Hanley Lake Shoreline Survey 2016

By Tip of the Mitt Watershed Council

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SUMMARY

During the early summer of 2016, the Tip of the Mitt Watershed Council conducted a shoreline survey of Hanley Lake as part of a comprehensive shoreline survey for the entire Elk River Chain of Lakes. Watershed Council staff and interns surveyed the upper Elk River Chain (Beals Lake through Intermediate Lake) in 2016 and the lower Elk River Chain (Lake Bellaire through Elk Lake) in 2017. Surveys were designed to document conditions that can potentially impact water quality, including the three biggest threats to inland lakes: nutrient pollution, habitat loss, and shoreline erosion.

Survey results indicate that human activity along the Hanley Lake shoreline is likely impacting the lake ecosystem and water quality. Nearly one-fifth (19%) of all shoreline properties had little to no vegetation growing at water's edge. Vegetation removal is concentrated along the western and southern shorelines, with extensive natural areas throughout the northern portion of the Lake. Shoreline erosion was found occurring on 33% of all properties, with the most predominant cluster near the narrow portion of the Lake.

The number of properties showing signs of nutrient pollution is relatively low, compared to other area lakes. *Cladophora*, an algal indicator of nutrient pollution, was documented at 11% of all properties. Shoreline Alterations, such as sea walls and riprap, were found along the shorelines of 23% of all properties. While this poses an issue for the aquatic habitat of Hanley Lake, rampant shoreline modification is not taking place, as it is in other area lakes having up to 80% of all shoreline properties with some form of alteration.

Steps can be taken to improve the habitat and water quality of Hanley Lake. Erosion sites can be repaired, vegetation can be allowed to regrow on the shoreline, providing improved pollutant filtration and erosion resistance. Outreach to shoreline property owners regarding lake-friendly shoreline management practices can help to improve conditions. Educating residents on beneficial and harmful activities is often all that is needed to bring about change.

INTRODUCTION

Background:

During the late spring of 2016, a shoreline survey was conducted on Hanley 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 a grant from the Michigan Department of Environmental Quality as part of a larger Elk River Watershed protection initiative.

In 1998, Clean Water Act funds were granted to eight organizations and agencies by the Michigan Department of Natural Resources for a three year project to protect water resources of the Elk River/Chain of Lakes Watershed. One of the project's tasks was a shoreline water resource/nonpoint source pollution survey. The survey was intended to document basic information for educational purposes and as a basis for water resource management decisions.

The 1998 survey was primarily conducted by small boat traveling closely along the shoreline. The description of shoreline property parcels, as observed from the water, was matched with maps showing parcel lines, tax numbers, and ownership information obtained from the equalization departments of the four counties covered by the watershed. This allowed the location of observed resource features to be later plotted on the maps with relative accuracy. The survey results were entered into a computerized database and depicted on a map generated by a geographic information system. In 1998, shoreline survey efforts documented shoreline erosion and *Cladophora* algae, but did not document vegetation removal or shoreline alterations.

The 2016 survey provides a comprehensive data set documenting shoreline conditions on Hanley 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, small and shallow lakes, such as Hanley Lake, are more 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. Nutrient pollution can be more problematic in small lakes due to extensive shallow areas that can support more aquatic plant growth.

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 result 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:

Hanley Lake is located in Antrim County of the northwest Lower Peninsula of Michigan. Hanley Lake is a small, narrow lake situated in the middle of the Elk River Chain of Lakes, which is a chain of 14 interconnected lakes draining into East Grand Traverse Bay. It is connected to Ben–Way Lake upstream via the Green River and its major outlet on the south end drains to Intermediate Lake.

Like other long, slender lakes in the Upper Chain, Hanley's deepest spot (27 feet) is near its outlet. This is most likely because the 'upstream' ends of the lakes have gradually filled in with sediment from the connecting inlet rivers.

Hanley Lake is unique among the Chain of Lakes in that its flushing rate (the amount of time it takes to move the entire volume of water through the lake) is only 5 days, which is the fastest among all lakes in the Chain. This is amazing, because the volume of water in Hanley Lake at any given time is 322 million gallons. In comparison, it takes 173 days to flush all the water through Intermediate Lake, and 6.9 years for Torch Lake.

The village of Central Lake is located at the south end of the lake near the outlet. The closest public access point is in the village of Central Lake, which is located on the north end of Intermediate Lake.

According to GIS files developed by the Watershed Council using elevation data acquired from the State of Michigan, the Hanley Lake Watershed encompasses approximately 56,183 acres, which includes the lake area (Figure 1). The immediate watershed accounts for 1,922 of these acres, while the remaining 54,261 acres are drainage through lakes upstream in the Chain. Land cover statistics were generated for the watershed using remote sensing data from the Coastal Great Lakes Land Cover project (NOAA 2010). Based on 2010 data, the majority of the watershed's land-cover is natural; consisting primarily of forest, wetlands, and grassland (Table 1). There is a substantial amount of agricultural land-cover in the watershed (27%) and some urban (2.5%). Both agricultural and urban land-cover changed by less than one percent between 1985 and 2010.

Table 1. Hanley Lake Watershed land-cover statistics.

