GOOD HARBOR BAY WATERSHED

PROTECTION PLAN

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Good Harbor Bay Watershed Protection Plan

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Good Harbor Bay Watershed Protection Plan Partners

Lime Lake Association (LLA), Little Traverse Lake Property Owners Association (LTLPOA), Little Traverse Conservationists (LTC), Michigan Department of Environmental Quality (MDEQ), Michigan Department of Natural Resources (MDNR), Leelanau Conservation District (LCD), Conservation Resource Alliance (CRA), Grand Traverse Band of Ottawa and Chippewa Indians (GTBOCI), Grand Traverse Regional Land Conservancy (GTRLC), Leelanau Conservancy, Natural Resources Conservation Service (NRCS), NW Michigan Council of Governments (NWCOG), Leelanau County Road Commission (LCRC), Benzie Leelanau Health Department (BLHD), Sleeping Bear Dunes National Lakeshore (SBDNL)

The Good Harbor Bay Watershed Protection Plan can be downloaded at the following websites: www.leelanauconservancy.org or www.leelanaucd.org

INTRODUCTION

The Good Harbor Bay watershed is located in Leelanau County, Michigan, approximately 25 miles from Traverse City, Michigan. The watershed includes 29,020 acres of land area or approximately 45.4 square miles, and intersects with the jurisdictions of five townships, and contains no municipalities. A watershed is an area of land that drains to a common point. On a very broad scale, imagine a mountain, and think of the highest ridges on the mountain as the boundaries of the watershed. Rain, melting snow, and wind carry pollutants from the ridges and sides of the mountains into the water in the valley. Watersheds are inherently defined by topography as water always follows the path of least resistance (EPA 2008).

The Good Harbor Bay watershed originates in the forested uplands, kettle holes and wetlands in Kasson Township and surface water generally flows north through the watershed until it outlets in to Lake Michigan's Good Harbor Bay in Cleveland Township. Major features of the Good Harbor Bay watershed include Lime Lake, Little Traverse Lake and Shalda Creek that travels through the Sleeping Bear Dunes National Lakeshore. The watershed extends along the shore of Good Harbor Bay and includes a number of small tributary streams that outflow into Good Harbor Bay. The watershed also includes a number of smaller lakes, wetland and forested areas, residential areas and resort properties.

The Good Harbor Bay watershed plan was developed to better examine and understand the watershed and to identify ways to protect the watershed's natural functions.

The rationale for watershed management is that if land activities are responsibly managed, the water within that watershed will be protected. All activities within a watershed affect the quality of water as it percolates through and runs across natural and developed landscapes. Watershed planning brings together the people within the watershed to address those activities, regardless of existing political boundaries. By working together, individuals within the watershed can design a coordinated watershed management plan that builds upon the strengths of existing programs and resources, and addresses the water quality concerns in an integrated, cost effective manner (EPA 2008).

The Good Harbor Bay Watershed Protection Plan is the result of a steering committee being formed in fall of 2011 to draft the first watershed plan for this area. This watershed planning effort includes the last major watershed in Leelanau County to complete the watershed planning process. The Good Harbor Bay Watershed Protection Plan is a comprehensive document that coordinates the Lime Lake Association (LLA), Little Traverse Lake Property Owners Association (LTLPOA), the Little Traverse Conservationists (LTC), and other project partner's ongoing efforts to protect water quality with other watershed-wide stakeholder groups to achieve designated and desired goals.

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Purpose

The Good Harbor Bay Watershed Protection Plan (GHB Watershed Plan) is a comprehensive document that coordinates the ongoing efforts of various partners to protect water quality with those of other watershed-wide stakeholder groups to achieve designated and desired goals. These goals are addressed in a consolidated task implementation chart designed to achieve and maintain the high water quality. It is important to note that this document is a planning framework that prescribes tasks designed to achieve watershed goals, however it is not regulatory in nature. The plan itself and the Steering Committee are non-political entities and neither have regulatory powers.

Background

The Good Harbor Bay watershed community has become increasingly interested in water resource issues. Notable examples are the efforts by the lake associations, Leelanau Conservancy and Sleeping Bear Dunes National Lakeshore.

The quality of life derived from healthy ecosystems and the numerous forms of high quality outdoor recreation that they provide makes the Good Harbor Bay watershed a very desirable area for residents and visitors alike. In order to maintain the quality of this resource, local governments, concerned citizens, and numerous agencies all need to work together towards a common goal – protecting the entire watershed from poor management decisions to prevent any further water quality degradation. Watershed protection means conscientious stewardship of all water and land within the watershed. This watershed protection plan summarizes existing watershed conditions, identifies and prioritizes major watershed pollutants and proposes specific tasks, project partners and costs to reduce the impact and amount of pollution entering the system. The GHB Watershed Plan also outlines the implementation and evaluation strategies as well as resources for the local units of government including township planning and zoning boards.

Watershed Characteristics

The Good Harbor Bay watershed is located in Leelanau County, Michigan, approximately 25 miles from Traverse City, Michigan. The Good Harbor Bay watershed has a total drainage area of 29,020 acres or approximately 45.4 square miles and is about 8-11 miles in length, and intersects with the jurisdictions of five townships, and contains no villages. The forested uplands, kettle holes and wetlands in Kasson Township form the southern limit of the watershed. Most of the northern portion of the watershed is within the Sleeping Bear Dunes National Lakeshore. The entire watershed empties, into Lake Michigan. The upland areas of the watershed flow into Lime Creek and Lime Lake in Cleveland Township. Lime Lake flows through Shetland Creek to Little Traverse Lake. Little Traverse Lake flows into Shalda Creek. A number of tributary streams flow into Shalda Creek after traveling through a number of wetland areas before it empties into Lake Michigan's Good Harbor Bay. Cleveland Township provides the majority of ground and surface water flow in the center of the watershed.

The Good Harbor Bay watershed extends east along the Good Harbor Bay shoreline up to the Village of Leland in Leland Township. One inland lake and a number of small streams empty into Good Harbor Bay. This portion of the watershed includes the Lake Michigan waterfront residential area along Michigan Highway 22 (M-22). The western portion of the Good Harbor Bay watershed includes the rest of the Good Harbor Bay shoreline and into a portion of the Sleeping Bear Bay area of Glen Arbor Township. The large portion of the western area of the watershed is within the Sleeping Bear Dunes National Lakeshore and includes School Lake, Bass Lake and Shell Lake. The Lakeshore area includes wetlands, dune and swale habitat and forested areas.

Priority and Critical Areas

Although watershed management plans address the entire watershed, there are certain areas within the Good Harbor Bay watershed that warrant more extensive management or specific protection consideration. Areas that are most sensitive to impacts from pollutants are considered **Priority Areas.** Areas that require focused monitoring, restoration, remediation and/or rehabilitation are considered **Critical Areas**.

