year. Cultural sources include septic and sewer systems, fertilizer application, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural practices, soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, some cultural sources (e.g., malfunctioning septic systems and animal wastes) 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). Chemical analyses of water samples to check for nutrient pollution can be effective, though costlier and more labor intensive than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituent concentrations can be measured, such as chloride, which are related to human activity and often elevated in areas impacted by malfunctioning septic or sewer systems. Physical measurements are primarily used to detect malfunctioning septic and sewer systems, which can cause localized increases in water temperature and conductivity (i.e., the water's ability to conduct an electric current). Biologically, nutrient pollution can be detected along the lake shore by noting the presence of *Cladophora* algae.

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, and can also be found in 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 thus, detection, in northern Michigan lakes is from mid-May to early July and from September to October.

The nutrient requirements 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 size of the growth on an individual basis is important in helping to interpret the cause of the growth, growth features of *Cladophora* are greatly influenced by such factors as current patterns, shoreline topography, size and distribution of substrate, and the amount of wave action on the shoreline. Therefore, the description has limited value when making year to year comparisons at a single location or estimating the relative amount of shoreline nutrient inputs. Rather, the presence or absence of any significant growth at a single site over several years is the most valuable comparison. It can reveal the existence of chronic nutrient loading problems, help interpret the cause of the problems, and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient input 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. While moving through the water column, 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 large 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 terrestrial animals. Greenbelts function to naturally control erosion; stabilizing the shoreline with plant root structures that protect against wave action and ice. The canopy of the greenbelt provides shade to near-shore areas, which is particularly important for lakes with cold-water fisheries. In addition, greenbelts provide a mechanism to reduce overland surface flow and absorb pollutants carried by stormwater from rain events and snowmelt.

Tributaries have great 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, but conversely 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 regards 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 algae growth in nearby shoreline areas.

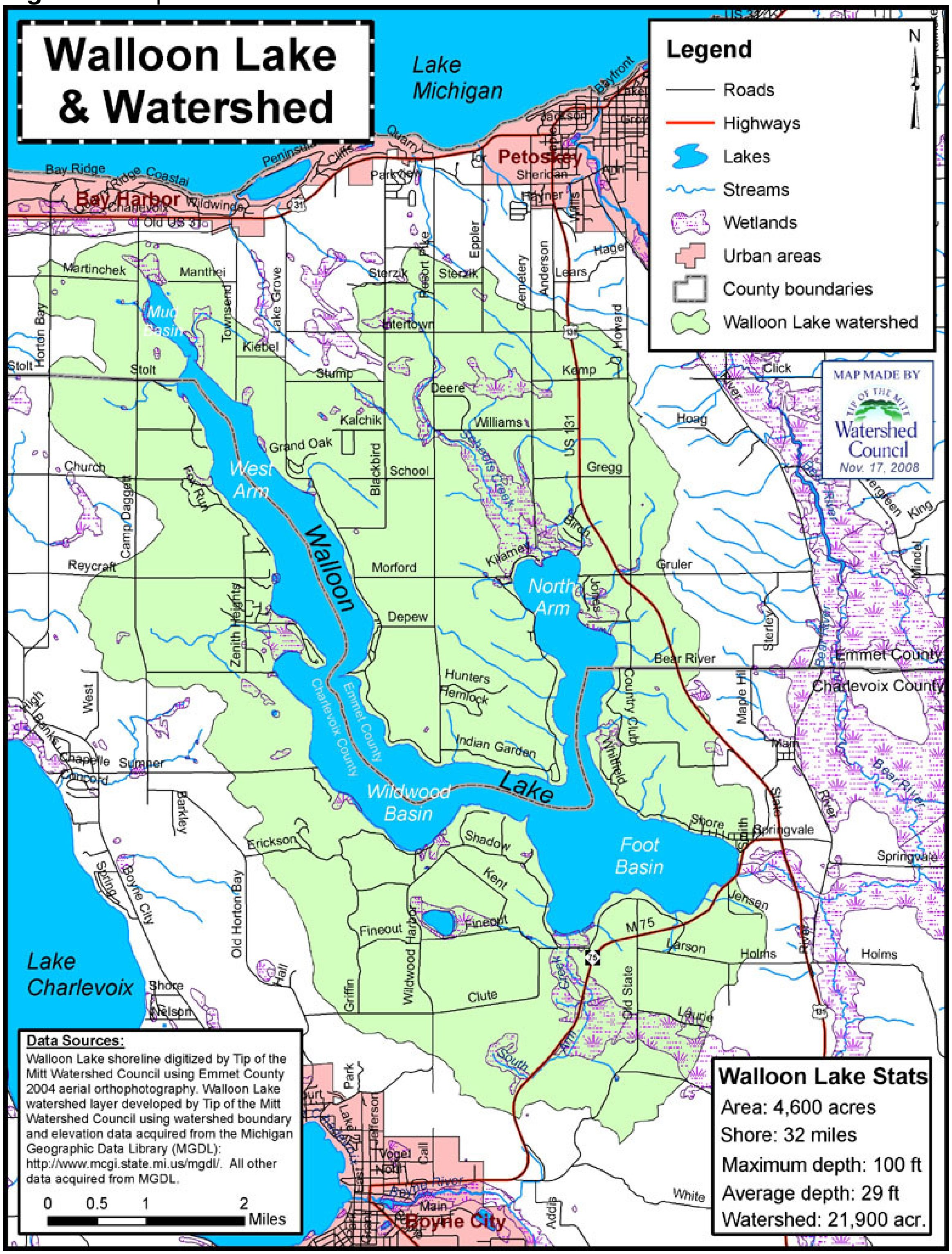
Responsible, low-impact, lake shoreline property management is paramount for protecting water quality. Maintaining a healthy greenbelt, regular septic tank pumping, treating stormwater with rain gardens, addressing erosion sites, and eliminating fertilizer, herbicide, and pesticide application are among many low-cost best management practices that minimize the impact of shoreline properties on lake water quality. Responsible stewardship on the part of shoreline property owners and living in harmony with the lake is vitally important for sustaining a healthy and thriving lake ecosystem.