Land Cover Type	1985 acres	1985 percent	2010 acres	2010 percent	Change (acres)	Change (percent)
Agriculture	14750	26.3	15199	27.1	449	0.80
Barren	77	0.1	101	0.2	24	0.04
Forest	23266	41.4	23043	41.0	-223	-0.40
Grassland	3746	6.7	3236	5.8	-510	-0.91
Scrub/Shrub	1280	2.3	1461	2.6	182	0.32
Urban	1367	2.4	1411	2.5	43	0.08
Water	1508	2.7	1520	2.7	13	0.02
Wetland	10190	18.1	10212	18.2	22	0.04
TOTAL	56183	100.0	56183	100.0	NA	NA

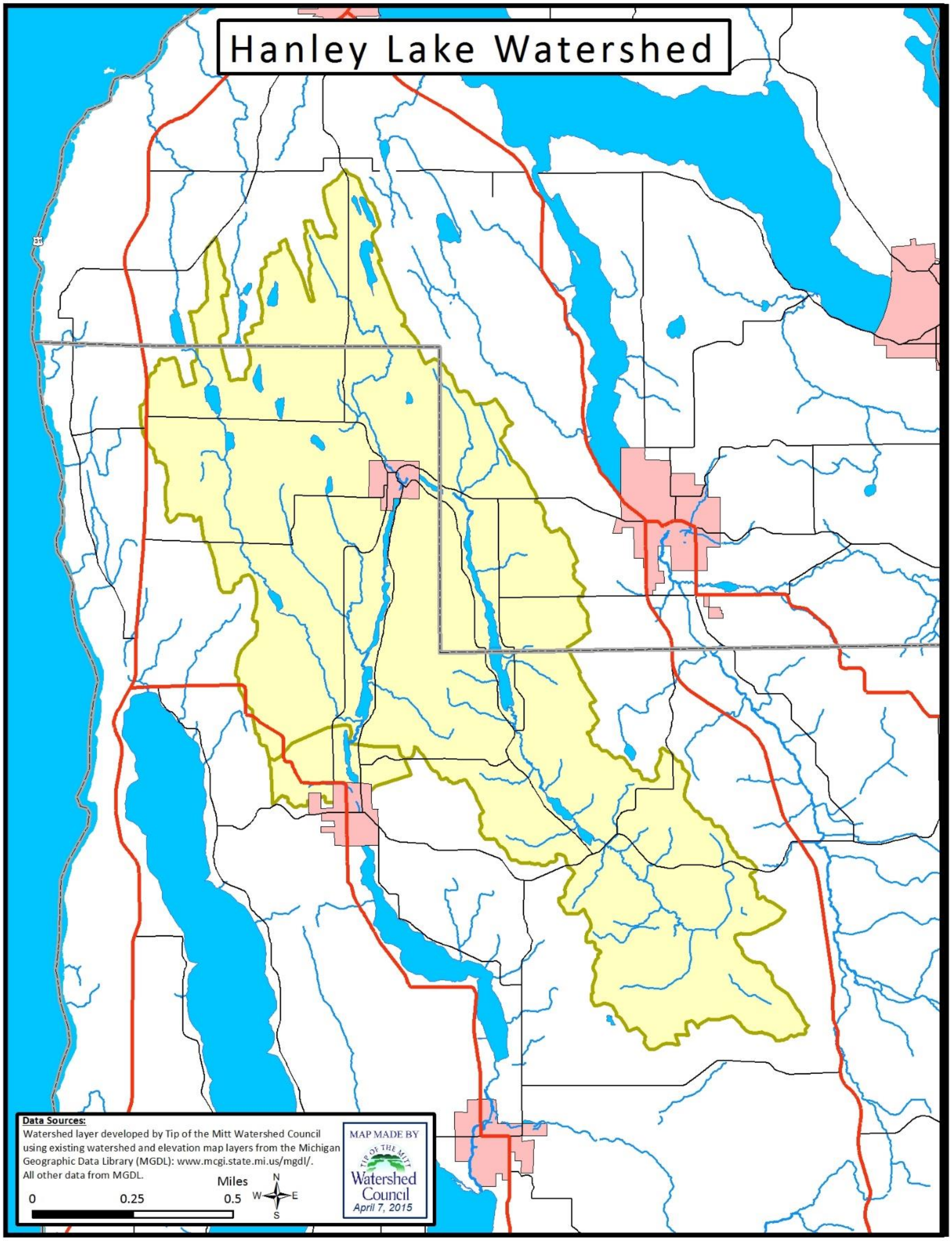


Figure 1. Map of Hanley Lake and its Watershed.