Priority Areas

Priority areas in the Good Harbor Bay watershed are defined as the geographic portions of the watershed that are most sensitive to impacts from pollutants and environmental stressors. The prescribed goals, objectives and tasks for these areas typically focus on preservation and protection. The priority areas for the Good Harbor Bay watershed are divided three different tiers of protection priorities that cover four geographic areas of the watershed (A-D). These tiers and areas are described below and shown in (Figure 27, page 143):

Priority Area Descriptions –

Area A- This area includes the kettle lakes and wetlands in the very upper part of the watershed in Kasson Township. This area contains several isolated kettle lakes with wetland complexes and significant amounts of forested land-use that maintains groundwater recharge for the watershed.

Area B- This area focuses on the wetlands and stream corridors feeding Lime Lake and includes the wetlands, riparian corridors, along Lime Creek.

Area C- This area focuses on the outlet of Lime Lake, Shetland Creek, between Lime Lake and Little Traverse Lake. This area also contains the majority of the coldwater fishery habitat for the watershed

Area D- This area includes the wetland complex on the western end of Little Traverse Lake (Shalda Creek), which flows through the Sleeping Bear Dunes National Lakeshore and eventually into Lake Michigan.

Tier 1:

- Habitat for or areas with threatened, endangered or species of special concern
- Existing public or protected land within the SBDNL, State, Conservancies and or Natural Areas, Preserves and Forest Reserves
- High Risk Erosion Areas

Tier 2:

- Surface water bodies (lakes/streams), shorelines, wetlands and land within 500’ of them.
- High Priority Land Protection areas (Top two tiers of Natural Lands Inventory and 500 foot Riparian Buffer)
- Ground water recharge areas

Tier 3:

- Steep Slopes
- Wildlife Corridors

Critical Areas

Critical Areas are specific sections of the watershed that are suspected to contribute a significant amount of pollutants or have been documented as impacted by stressors or pollutants and require restoration to achieve designated or desired uses. Critical Area designation indicates that implementation of identified tasks will be needed to achieve load reductions identified in the plan (Figure 27). The critical areas for the Good Harbor Bay Watershed include the following areas:

- Little Traverse Lake outlet system
- Lime Creek Road Crossings- Narlock and Cemetery Road
- Sugar Loaf Resort and area golf courses

Designated and Desired Uses

Identified designated uses and water quality standards for Michigan surface waters were used to assess the condition of the watershed. Michigan’s surface waters are protected by Water Quality Standards for specific designated uses (R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended). These standards and designated uses are designed to 1) protect the public's health and welfare, 2) to enhance and maintain the quality of water, and 3) to protect the state's natural resources. Protected designated uses as defined by Michigan's Department of Environmental Quality that are found in the Good Harbor Bay watershed include: agricultural, industrial water supply, navigation, warmwater and/or coldwater fishery, other indigenous aquatic life and wildlife, fish consumption, and partial and total body contact recreation.

None of the designated uses for the Good Harbor Bay watershed are impaired on a watershed wide scale (Table 20, Page 108). The steering committee and stakeholder input verified the need to establish specific desired uses particular to the Good Harbor Bay watershed that are not addressed by designated uses based on state water quality standards. Desired uses can be defined as the ways in which people use the watershed and how they would like to manage and protect the watershed to ensure the sustainability of those uses for future generations. Desired uses for the Good Harbor Bay watershed include recreational, aesthetic, human health, and ecosystem preservation.

Pollutants, Sources, and Causes

Designated and desired uses may be negatively affected by a number of different pollutants and environmental stressors in the Good Harbor Bay watershed. The term environmental stressor is used to describe factors that have a negative effect on the ecosystem or water quality, but are not accurately categorized as a specific pollutant. The Good Harbor Bay watershed has pollutant threats from loss of habitat, invasive species, excessive nutrients, sedimentation of stream channels, as well as failing septic systems near water bodies and improper waste disposal. Habitat loss, invasive species and excessive nutrient loading are the primary threat to the watershed, followed by hydrology and sediment. Other issues that threaten these designated and desired uses include toxic substances, pathogens, and thermal pollution. These specific threats were identified through scientific research reports, water quality monitoring reports, steering committee member input and contributions from watershed residents, general public input and scientific experts on the Good Harbor Bay watershed. Table 25 identifies known or suspected sources and causes of pollutants and environmental stressors that impact specific designated or desired uses.

Watershed Goals:

The following goals for the Good Harbor Bay watershed were developed by the Steering Committee to protect the designated and desired uses of the watershed:

1. Protect aquatic and terrestrial ecosystems.
2. Protect the quality and quantity of water resources.
3. Preserve high quality of recreational opportunities.
4. Ensure that all property owners, visitors, users and other stakeholders understand stewardship and are able to support and promote watershed protection activities.
5. Protect the health and safety of watershed users, residents and stakeholders.
6. Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected.

The goals are recommendations for implementation efforts within the watershed. Each goal generally has multiple objectives that outline specific elements required to meet the goal. Tasks are then assigned to address the individual goals and multiple objectives. The detailed task implementation chart describes the task, provides interim milestones, approximates projected costs and assigns a plausible timeline for completion. The implementation tasks in Chapter 8 are designed to address individual watershed objectives under each main goal. Some of the tasks are designed to address multiple objectives under one treatment. And many of the tasks are grant or dependent on funding availability.

Pollutant Load Reductions

To help maintain the high water quality resources of the Good Harbor Bay watershed it is important to address known sources of pollution while at the same time preventing increases in pollutant loading overtime from emerging or currently unknown pollutant sources. Protecting Priority Areas identified in the GHBWPP with voluntary conservation easements is an excellent strategy to meet this objective. The Leelanau Conservancy is the local land conservancy using these strategies to protect high quality land in the Good Harbor Bay watershed, in addition to the rest of Leelanau County.

Land conservation BMPs are excellent ways to preserve water quality. When dealing with pollutant reduction from these specific types of BMPs the idea is to estimate the amount of pollution prevented from entering the watershed by keeping the land in its natural state. The load reduction is essentially the difference between the loading from the current land use and the loading from a more developed land use.

Permanent Conservation Easement Pollutant Load Reduction (lb/yr)

The total pollutant load reduction from a permanent conservation easement is determined by subtracting the total pollutant loading coefficient for the more developed land use, such as low density residential, from the total pollutant loading coefficient for a more natural land use, such as wetland or forest.

Table 30, page 161 contains annual pollutant loading coefficients for various land uses found in the Good Harbor Bay watershed as determined by measured total phosphorus concentrations and their respective nitrogen and sediment ratios. Subtracting annual pollutant loads for forested land uses in Table 31 from the annual pollutant loads for low density residential (LDR) and then multiplying by the conservation easement acreage yields an estimation of the reduction in annual pollutant load resulting from a permanent conservation easement implementation in Priority Areas.