Study area:

Walloon Lake is located in the northwest Lower Peninsula of Michigan; in Bear Creek and Resort Townships of Emmet County and Bay, Evangeline, and Melrose Townships of Charlevoix County. Based on digitization of 2005 aerial orthophotography from the Michigan Geographic Data Library, the shoreline of Walloon Lake measures 30.5 miles and lake surface area totals 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 out 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 Lake, 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 (Sportsman's Connection 2002). 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 Lake. Broad shallow areas are found between the various basins and throughout Mud Lake.

Figure 1. Map of Walloon Lake and watershed.



Walloon Lake is a drainage lake with water flowing into and out of the lake. The primary inlets include the 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 (USGS, 1990). 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 ends of the Schoof's and South Arm Creeks' watersheds, as the perimeter of the Mud Lake 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 small 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 2006 data, the majority of the watershed's landcover is natural; consisting

Table 1. Walloon Lake watershed land-cover statistics.

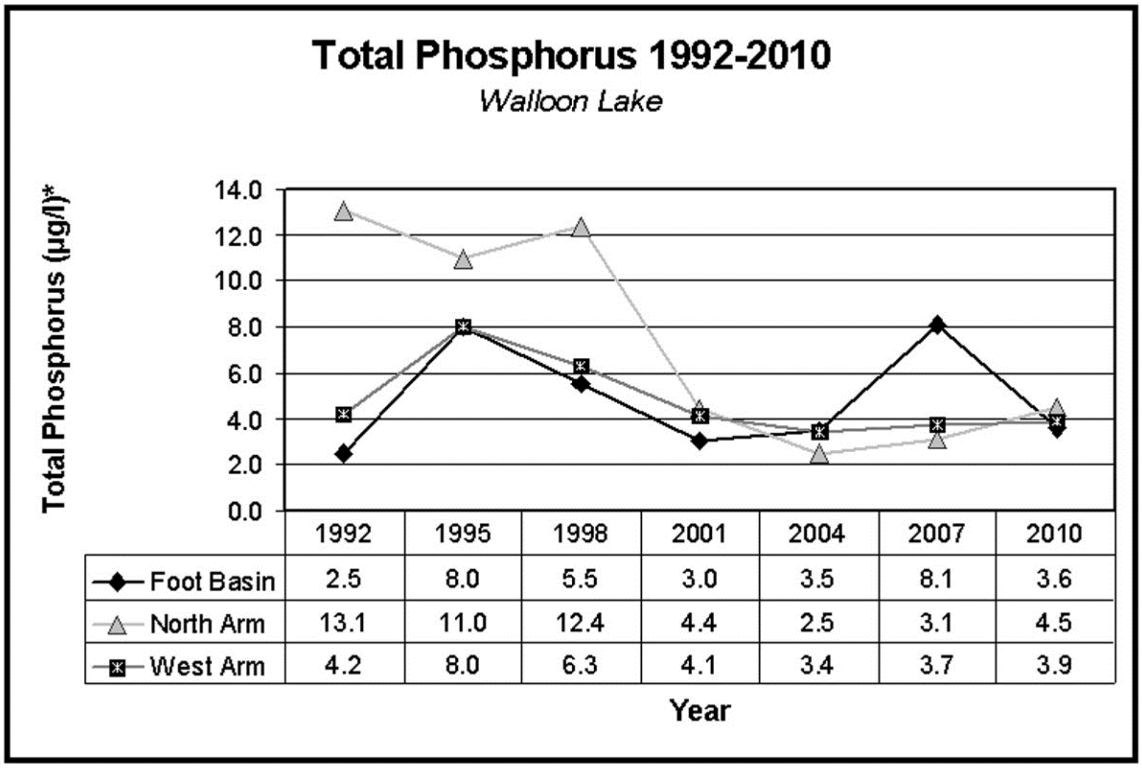
Land Cover Type	Acres (2000)	Percent (2000)	Acres (2006)	Percent (2006)	Change, Acres (2000-2006)	Change, Percent (2000-2006)
Agriculture	5499.14	20.74	5835.38	21.99	336.24	1.25
Barren	34.71	0.13	47.73	0.18	13.01	0.05
Forested	10100.97	38.10	10468.19	39.46	367.21	1.35
Grassland	3162.54	11.93	1974.97	7.44	-1187.57	-4.49
Scrub/Shrub	521.03	1.97	619.82	2.34	98.79	0.37
Urban/residential	691.33	2.61	927.45	3.50	236.12	0.89
Wetland	1788.91	6.75	1958.49	7.38	169.58	0.63
Water	4711.44	17.77	4699.15	17.71	-12.29	-0.06
TOTAL	26510.07	100.00	26531.17	53062.35	NA	NA

primarily of forest, wetlands, and grassland. There is a moderate amount of agricultural landcover in the watershed (~22%), but little urban (~3.5%). Both agricultural and urban landcover increased by roughly one percent between 2000 and 2006.

The water quality of Walloon Lake has been monitored consistently for more than two decades. The Walloon Lake Association has actively supported water quality monitoring programs on Walloon Lake, 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.