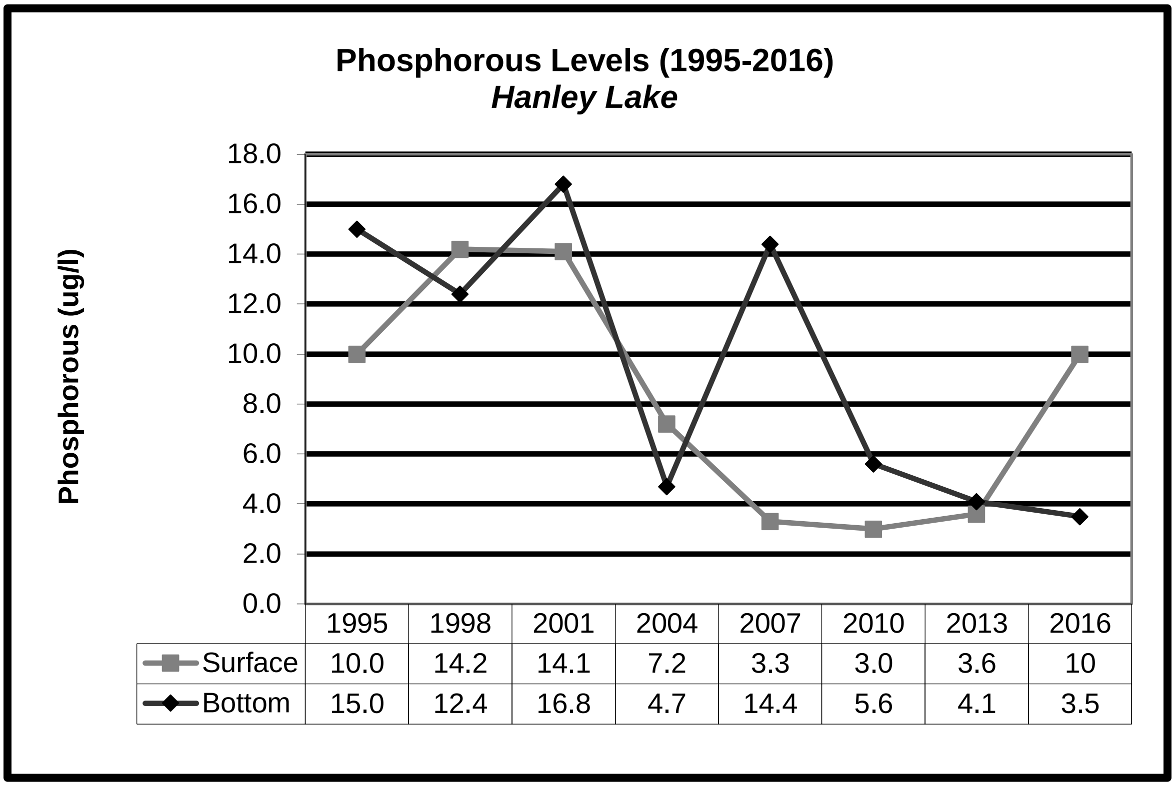
According to data collected in programs coordinated by the Tip of the Mitt Watershed Council, Hanley Lake contains high quality waters that are typical for the region. As part of the Watershed Council's Comprehensive Water Quality Monitoring Program (CWQM), numerous parameters have been monitored in Hanley Lake on a triennial basis since 1995. Dissolved oxygen concentrations have typically exceeded standards established by the State of Michigan and pH has consistently complied with State standards (Table 2). Chloride levels have increased gradually over time, indicating that there are some impacts from urbanization and residential development. Typical of high-quality lakes in northern Michigan, nutrient concentrations on Hanley Lake have been quite low (total phosphorus, nitrate and total nitrogen), with phosphorus levels decreasing through time. Based on the Redfield Ratio of 16:1 (nitrogen: phosphorus), the limiting nutrient in Hanley Lake is phosphorus, which means that phosphorus is the nutrient in smallest supply and which would stimulate the most plant growth.

Table 2. Hanley Lake data from the CWQM program.

	DO	**pH**	**Conductivity**	**Chloride**	**Nitrate**	**TN**	**TP**
Units	PPM	Units	microSiemens	PPM	PPB	PPB	PPB
Average	9.48	7.17	338.91	8.49	344.06	610.01	9.08
Minimum	0.65	0.00	282.20	7.00	190.00	383.60	0.80
Maximum	12.18	8.42	406.90	10.90	510.00	810.00	34.2