(Low Density Residential lbs/ac/yr – Forested lbs/ac/yr) x Conservation Easement acres = Load reduction from permanent conservation easement

The watershed plan goal is to permanently protect 2500 acres of land within identified Priority Areas throughout the watershed by 2024 (See Land Protection and Management Goals in Section 5.2). Successful implementation of permanent voluntary conservation easements over 2500 acres will prevent 168,750 tons of sediment, 4500 lbs N, and 602.6 lbs P from entering the Good Harbor Bay watershed each year (Table 31, page 162).

Information and Education Strategy

Chapter 9 outlines an Information and Education Strategy that addresses the communication necessary for implementing the watershed protection plan. These outreach efforts are important because developing and carrying out a vision for stewardship of the Good Harbor Bay watershed will require the public and community leaders to become knowledgeable about the issues and solutions, engaged and active in implementing solutions and committed to both individual and societal behavior changes necessary.

Evaluation Procedures

An evaluation strategy will be utilized to measure progress during the Good Harbor Bay Watershed Protection Plan's implementation and to determine whether or not water quality is improving. The timeline for the evaluation is approximately every 5 years, with ongoing evaluation efforts completed as necessary. The main purpose of the evaluation strategy is to measure how well the stakeholders are doing at actually *implementing* the watershed management plan and assesses if project milestones are being met. Measuring accurate pollutant load reductions is the most essential element of the evaluation strategy since it will provide objective, quantified results. The evaluation strategy will also focus on public education of watershed issues and will monitor success of the Information and Education Strategy by looking at public perception of watershed issues over time. The Good Harbor Bay Watershed steering committee has a goal to meet yearly to go over the watershed plan and review the goals, task, outreach and education and accomplishments.

CHAPTER 2: GOOD HARBOR BAY WATERSHED DESCRIPTION

2.1 LOCATION AND SIZE

The Good Harbor Bay watershed has a total drainage area of 29,020 acres, or approximately 45.4 square miles (Figure 1). The watershed extends to 11 miles in length. The watershed intersects with the jurisdictions of five townships, and contains no municipalities. The forested uplands, kettle holes and wetlands in Kasson Township form the southern limit of the watershed. Most of the northern portion of the watershed is within the Sleeping Bear Dunes National Lakeshore. The entire watershed outfalls or empties into Lake Michigan. The upland areas of the watershed flow into Lime Creek and Lime Lake in Cleveland Township. Lime Lake flows through Shetland Creek to Little Traverse Lake. Little Traverse Lake flows into Shalda Creek. A number of tributary stream flow into Shalda Creek after traveling through a number of wetland areas before it outfalls into Lake Michigan's Good Harbor Bay. Cleveland Township provides the majority of ground and surface water flow in the center of the watershed.

The highest elevations of the watershed in upland area (Kasson Township) are about 1,000 feet (NAVD88). The average daily elevation of Lake Michigan is 579 feet, which mean a total fall of the land through the watershed of 420 feet. The majority of upland soils in the watershed are loamy sandy soils.

Lime Lake is an oval shaped morainal lake 1.6 miles long, along its north-south axis, and 0.8 miles wide, covering 670 acres. Its bottom is a mixture of marl and sand. In the northeast corner the bottom is covered with slabs and edgings from a former sawmill. The lake is 67 feet deep at its deepest point just west of the center of the lake. There is also a shallow spot near the center which some residents remember as being an island in the 1930's (Steinburg et al. 1994).

Little Traverse Lake is a crescent shaped lake, 2.1 miles long and 0.7 miles wide at its widest point, covering an area of 640 acres. It is 54 feet deep at its deepest point northwest of the center of the lake. The bottom is primarily a mixture of marls, silts and sands with marls on the south side, silts and sand on the north side, and an area of gravel bottom at the eastern end (Steinburg et al. 1994).

Neither lake has a truly independent watershed, but rather, the lakes are interconnected. Due to the nature of the soils both surrounding the lakes and in the watershed as a whole, there is also extensive groundwater movement throughout (Steinburg et al. 1994). These soils also influence the way in which home development or other land uses can be accomplished around the lakes, while still maintaining water quality. Through sandy soils, groundwater may travel as much as 15 meters per day (Steinburg et al. 1994).

The average water level in Lime Lake is 617 feet (188 m) and the mean water level for Little Traverse Lake is 594 feet (181 m). In general, Lime Lake is 23 feet above Little Traverse Lake. Little Traverse Lake is approximately 14 feet above than the mean water level of Lake Michigan (Steinburg et al. 1994).

The Good Harbor Bay watershed extends east along the Good Harbor Bay shoreline up to the Village of Leland in Leland Township. One inland lake and a number of small streams empty into Good Harbor Bay. This portion of the watershed includes the Lake Michigan waterfront residential area along Michigan Highway 22 (M-22). The western portion of the Good Harbor Bay watershed include the rest of the Good Harbor Bay shoreline and into a portion