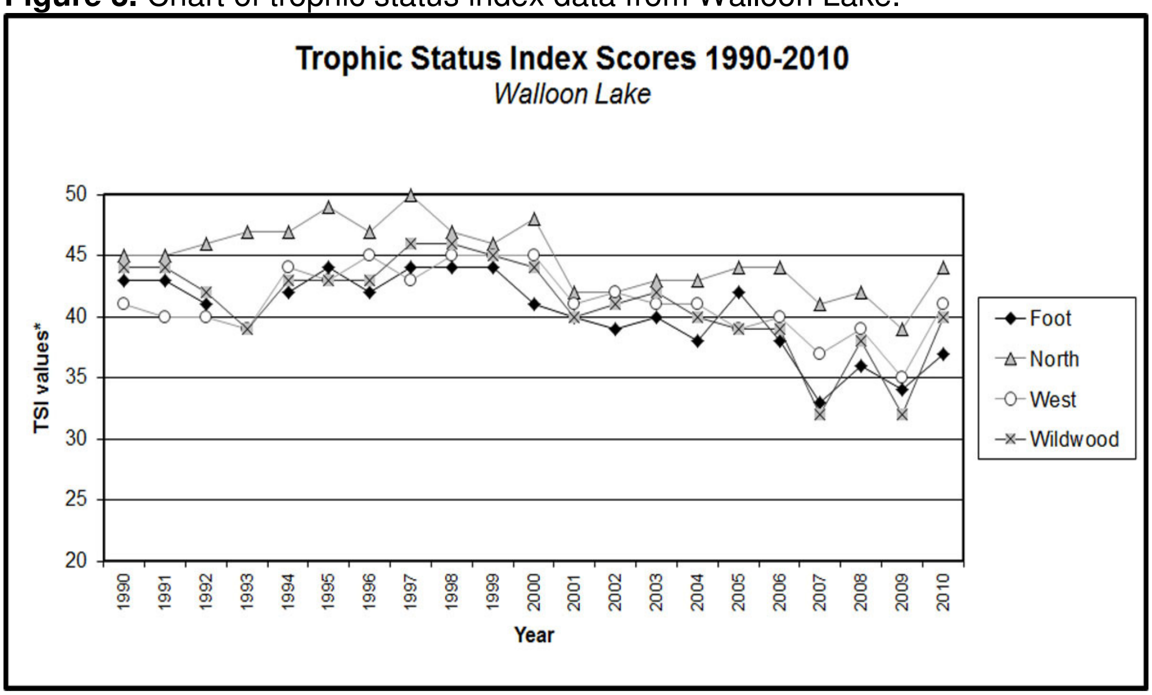
Data collected through these programs indicate that water quality has been consistently high. Total phosphorus data collected in the CWQM program show that levels have dropped considerably throughout the last 20 years and are generally found below 10 parts per billion (PPB), which is typical for high quality lakes of Northern Michigan (Figure 2). Volunteer Lake Monitoring data indicate that biological productivity has decreased in Walloon Lake, which is probably a result of the introduction of invasive zebra mussels. 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 2010 to document shoreline conditions that potentially impact water quality at every lakeshore property. 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 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.

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 waters edge landward into the property. Ratings for length ranged from zero to four while depth ranged from zero to three and were based on the following:

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

Greenbelt ratings for length and depth were summed to produce an overall greenbelt score. 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 field work, 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 1020 parcels on Walloon Lake. The length of shoreline per parcel varied from less than 20 feet to more than a mile. Approximately 85% (865) 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 892 properties (87%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 462 parcels (45% of the total or 52% of properties with suitable habitat). At properties where *Cladophora* growth was observed, nearly 50% consisted of light or very light growth whereas only ~16% of parcels had growth in the heavy or very heavy categories (Table 3).

Table 3. *Cladophora* density results.

***Cladophora* Density**	**Parcels**	**Percent**
Very light	29	6.28
Light	198	42.86
Light to Moderate	60	12.99
Moderate	64	13.85
Moderate to Heavy	37	8.01
Heavy	54	11.69
Very Heavy	20	4.33
TOTAL	462	100.00

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Over half of greenbelts (55%) along the Walloon Lake shoreline were found to be in good or excellent condition (Table 4). However, over a quarter of shoreline properties (28%) 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)	75	7.35
1-2 = Poor	207	20.29
3-4 = Moderate	170	16.67
5-6 = Good	298	29.22
7 = Excellent	270	26.47

Some form of shoreline alteration was noted at over 75% of shoreline properties (Table 5). The majority of alterations consisted of riprap (71%) while seawalls, as well as seawalls mixed with riprap, accounted for approximately 19% of altered shorelines.

Table 5. Shoreline alteration results.