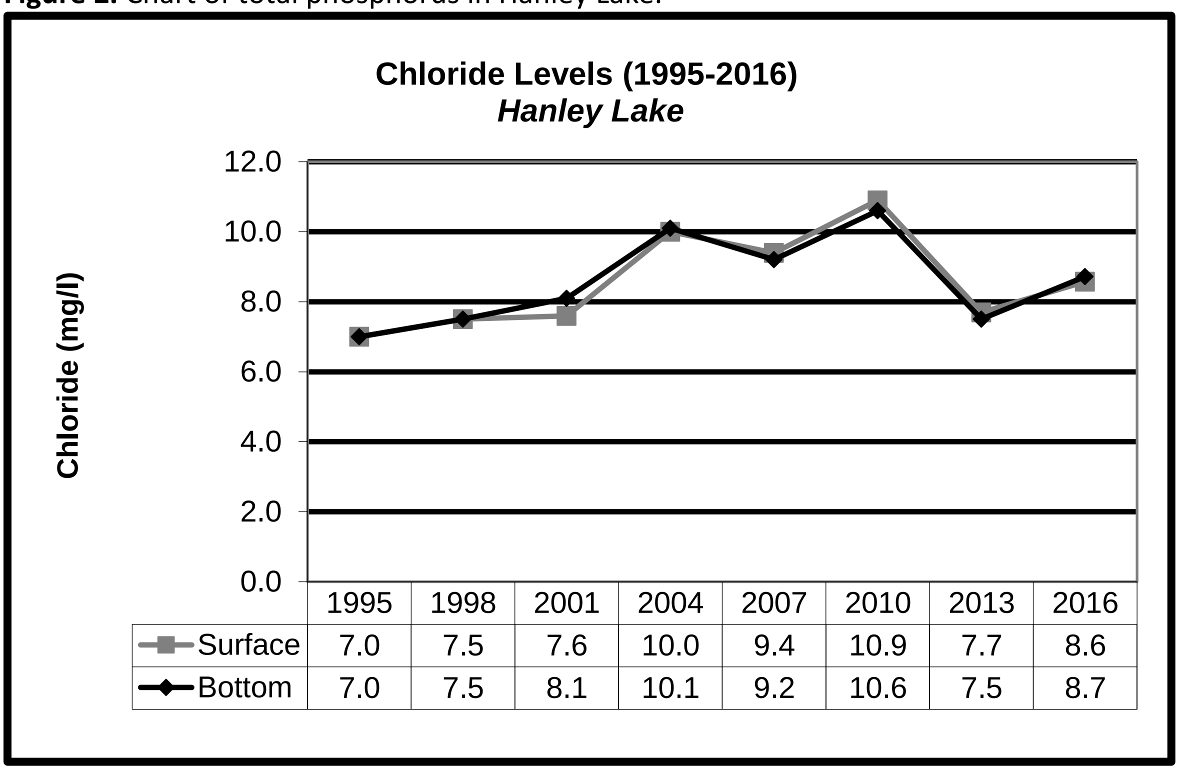
*DO = dissolved oxygen, TN = total nitrogen, TP = total phosphorus, PPM = parts per million, PPB=parts per billion.

Hanley Lake is classified as a mesotrophic lake (trophic status index values have ranged from 39 to 48). Mesotrophic lakes are in the middle of the road in terms of biological productivity; somewhere between the nutrient poor large, deep lakes with lackluster fisheries and the overly productive small, shallow lakes with excessive algae and plant growth. Phosphorus data from the CWQM program supports this characterization as averaged concentrations have typically been higher than large, deep lakes in the area(Figures 2 and 3). Invasive zebra mussels, which are now found in Hanley Lake, usually cause increased water clarity and reduced algal biomass by filter feeding on planktonic algae. Zebra mussels provide an explanation for the decrease in total phosphorus.



	1995	1998	2001	2004	2007	2010	2013	2016
Surface	10.0	14.2	14.1	7.2	3.3	3.0	3.6	10
Bottom	15.0	12.4	16.8	4.7	14.4	5.6	4.1	3.5

Figure 2. Chart of total phosphorus in Hanley Lake.



	1995	1998	2001	2004	2007	2010	2013	2016
Surface	7.0	7.5	7.6	10.0	9.4	10.9	7.7	8.6
Bottom	7.0	7.5	8.1	10.1	9.2	10.6	7.5	8.7

Figure 3. Chart of chloride concentrations in Hanley Lake.

METHODS

The Hanley Lake shoreline was comprehensively surveyed in 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 3. 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 Antrim 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 Hanley 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 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 107 parcels on Hanley Lake. Approximately 63% (67) of shoreline properties on Hanley Lake were considered to be developed.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 53 properties (49%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 12 parcels (11% of the total or 23% of properties with suitable habitat). At properties where *Cladophora* growth was observed, most (83%) consisted of light-moderate to moderate growth, whereas only 2 parcels had growth in the light category and no algae was documented in the heavy categories (Table 4).

Table 4. *Cladophora* density results.

***Cladophora* Density**	**Parcels**	**Percent**
Very light	0	0%
Light	2	2%
Light to Moderate	4	4%
Moderate	6	6%
Moderate to Heavy	0	0%
Heavy	0	0%
Very Heavy	0	0%
TOTAL	12	11%

The majority of notable Cladophora growth was distributed across the Lake's middle section, particularly on the eastern shoreline. (Figure 4). The northern and southern portions of the Lake had very little *Cladophora* growth occurring.