Figure 1: Good Harbor Bay Watershed – Base Map

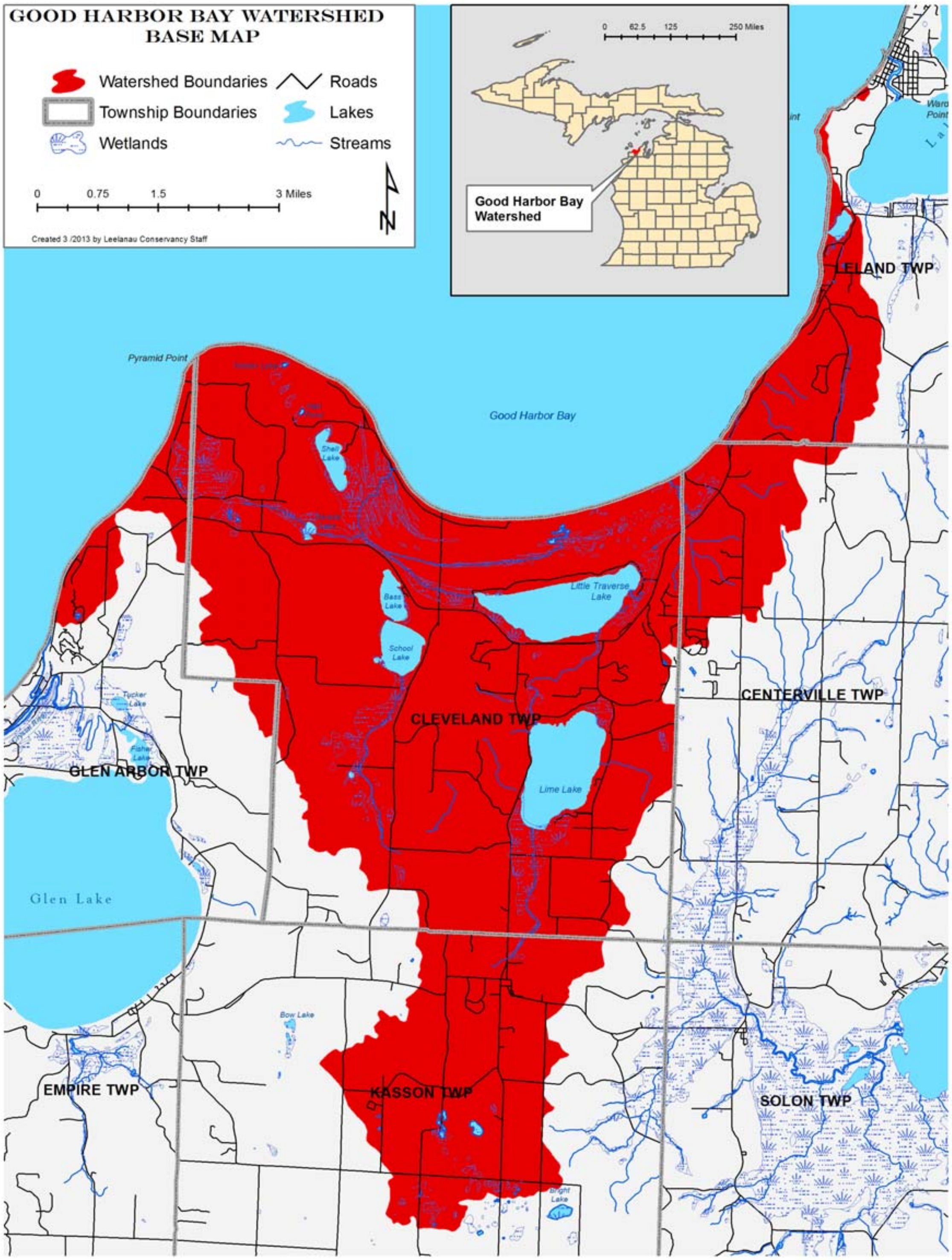


Figure 2: Good Harbor Bay Watershed – Aerial Photo Map

2.2 HYDROLOGY AND GROUNDWATER RECHARGE

There are many surface water bodies in the Good Harbor Bay watershed including numerous streams and lakes including Lime Lake, Little Traverse Lake, Shell Lake, School Lake and Bass Lake. The hydrologic balances for the Lime and Little Traverse Lakes were computed by Bill Cutler of the Leelanau Conservancy in November 1993 and are summarized below by Steinburg et al 1994.

Lime Lake

Lime Lake is a 670-acre lake with a maximum depth of 67 feet (Table 1), and extensive shoal areas with depths less than 15 feet (Seites 2011). The substrate in Lime Lake is predominately sand and marl, with some areas of cobble and gravel present. Vegetation in Lime Lake is sparse, though there is some emergent vegetation near the shoreline and some small submerged weed beds in water from 5 to 20 feet deep (Seites 2011). Lime Lake is fed by several hillside seeps, springs, and small creeks, with the largest being Lime Creek which flows in at the southern end of the lake. Shetland Creek flows out of the north end of Lime Lake and into Little Traverse Lake, and from there Shalda Creek flows out of Little Traverse Lake and into Good Harbor Bay on Lake Michigan (Seites 2011).

Lime Lake receives 47% (7.0 cfs) of its water supply from subsurface groundwater discharge, another 33% (4.9 cfs) from surface flow, and the remaining 20 % (3.0 cfs) from precipitation (Steinburg et al. 1994) (Table 2). Additionally, a good portion of the measured surface flow values include groundwater seeps, which flow over the land a short distance before reaching the lake. Groundwater is an extremely important factor in the hydrological budget of Lime Lake. Therefore it is essential that groundwater is replenished or “recharged”. This underscores the importance of protecting upland areas from impervious surfaces or other development that can inhibit the percolation of precipitation through the soil into the groundwater and decrease groundwater recharge. Areas that have a low slope gradient combined with permeable soils in general have a higher potential for groundwater recharge, especially when adjacent to high slope gradient uplands (Steinburg et al 1994).

Table 1: Parameters Lime and Little Traverse Lakes

Parameters	Lime Lake	Little Traverse Lake
Maximum length (feet)	8,448	11,088
Maximum Breadth (feet)	4,224	3,686
Surface Area (acres)	670	640
Volume (Cubic feet)	521,000,000	267,000,000
Maximum Depth (feet)	67	54
Mean Depth (feet)	17.8	9.6
Turnover Time (years)	1.1	0.4
Shoreline (feet)	22,992	27,026
Shoreline Development	1.2	1.44

(Source: Steinburg et al 1994)

Table 2: Lime Lake Water Balance

Lime Lake Water	Rate of Flow (cubic feet per second)	Percent of Total
Streams In:	4.9 cfs	33%
Precipitation	3.0 cfs	20%
Ground Water In:	7.0 cfs	47%
Total In:	14.9 cfs	100%

Streams Out:	11.8 cfs	79%
Evaporation Out:	3.0 cfs	20%
Groundwater Out	0.1 cfs	1%
Total Out:	14.9 cfs	100%

(Source: Steinburg et al 1994)

Lime Creek, Shalda Creek and Shetland Creek are the main stream systems in the Good Harbor Bay watershed. The primary tributary flowing into Lime Lake is Lime Creek, originating near Maple City and entering through a wetland area at the southern end of the lake. There are several other small ground water tributaries along the west side of Lime Lake, one just south of the public access point and one midway up the west side (Steinburg et al. 1994). There are also several springs feeding the lake in the southwestern quadrant. The springs create cold spots and sometimes the up welling water causes a noticeable disturbance at the lake surface (Steinburg et al. 1994). Lime Lake is primarily groundwater fed, [with several small stream tributaries] from the east and west shores, which are surrounded by high hills. Weed beds are thickest in the southern end, possibly due to the influx of nutrients from the ground water, springs and Lime Creek (Steinburg et al. 1994). The primary discharge from Lime Lake is through Shetland Creek which drains the lake from the northwest comer and then flows north and east to Little Traverse Lake. The water level in Lime Lake is maintained by a small rock pile at the entrance to Shetland Creek (Steinburg et al. 1994). A summary of the history and status of the rock pile is described below this section.

Approximately 50-60% of the shoreline of Lime Lake is developed with homes and cottages, and the surrounding land is predominately forested and residential. Lowland swamps dominated by cedar, hemlock, and birch trees surround the lake, while rolling hillsides with upland hardwoods and conifers round out the nearby landscape (Seites 2011). The northeastern corner of the lake has some slab wood on the bottom, remnant from the Lime Lake Lumber Company mill that was constructed around 1880 (NPS 2011). Timber was harvested from the land surrounding Lime and Little Traverse Lakes, cut at the mill, and then hauled down a 3-mile plank road to Good Harbor Bay for shipping (NPS 2011).

Rock Pile History and status (Submitted by Mark Fisher, Dean Manikas- Lime Lake Association)

Annually, people express concerns regarding the lake level, either being too high or too low. Here is a summary of the history of the dam located at the north end of the lake:

The rock pile on the north shore of Lime Lake, at the mouth of Shetland Creek, has roots going back to the early 1970’s. In a Lime Lake Association newsletter from August 1973, it stated the lake level that summer was 10” lower than past years because someone removed all the natural obstructions from the mouth area of Shetland Creek. It also stated during the past several falls, salmon spawning had eroded a natural clay/marl creek bottom that was at the mouth area.