Alteration Type	Number of Parcels	Percent of Parcels
Riprap (small)	253	32.90
Riprap (boulder)	295	38.36
Seawalls	30	3.90
Mixed (riprap and seawalls)	115	14.95
Other*	76	9.88
TOTAL	769	100.00

**other includes rock groins, boat ramps, boat houses, beach sand, or mixed.*

Erosion was noted at 168 parcels (~17%) on the Walloon Lake shoreline (Table 6). Nearly 60% of shoreline properties with erosion were classified as minor in terms of severity, while only 4% of properties were experiencing severe erosion.

Table 6. Shoreline erosion results.

Erosion Category	Number of Properties	Percent of Properties
Minor	100	59.52
Moderate	61	36.31
Severe	7	4.17
TOTAL	168	100.00

Tributaries (e.g., streams, creeks) were documented at 39 properties. The actual number is likely lower because tributaries located between land parcels are often tallied for both properties.

A map was developed to display and examine clusters and patterns in the occurrence of heavy *Cladophora* growths and poor greenbelts on the Walloon Lake shoreline. Shoreline areas with clusters of properties that had heavy *Cladophora* growth were found primarily in the North Arm; including an area in the northwest to the west and south of Schoof's Creek, another to the northeast in the vicinity of Gruler Road, and along the eastern shore near Bear River Road. In the West Arm, there were a few small clusters of heavy algae growth; one on the east shore to the south of Townsend Road and the other located on the western shore along Fox Run Road. Additionally, there were scattered areas of heavy *Cladophora* growth along the north shore of the narrows between the Foot and Wildwood basins and on the north shore of the foot basin extending approximately a mile north-northwest from the boat launch in Walloon Lake Village.

Groupings of properties with poor greenbelts occurred throughout the lake, but were more prevalent in the North Arm and Foot Basin. The most extensive shoreline area containing nearly contiguous poor greenbelts occurred on the west shore of the North Arm, extending from near the middle of the basin to the northern shore. Other clusters of poor greenbelts in the North Arm were found near Gruler Road extending approximately a half mile south, and along half-mile stretches of both the east and west shores in the southern end of the basin. Poor greenbelts in the Foot Basin were clustered in a half-mile stretch of shoreline extending from Walloon Lake Village to the north, a mile-long section following South Shore Drive between Washburn Road and M75, and in a shorter stretch on the west side of the basin near Conkle Road (1/3 of a mile). In the narrows between the Foot and Wildwood Basin, from Ellis Road to Burns Farm Road, a short 1/3-mile stretch of shoreline had a group of properties with poor greenbelts. On the north end of the Wildwood Basin, at Tamarack Point, another cluster extended a half-mile along the shoreline. In the West Arm, there were a number of small clusters of poor greenbelts, the largest of which was a quarter-mile long and in the area of Depew Road.

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 2010 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 on nearly half of the shoreline properties, over a quarter of greenbelts were in poor condition, and three quarters of the lakeshore properties had altered shorelines. Although less extensive, the amount of 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 terms of *Cladophora* growth. The total number of properties with documented *Cladophora* growth increased by over 16% between 2005 and 2010 (Table 7). With regards to *Cladophora* density, there was an increase of 9% in the number of properties where heavy growth was observed. The data indicate that nutrient pollution around Walloon Lake is increasing and in need of attention.

Table 7. *Cladophora* density comparisons: 2001 to 2010.

Cladophora* Growth	**2001 Survey Results**	**2005 Survey Results**	**2010 Survey Results**
Light	270 properties (72%)	177 properties (58%)	228 properties (49%)
Moderate	83 properties (22%)	82 properties (27%)	127 properties (27%)
Heavy	22 properties (6%)	45 properties (15%)	111 properties (24%)
TOTAL[ƚ]	375 properties (38%)	304 properties (30%)	466 properties (46%)

** 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.

Of the shoreline areas showing evidence of potential nutrient pollution, some of the algae growth is undoubtedly associated with septic system leachate or other factors associated with development and human activities, but others are probably due to natural factors. There are numerous streams, springs, and seeps flowing into Walloon Lake at different points along the shoreline that may be delivering nutrients that naturally increase 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 (TOMWC 2010). 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 (TOMWC 2010). 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.