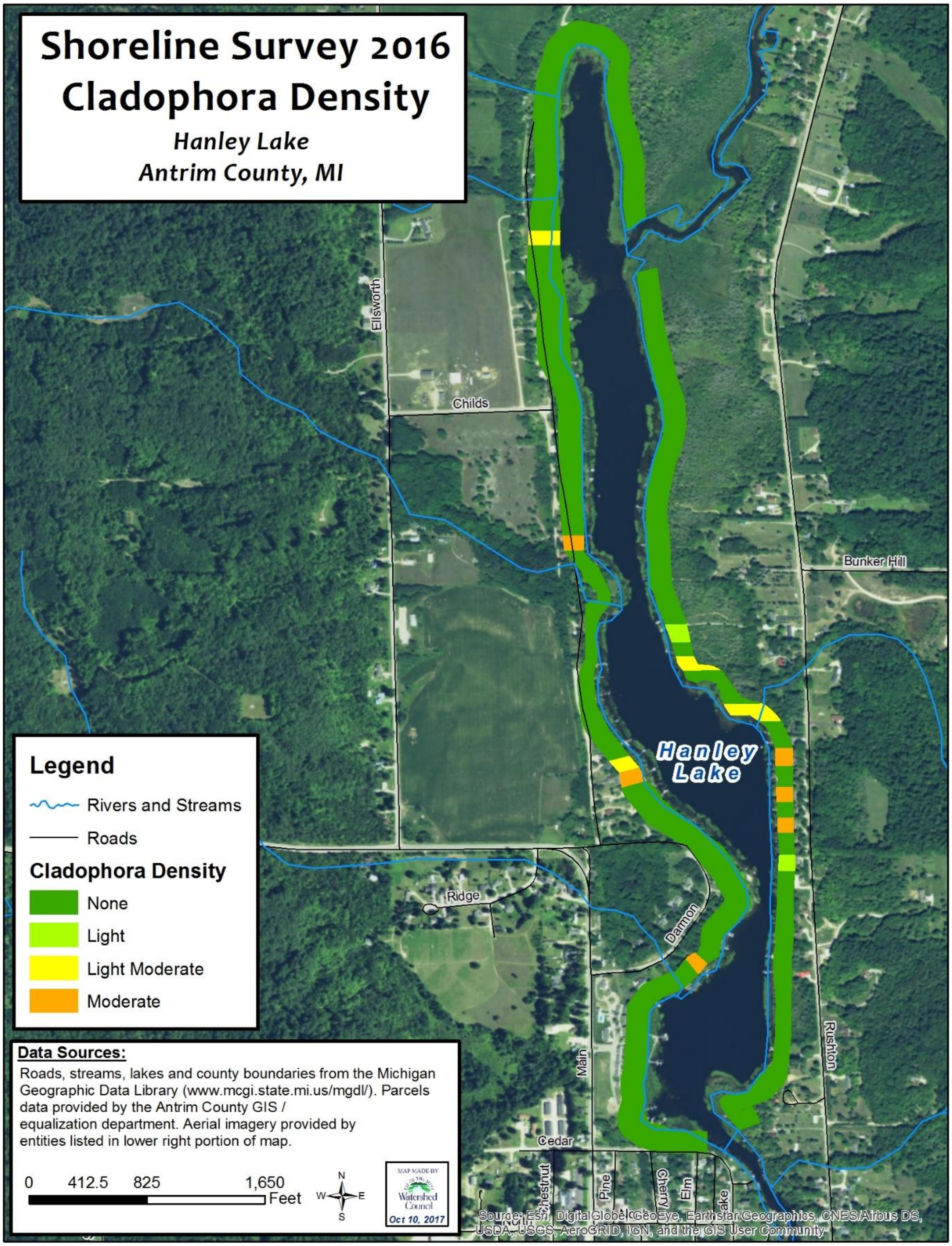


Figure 4. *Cladophora* algae density results for Hanley Lake.

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Over half of all greenbelts (61%) along the Hanley Lake shoreline were found to be in good or excellent condition (Table 5). Nearly one fifth of parcels (19%) received a greenbelt rating in the poor or very poor categories.

Table 5. Greenbelt rating results.

Greenbelt Rating		Number of Parcels	Percent of Parcels
0	Very Poor (absent)	3	3%
1-2	Poor	17	16%
3-4	Moderate	22	21%
5-6	Good	29	27%
7	Excellent	36	34%

Vegetation removal is concentrated along the western and southern shorelines, with extensive natural areas throughout the northern portion of the Lake (Figure 5).