In October 1975 the Lime Lake Association (LLA) made application with the Michigan Department of Natural Resources (MDNR) to construct a temporary weir across the mouth of the Shetland Creek. This application was later withdrawn.

The lake level continued to be problematic over the years. In the early 1980's some lake residents put rocks in a large hole the salmon created just north of the mouth of the creek. A small rock pile was added at the mouth. During the 80's and early 90's there were differences in opinion about the ideal lake level. Unknown individuals would remove or add rocks trying to adjust the lake level without taking into consideration heavy rains, periods of drought, and the effects on the lake's general health.

The tug of war continued and in the summer of 1993, one resident on the lake filed a complaint with the MDNR. In August of 1993 the DNR cited the property owner of the land adjacent to the rock pile for violations of the Inland Lake and Streams Act. The citation specified the unauthorized activity as the individual, "Placed fieldstone across the outlet of Lime Lake (Shetland Creek)." Following the citation a series of misunderstandings developed between the DNR staff and residents of the lake. As a result, one lake owner took it upon himself to remove all the rocks from the mouth of the creek.

The removal of the rocks resulted in an order of restoration from DNR representative, Stuart Kogge, to restore the rocks to the original 1992 elevation. Mr. Kogge also recommended that the Lime Lake Association file an application to the DNR for a permit to allow the lake association to restore the dam in order to stabilize the lake level and protect the creek. With Mr. Kogge's help designing the rock pile, the lake association submitted an application for the rock pile. The DNR approved the application and issued the permit #94-6-112.

On April 8, 1994 a rock pile was constructed at the mouth of Shetland Creek according to DEQ permit #94-6-112. Over the following two years, the rock level was adjusted until an acceptable lake level was reached. The lake level will fluctuate depending on amounts of rain and evaporation. In any given year, over time, the lake level will return to the correct level.

Since the permit was granted, the Lime Lake Association Board has annually monitored the rock pile height. The lake level is cyclical be nature, highest after spring thaw and heavy rains, and lowest in late August after a summer of evaporation and low precipitation. Data on evaporation rates is provided by the MSU Research Station in Bingham Township and monitored by the Board. This data shows a direct correlation between the level of the lake and the amount of rainfall and evaporation over a given period of time.

Low lake levels may cause inconvenience for residents on the north end (e.g., trouble with boat mooring, pooling water behind sandbars) but low lake levels do no damage to the lake shoreline or ecology. High levels (as currently experienced after a very wet fall and last spring after the heavy snows of last winter) impact water quality through excessive runoff and soil deposits from shoreline erosion. According to the shoreline survey from the summer of 2013, as part of the Watershed planning work, 74% of Lime Lake shoreline has evidence of minor to severe erosion. Erosion does add excessive sediment to the lake's water, affecting its ecology. Additionally, excessively high water levels may foul the lake further by compromising existing septic systems. (Neighbors to the north on Little Traverse Lake have been experiencing all of these problems as noted at township meetings and in the Enterprise). Low levels may be inconvenient but high levels can be costly to property owners and destructive to the lake's ecology.

Left in its natural state, the water level would have greater lows. As some "old timers" report, years before there were houses on the north shore, people would drive their cars onto the north end sand bars for a good washing in the late summer.

The varying lake level is a natural process, mitigated by a regulated rock pile to preserve the quality of our water. The Lime Lake Association Board is the only entity authorized to adjust the rock pile, by DNR order.

Little Traverse Lake

Little Traverse Lake is 640 acres and 267,000,000 cubic feet in volume (Table 1, page 18). It receives 16% (3.4 cfs) of its water supply from subsurface groundwater discharge, another 71% (15.3 cfs) from surface flow, and the remaining 13% (2.8 cfs) from precipitation (Table 3) (Steinburg et al. 1994). Little Traverse is primarily fed by surface water (71 %) (Steinburg et al. 1994). The primary tributary into Little Traverse Lake is Shetland Creek which empties into the lake at its South Eastern edge. Numerous small ground water flows [and small tributaries] enter the lake off the hills to the east and southwest with some minor groundwater flow from the south (Steinburg et al. 1994). The primary discharge is via Shalda Creek which exits the lake at the western ends of Little Traverse Lake and flows to Lake Michigan.

Lime Lake is predominantly fed by ground water; however, Little Traverse Lake receives most of its water by surface water recharge and has higher total flow. The nominal turnover for the lakes is the time required to completely change the water in the lake. (Steinburg et al 1994).

Table 3: Little Traverse Lake Water Balance

Little Traverse Lake	Rate of Flow (cubic feet per second)	Percent of Total
Streams In:	15.3 cfs	71%
Precipitation	2.8 cfs	13%
Ground Water In:	3.4 cfs	16%
Total In:	21.5 cfs	100%

Streams Out:	18.4 cfs	86%
Evaporation Out:	2.8 cfs	13%
Groundwater Out	0.3 cfs	1%
Total Out:	21.5 cfs	100%

(Source: Steinburg et al 1994)

The streams are not the only outlets in this watershed. Just as the lakes have ground water recharge they also discharge via ground water flow (Steinburg et al. 1994). A shallow unconfined aquifer of sands and some gravel extends from the surface to depths of 30 to 70 feet. According to Steinburg et al (1994) the upper aquifer is in direct hydraulic connection with Lime Lake, Little Traverse Lake and Lake Michigan, and is recharged by precipitation within the basin. immediately below the upper, unconfined aquifer is a silt and clay aquitard that is present throughout the lake basin. The aquitard is composed of silts, silt and sandy clays, and pure clays. It is estimated to range from 10 to 80 feet in thickness, and provides flow separation between the upper unconfined aquifer and a lower, confined aquifer system (Steinburg et al. 1994). Beneath the aquitard is the confined aquifer system, which probably has little or no flow interaction with Lime or Little Traverse lakes or surface water streams. A north-south cross section shows the upper surface of the lower confined aquifer rising with the land slope to the south. The recharge area for the deeper aquifer is probably the Kasson Moraine area, an elevated plateau, with thick sand and gravel deposits just south of Maple City (Steinburg et al. 1994).

The deeper aquifer can be excluded in determining the hydrologic budget for the watershed, as only ground water recharge and flow within the upper, unconfined aquifer is in communication with the lakes of the watershed (Steinburg et al. 1994). Most residential water wells in the area draw from the lower confined aquifer. Along the north shore of Lime Lake and along portions of Little Traverse Lake, some shallow wells only reach into the upper, unconfined aquifer and are therefore vulnerable to ground water contamination (Steinburg et al. 1994).