These data suggest a decrease in nutrient pollution, but there are a few factors to consider when interpreting such data. One is that all water quality data referenced above have been collected out in open water, far removed from shoreline areas where the majority of nutrient pollution tends to occur. Perhaps of greater importance, zebra mussels have altered the lake ecosystem; disrupting natural nutrient cycling, and probably causing the documented decrease in nutrient concentrations and algal biomass, as well as the increase in water clarity.

Results from the greenbelt assessment portion of the survey show a different trend on Walloon Lake, one of dramatic improvement. Between 2001 and 2010, the number of properties with poor greenbelts decreased by 24% while properties with good greenbelts increased by 34% (Table 8). However, the figures used for this comparison may not be entirely accurate because methodologies for assessing shoreline vegetation changed between the 2001 and 2010 surveys.

Table 8. Greenbelt rating comparisons: 2001 to 2010*.

Greenbelt Rating	2001 Percent	2010 Percent
Poor	52	28
Moderate	27	17
Good	21	55

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

Although the shoreline vegetation in Walloon Lake appears to be in much better shape than in 2001, the lake ecosystem would benefit from further improvements. Greenbelts continue to be in poor condition throughout much of the lake, with over a quarter of properties possessing little to no vegetation beyond turf grass. 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 25% 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.

Relative to shore surveys conducted on other lakes in the region, Walloon Lake falls somewhere in the middle of the range in terms of the percentage of properties with *Cladophora* growth, with heavy *Cladophora* growth, and with poor greenbelts (Table 9). The percentage of properties on Walloon Lake with erosion was higher than other lakes for which data were available. The percent of properties with altered shoreline was also high on Walloon Lake relative to other lakes in the region.

Table 9. Shore survey statistics from Northern Michigan lakes.

Lake Name	Survey Date	***Cladophora****	Heavy Algae*	Erosion*	Greenbelts*	Alterations*
Black Lake	2005	20%	21%	ND	ND	ND
Burt Lake	2009	47%	29%	6%	36%	46%
Huffman Lake	2006	60%	22%	ND	ND	76%
Charlevoix	2007	17%	20%	9%	30%	61%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2008	59%	50%	12%	64%	58%
Sixmile Lake	2008	14%	5%	11%	34%	30%
Thumb Lake	2007	4%	0%	ND	ND	39%
Walloon Lake	2010	46%	24%	16%	36%	75%

**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. Greenbelt percentage reflects the percentage of parcels with greenbelts in poor condition. ND=no data.*

Erosion and altered shorelines are issues of concern on Walloon Lake due to the relatively high percentage of occurrence. However, erosion was considered minor at 60% of properties and only 4% of properties had severe erosion (Table 6). With regards to altered shorelines, over 70% consisted of riprap, which as far as alterations go, is one of the least damaging types in regards to lake ecosystem health (Table 5). Furthermore, only 4% of noted alterations were seawalls, which are frowned upon by water resource managers due to negative impacts that range from near-shore habitat loss to ice-induced erosion in neighboring shoreline areas. Although there were few severe erosion sites on the lake and a small percentage of seawalls, correcting eroded areas, preventing further erosion, and reducing the length of altered shoreline will benefit the Walloon Lake ecosystem.

In spite of the problems exposed by this survey, the water quality of Walloon Lake remains high. Due to its oligotrophic (nutrient poor) 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 <u>general</u> 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 dangers to the lake 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 *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 contract the Watershed Council to perform site visits and even conduct ground water 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 have the option to contract the Watershed Council to perform site assessments and carry out projects to improve greenbelts and/or correct erosion problems.

6. Utilize the internet and the Lake Association's web page to share survey information. A general summary report and this detailed report can be posted on the Association's web page because they do not contain any property-specific information. Property-specific information can be shared via the Association's web page 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 land owner information. By doing so, property owners will receive the correct information regarding their parcel. This information is also useful for empowering the lake association 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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