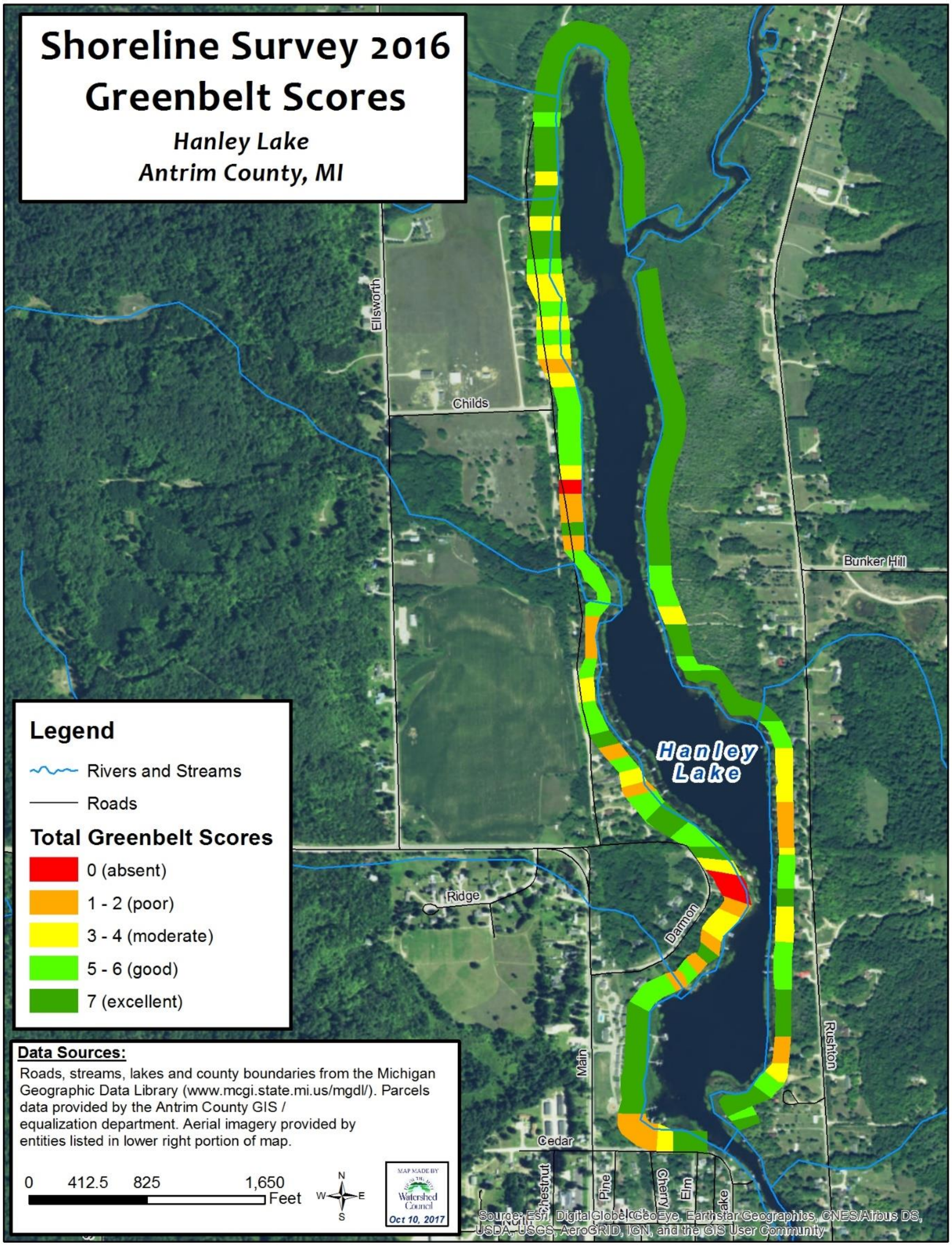


Figure 5. Greenbelt score totals results for Hanley Lake.

Some form of shoreline alteration was noted at 23% of shoreline properties (Table 6). The majority of alterations consisted of riprap (both mid-sized rocks and boulders (10%), while seawalls (wooden, concrete, or metal), were found along 6% of all shorelines. Beach sanding was found to occur at 9% of all shoreline parcels.

Table 6. Shoreline alteration results.

Alteration Type	Number of Parcels*	Percent of Parcels With Alteration*
Riprap (small)	7	7%
Riprap (boulder)	3	3%
Seawalls	6	6%
Beach Sand	10	9%
Unaltered	82	77%

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

Erosion was noted at 35 parcels (33%) on the Hanley Lake shoreline (Table 7). 54% of shoreline properties with erosion were classified as minor in terms of severity, while roughly 46% of erosion sites were considered moderate and no erosion was considered to be severe.

Table 7. Shoreline erosion results.

Erosion Category	Number of Properties	Percent of Properties*
Minor	19	18%
Moderate	16	15%
Severe	0	0%
TOTAL	35	33%

The most predominate cluster of shoreline erosion occurred near the narrow portion of the Lake.