Shalda Creek is the main outflow of water from the watershed into Lake Michigan. Originally Little Traverse's outlet into Shalda Creek was 27 feet wide (Len Allgaier). In the fifties the road was paved and the logger’s wooden bridge spanning it was replaced, closing the outlet down to a 42 inch diameter culvert reducing the outlet area significantly. Today, the width of Shalda Creek is 27 feet (personal communication with Len Allgaier, measured by Brett Fessel with the Grand Traverse Band of Ottawa and Chippewa Indians (GTB). Direct overland runoff to the lake is insignificant, as rainwater quickly infiltrates soils and becomes integrated with the groundwater and surface spring inputs to the lake. Thus, land use practices in the entire watershed have a much greater potential to impact water quality than is the case for many other watersheds in the State with less permeable soils.

In 2011 and continuing today (2015) Little Traverse Lake is experiencing high water levels, specifically on the north side. Concerns were raised over the culvert on the west end of the lake. Local residents along with various organizations including the Little Traverse Lake

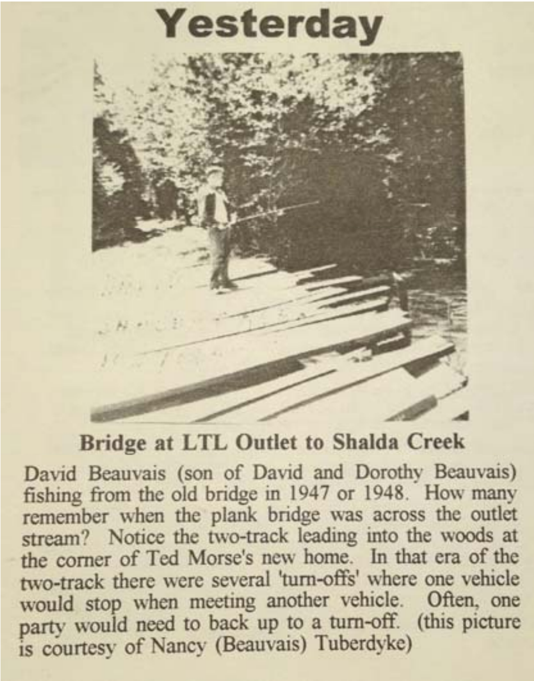
Property Owners Association, Cleveland Township, Little Traverse Conservationists, the Michigan Department of Environmental Quality, Sleeping Bear Dunes National Lake Shore (SBDNL), the Leelanau County Road Commission and the Grand Traverse Band of Ottawa and Chippewa Indians, have been working together to come up with a reasonable solution. The SBDNL hydrologist study was commissioned in response to this concern in 2011 to determine the main cause of the high lake levels. The results of this report are summarized in Chapter 4-Critical Areas (page 146). For more details on this study see the appendices (B-D).

Approximately 1/2 mile downstream of the Traverse Lake Road culvert, Bohemian Road or County Road 669, is similarly paved across Shalda Creek using a single culvert, which is currently submerged between 1-2 feet at its discharge end (Source, Len Allgaier). The elevation drop between the mean level of Little Traverse Lake and the mean level of Lake Michigan is 18 feet or 6 feet of drop per mile.

Below and on the next few pages are a few current and historical photos of the Lime Lake outlet to Little Traverse Lake (Shalda Creek) and Little Traverse Lake shoreline as well as the culvert on the west end of Little Traverse Lake and the culvert on County Road 669.

Figure 3: Shalda Creek outlet to Little Traverse Lake

Figure 4: Original Bridge across 27 foot wide Shalda Creek


Yesterday

Bridge at LTL Outlet to Shalda Creek

David Beauvais (son of David and Dorothy Beauvais) fishing from the old bridge in 1947 or 1948. How many remember when the plank bridge was across the outlet stream? Notice the two-track leading into the woods at the corner of Ted Morse's new home. In that era of the two-track there were several 'turn-offs' where one vehicle would stop when meeting another vehicle. Often, one party would need to back up to a turn-off. (this picture is courtesy of Nancy (Beauvais) Tuberdyke)

Figure 5: Original (pre culvert(s) beach protecting shore from erosion

Figure 6: Fall 2014 photo of Culvert on West end of Little Traverse Lake and Shalda Creek

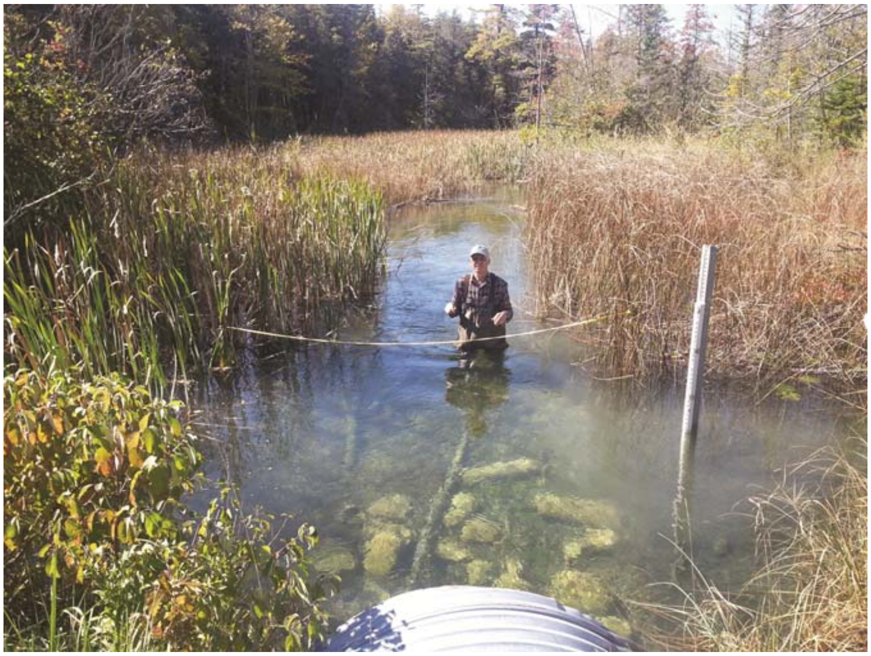


Figure 7: August 2014 photo of Culvert on County Road 669 (Shalda Creek Crossing), looking upstream towards Little Traverse Lake

Figure 8: August 2014 photo of Culvert on County Road 669 (Shalda Creek Crossing), looking downstream

Figure 9: August 2014 photo of Culvert -County Road 669 (Shalda Creek Crossing), looking upstream