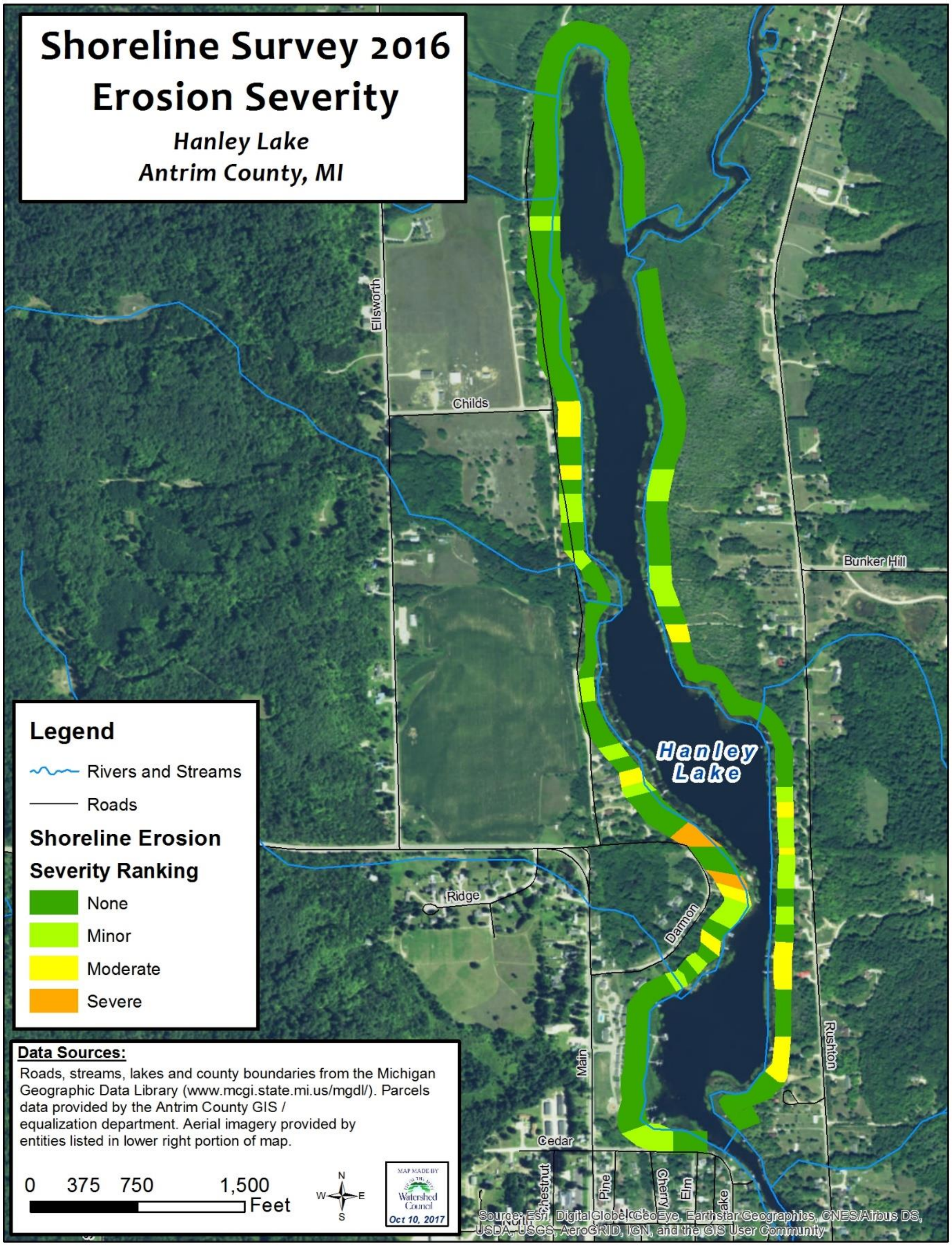


Figure 6. Shoreline erosion severity results for Hanley Lake.

DISCUSSION

In general, development of shoreline parcels can negatively impact a lake's water quality due to a multitude of factors. Among the most serious impacts are: 1) loss of vegetation that would otherwise absorb and filter pollutants in stormwater runoff as well as stabilize shoreline areas and prevent erosion, 2) increased impervious surface area such as roofs, driveways and roads, which leads to greater inputs of stormwater runoff and associated pollutants, and 3) waste and byproducts of human activity such as septic leachate, fertilizers and decomposing yard waste that potentially reach and contaminate the lake water. Clearly, there are many problems associated with development, but there are also many solutions for reducing or even entirely eliminating impacts.

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

Results from the 2016 shoreline survey indicate that some of the aforementioned issues may pose a threat to the water quality and overall health of Hanley Lake. Removal of shoreline vegetation, while not as prevalent on Hanley Lake as other lakes, is a concern. A substantial number (19%) of all shorelines exhibited greenbelts that were in poor condition. Erosion is also a concern, with light to moderate erosion commonly occurring throughout the same areas most heavily impacted by vegetation removal. Algal indicators of nutrient pollution are far less extensive than the above issues.

Comparisons with prior shoreline surveys show changes in these measurements over time. The total number of properties with documented *Cladophora* growth increased slightly since 1998 (Table 8). Outreach regarding septic system maintenance, phasing out of old systems, and properly siting new systems may play a role in reduction in nutrient pollution related to septic systems. Where human-caused nutrient pollution is occurring, the source has to be identified in order to address the problem. Although impeded by factors such as wind, wave action, currents, and groundwater paths, efforts by trained personnel to identify specific nutrient input sources on individual properties are often successful.

Table 8. Critical shoreline survey parameter comparisons: 1998 to 2016.

Survey Parameter	**1998 Survey Results**		**2016 Survey Results**	
	Properties	%	Properties	%
Cladophora Algae Presence	1	1%	12	11%
Poor Greenbelts (score 0-2)	ND	ND	20	19%
Erosion	0	0%	35	33%
Shoreline Alterations	ND	ND	25	23%

Shoreline erosion, nonexistent in 1998, has increased drastically. This may be due to changes in shoreline management, or increases in recreational use of high-speed boats.

Compared to other lakes in the region, Hanley Lake has a relatively low number of parcels exhibiting *Cladophora* growth (Table 9). This is due, at least in part, to a lack of suitable substrate for *Cladophora* growth. Results from this survey indicate that just over half (51%) of all properties lack habitat suitable for *Cladophora* growth. Suitable habitats include hard surfaces such as rocks, boulders, riprap, submerged wood, and metal seawalls. This limits the usefulness of *Cladophora* as an indicator of nutrient pollution. With no supporting habitat for *Cladophora*, it is difficult to make assertions about the level of nutrient pollution occurring along certain stretches of Hanley Lake's shoreline using the methods at hand.

Table 9. Shore survey statistics from Northern Michigan lakes.