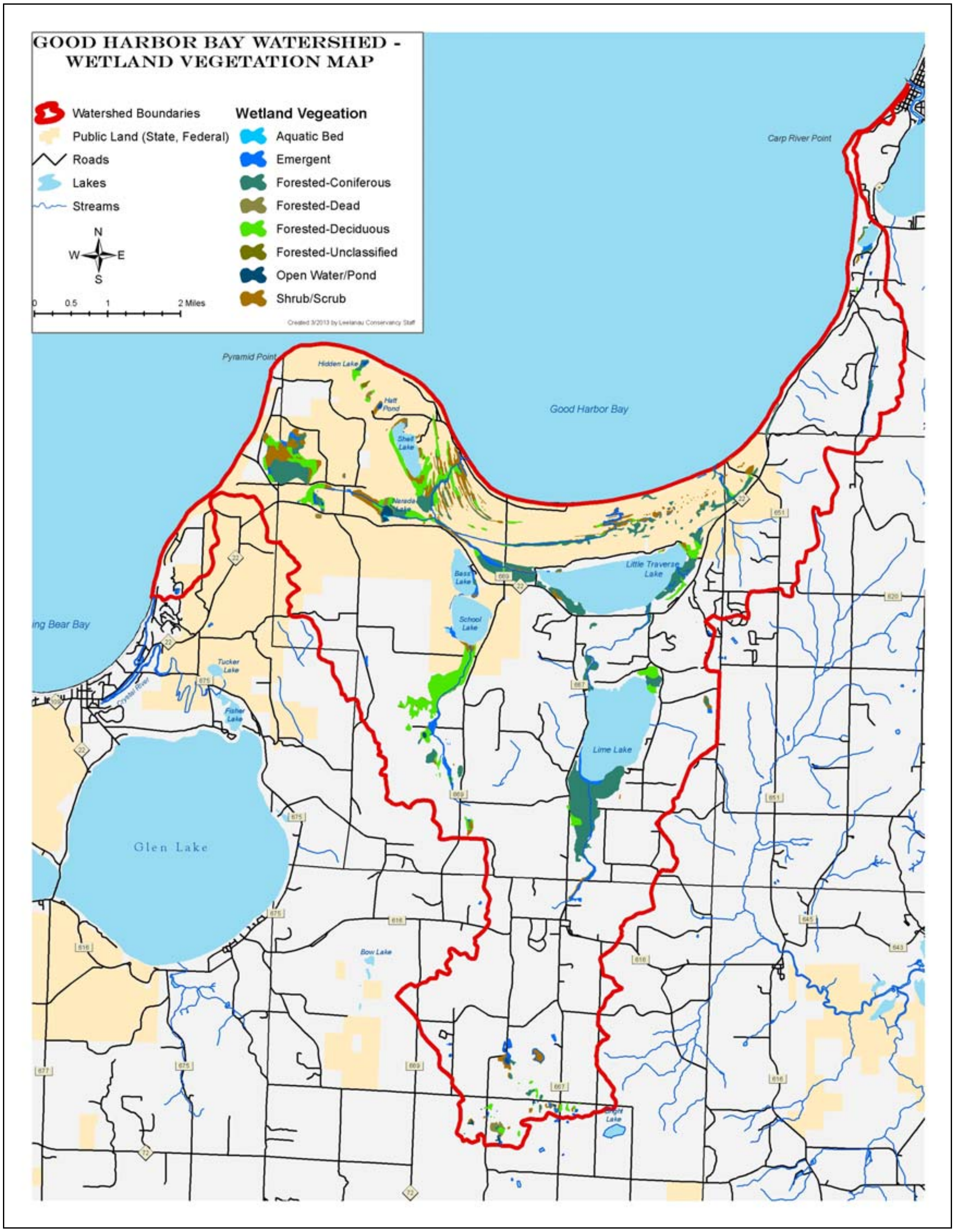
Figure 10: 2014 photo of Culvert -County Road 669 (Shalda Creek Crossing), looking upstream

Wetlands

Wetlands comprise a vital link in the preservation of high water quality in the Good Harbor Bay Watershed. The watershed buffers between upland habitats and surface water bodies. These relatively narrow bands of wetlands along stream channels and at the base of infiltration basins protect groundwater springs and small stream channels by filtering out sediment and extracting nutrients from surface run-off before it reaches the stream channel and ultimately the lake (Figure 11).

Wetland soils and vegetation are also very important natural defenses against flooding by absorbing surface runoff and storm water and releasing it slowly into streams and groundwater. In addition to the water quality benefits of intact wetlands, the Good Harbor Bay Watershed contains critical habitat for several threatened and endangered plants and animal populations (see section 2-7). The diversity of micro-habitats found within wetlands allows them to host more types of plants and animals than any other biological community.

Figure 11: Composite Wetlands of the Watershed



In order to perpetuate the enjoyment and use of the Good Harbor Bay watershed it is essential to protect sensitive wetland areas. Recreational interests such as birding, fishing, hunting and wildlife viewing are all enhanced by the healthy and intact wetland areas adjacent to Lime and Little Traverse Lake. Development in and adjacent to wetland areas threatens to degrade the aquatic resources, which are the heart of this watershed's desirability and attractiveness.

Currently the Federal Army Corps of Engineers and the State of Michigan regulate wetlands that are 5 acres or greater or connected to the Great Lakes. Additionally, the State of Michigan also protects wetlands under state law PA 451 of 1994 if they meet any of the following conditions:

- Located within 1,000 feet of one of the Great Lakes or Lake St. Clair.
- Connected to an inland lake, pond, river, or stream.
- Located within 500 feet of an inland lake, pond, river or stream.
- Not connected to one of the Great Lakes or Lake St. Clair, or an inland lake, pond, stream, or river, and less than 5 acres in size, but the DEQ has determined that these wetlands are essential to the preservation of the state's natural resources and has notified the property owner.

A study to identify potential wetland areas, combining different sources of wetland information using Geographic Information Systems (GIS) software, was completed in early 2000 by the Northwest Michigan Council of Governments (NWMCOG) through the Special Wetland Area Management Project (SWAMP), coordinated by the Michigan Department of Environmental Quality (DEQ). The dataset is a composite of three sources of wetland information:

1. The National Wetland Inventory (NWI), conducted by the U.S. Fish and Wildlife Service.
2. The U.S. Soil Conservation Service Soil Survey, which identifies hydria soils and soils with hydric inclusions and/or components.
3. The Michigan Resource Inventory System (MIRIS) Land Cover interpretation from aerial photographs.

Section 5.3, Priority and Critical Areas, describes the most important wetland areas in the watershed for maintaining water quality and sustaining rare plants, animals and habitats. The largest wetland areas within the watershed are found south of Lime Lake along Lime Creek

(Figure 6). Lime Creek and Shalda Creek are the largest surface water tributaries to Lime and Little Traverse Lake, meandering through an ecologically rich wetland that provides a diverse habitat for many plant and animal species, some threatened or endangered. The undisturbed wetland located there is critical to the creek's biological diversity and its preservation is a high priority in the watershed.

Looking at the data in Table 4, the total wetland area in the Good Harbor Bay watershed is approximately 4200 acres or 14.5 % of the total watershed area, compared to only 4.4 % using only the land use data (Tables 8 and 9, Figure 15, pages 51-53). These data provide a useful tool in determining the location of potential wetland areas, but because the data has not been field checked, it does not guarantee the presence or absence of a wetland. It should be used only for general planning purposes.