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Beals Lake	2016	0%	0%	0%	17%	0%
Ben-Way Lake	2016	3%	0%	84%	47%	40%
Burt Lake	2009	47%	29%	4%	36%	46%
Bellaire Lake	2017	35%	1%	27%	30%	55%
Charlevoix, Lake	2012	22%	19%	14%	34%	79%
Clam Lake	2017	48%	5%	30%	51%	55%
Crooked Lake	2012	29%	26%	14%	51%	65%
Douglas Lake	2015	27%	6%	17%	53%	60%
Elk Lake	2017	84%	2%	52%	30%	87%
Ellsworth Lake	2016	40%	14%	38%	24%	23%
Hanley Lake	2016	11%	0%	33%	19%	23%
Huffman Lake	2015	14%	0%	7%	57%	70%
Huron, Duncan Bay	2013	41%	2%	19%	45%	63%
Huron, Grass Bay	2013	0%	0%	4%	0%	8%
Intermediate Lake	2016	19%	9%	53%	63%	77%
Lance Lake	2014	19%	0%	12%	35%	31%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2016	44%	6%	36%	59%	76%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Scotts Lake	2016	0%	0%	2%	18%	7%
Silver Lake	2014	3%	0%	70%	53%	65%
Skegemog Lake	2017	52%	5%	40%	46%	76%
St. Clair Lake	2016	4%	0%	13%	34%	21%
Six Mile Lake	2016	10%	24%	13%	41%	37%
Thayer Lake	2017	11%	1%	32%	16%	22%
Thumb Lake	2007	4%	0%	ND	ND	39%
Torch Lake	2017	39%	5%	26%	20%	ND
Walloon Lake	2016	62%	2%	17%	39%	80%
Wildwood Lake	2014	5%	0%	22%	45%	50%
Wilson	2016	27%	5%	29%	11%	14%
AVERAGE	NA	24%	6%	26%	36%	47%

**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 Hanley Lake are experiencing some form of erosion, the majority (54% of all erosion sites) are considered minor and no erosion is considered to be severe. Many properties with patches of lawn at water's edge experience a minor undercutting caused by waves and ice shove. Properties with artificial beach sand usually experience some loss of sand into the lake, evidenced by small erosional rills leading into the lake. Although not catastrophic, these types of minor erosion do have the ability to degrade the water and habitat quality of Hanley Lake. In addition, the wake from large boats may be exacerbating erosion as unnaturally large waves break along the shoreline. This is further evidenced by clusters of erosion that occur near the narrow portion of the lake, the same area in which boat traffic is forced to operate close to the shoreline.

Small lakes have less water surface width for wind to generate waves (fetch), resulting in smaller naturally occurring waves and less regular impact to the shoreline from wave energy. Likewise, winter ice-shove is also less impactful on smaller lakes. Without exposure to erosional forces commonly found on larger lakes, shorelines generally retain more vegetation and require less armoring. Repair of the current erosion sites should be relatively easy to accomplish with plantings, as the low-energy shoreline allows for establishment of new plants.

To prevent changes to the lake ecosystem, changes need to be made in shoreline property management. Mismanagement of shoreline properties can degrade the lake's water quality, diminish fisheries, and even create an environment that poses threats to human health.

RECOMMENDATIONS

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

1. Keep the specific results of the survey confidential (e.g., do not publish a list of sites

where *Cladophora* algae were found) as some property owners may be sensitive to publicizing information regarding their property.

2. Send a general summary of the survey results to all shoreline residents, along with a packet of informational brochures produced by the Watershed Council and other organizations to provide information about threats to the Lake's ecosystem and public health as a result of poor shoreline property management practices as well as practical, feasible, and effective actions to protect water quality.
3. Organize and sponsor an informational session to present findings of the survey to shoreline residents and provide ideas and options for improving shoreline management practices that would help protect and improve the Lake's water quality.
4. Inform owners of properties with heavy *Cladophora* growths of specific results for their property, ask them to fill out a questionnaire in an attempt to interpret causes of the growth, and offer individualized recommendations for water quality protection. Following the questionnaire survey, property owners have the option to have the Watershed Council perform site visits and conduct groundwater testing in an effort to gain more insight into the nature of the findings. Again, it should be stressed that all information regarding names, specific locations, and findings be kept confidential to encourage property owner participation in this project.
5. Inform owners of properties with poor greenbelt scores and those with severely eroded shorelines of specific results for their property. Supply these property owners with information (e.g., brochures) regarding the benefits of greenbelts and/or the problems associated with erosion. Encourage property owners to improve greenbelts using a mix of native plants and to correct erosion problems. Property owners can have the Watershed Council perform site assessments and carry out projects to improve greenbelts and/or correct erosion problems.
6. Utilize the Internet and other organizations' websites to share survey information. A general summary report and this detailed report can be posted websites because they do not contain any property-specific information. Property-specific information can be shared by randomizing and encrypting the shoreline survey database and providing

property owners with a code number that refers specifically to survey results from their property. The Watershed Council is available to assist with this approach.

7. Continue to support the Tip of the Mitt Watershed Council Volunteer Lake and Stream Monitoring programs by providing volunteer support. The information collected by volunteers is extremely valuable for evaluating water quality and determining trends. To date, very little has data has been collected for St. Clair Lake through the Volunteer Lake Monitoring Program.
8. Repeat some version of the survey periodically (ideally every 5 - 10 years), coupled with the follow-up activities described previously, in order to promote water quality awareness and good management practices on an ongoing basis. During each subsequent survey, more details about shoreline features are added to the database, which can be utilized for other water resource management applications.

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