Table 4: Composite Wetland Areas in the Good Harbor Bay Watershed

Type of Wetland	Acres	% of Watershed
Aquatic Bed	1.4	0.005
Emergent	152.3	0.5
Forested:	897.2	3.1
Conifer	27.2	0.09
Dead	566.5	1.9
Deciduous	9.0	0.03
Unclassified	40.8	0.14
Open Water	406.9	1.4
Shrub Scrub	2101.3	7.2
Total	4,202.5	14.5

**The wetland descriptor in the land use tables (Tables 8 and 9) do not contain all wetlands. Total wetlands are delineated in the table above, and cover 20% of the watershed. As an example of this difference, Table 6 represents cedar swamp areas as coniferous forest, as opposed to the 'forested-conifer' wetland description in the above table.*

2.3 GEOLOGY AND SOILS

(written by Jaime Leanderson)

Geology

The geology of the Good Harbor Bay watershed consists of sand, gravel and related deposits that overlie much older limestone and shale, found only at depths below about 400' to 500'. The surface deposits that host the aquifers, lakes, streams, etc, and the morphologies of the deposits are the result of glaciation during the continental Wisconsin Glacial stage. This stage began about 85,000 years ago and reached its peak about 21,000 years ago. However, the glacial deposits in the watershed were deposited during the last three glacial advances, the Port Huron Stadial (~13,300 to ~13,000 years ago), the Greatlakean Stadial (~>11,800 to ~11,500 years ago).

Continental glaciers form at times of global cooling when ice accumulates at high latitudes and moves south. During especially cold periods the advance of the leading margin was relatively rapid. During warmer periods, the leading edge would melt faster than the ice was advancing. The leading edge then retreated back to the north even though the glacier was still moving south.

The glaciers eroded the rocks they were moving over and transported the loose debris in the ice, which was then released when the ice melted. In the watershed area, the transport and deposition of this sediment was accomplished by three agents: ice, water and wind. Ice was the dominant transporting agent because it has a high viscosity that allowed it to transport particles up to boulder size, which are found in the gravels today. However, that same high viscosity prevented particles from sinking so there was no deposition directly from the ice.

Water and wind were the main transport and deposition agents once the ice melted. Because water has a higher viscosity than air, it can transport larger particles. The velocity of both determines the maximum size of the particles that could be transported by each agent. Fast-moving water transported boulder-sized particles, while slower moving water carried only sand and finer particles. Fluctuations in velocity led to the formation of alternating and discontinuous layers of sand and gravel. Very slow moving or stagnant water, e.g., in lakes, led and still leads to the deposition of clay. Wind is capable of transporting and depositing particles that are sand-sized and smaller. The distribution of clay, sand and gravel layers has a significant impact on the formation of aquifers and on the movement of subterranean water through them, which is difficult to predict due to complex geometry of the different layers of sediment.

During the Port Huron Stadial the ice margin was located south of Traverse City and extended down to the east of Manistee; the watershed was covered with ice at this time. Melting of the ice and transport of the sediment to the glacial margin formed the Port Huron Moraine. Either during the advance or retreat of the glacier wide areas of sediment (till) was deposited across most of Good Harbor Bay watershed and is exposed today in large patches both to the east and west of Little Traverse and Lime Lakes. Much of this till is consolidated as the result compaction by the weight of the overlying Greatlakean ice Stadial ice sheet that overrode the Port Huron till. The movement of the Greatlakean ice sculpted the Port Huron till into linear hills, called “drumlins”. Most of the drumlins have the shape of overturned canoes. However, Sugar Loaf has a steep northern end and a long tail that extends to the south. The orientation of the drumlins indicates the Greatlakean ice moved from the north-northeast to the south-southwest.

The margin of a continental glacier is lobate with lobes the width of a state or country down to the width of a township. One large lobe scoured out Lake Michigan. Melting of the ice underneath the glacier resulted in accumulation of bodies of water that were under tremendous pressure. Locally, this water would erupt from the front of the glacier in a massive flood. If there was semi-consolidated sediment under the ice, it was scoured out in linear tunnels and deposited in sheets of sediment in front of the glacier.

At the beginning of the Greatlakean Stadial it appears that glacial margin extended from south of Lake Leelanau northwest to the south end of the watershed where the swampy ground is located along County Rd. 667, 4 miles south of Maple City, and then west to the south of Glen Lake. Melting under the ice sheet, probably east of North Manitou Island, led to the flow of subterranean water south under what is now Good Harbor Bay into the Little Traverse-Lime Lake basin south to the ice margin. A minor arm of this tunnel formed the basin that is occupied by Bass and School Lakes. The water exited in floods, probably forming outwash gravel deposits, and then was covered by loose sediment that washed down and to the south from the top of the glacier. This sediment was deposited in a terminal moraine that marks the high ground at the south end of the watershed. The last advance of the ice sheet was confined to the tunnel valleys. Melting of this ice deposited till on the east side of Little Traverse and Lime Lakes forming the boundary between the Good Harbor Bay and Lake Leelanau watersheds, represented by the ridge between the villages of Maple City and Cedar.

The 55' deep circular depression on the northwest part of Little Traverse Lake may be a kettle formed by a block of ice that remained from this glacial tongue and melted in place..

Melting of the retreating Greatlakean ice created lakes that fluctuated in elevation in the Lake Michigan basin. This marked the beginning of a period of water and wind transport and deposition and of erosion that is still going on today. Two of these lakes had the greatest effect on the watershed. The first was the Main Algonquin Lake, around 11,000 years ago. Landforms related to the Lake range in elevation between about 630 to 650 feet. Likewise, Lake Nipissing produced near shore features ~5,000 years ago that are present at an elevation of about 605 feet.

Lake Algonquin lay at an elevation about 60 feet above present day Lake Michigan and eroded the Late Wisconsin till along the shoreline forming bluffs, which can still be seen today. Northeast of the intersection of M22 and Good Harbor Road it appears that the base of the lake Algonquin bench remains. West of Bass and School Lakes, the edge of the Algonquin bluffs run west to the south of M22 past the bend in the road at Kelderhouse Cemetery, and then over the present boundary between the Glen Lake and Good Harbor Bay watersheds. As is typical of this shoreline, the boundary is a straight or a smooth, arcuate landform. The high hills at Pyramid Point and north of the Leelanau School were islands at this time.

Lake Algonquin also formed two finger-like embayments that lay in the Little Traverse Lake-Lime Lake and Bass Lake-School Lake embayments that formed under the ice. The shoreline of Lake Algonquin in the Little Traverse Lake-Lime Lake embayment extended from Good Harbor Bay to about 1 ½ miles north of Maple City. In the Bass Lake-School Lake embayment it extended about 1 ½ miles south of School Lake.

Lake Nipissing locally eroded the Algonquin bench leaving flat benches in some locations. Parts of M22 appear to lie on a Nipissing bench between Little Traverse Lake and Duck Lake. Elsewhere, the Algonquin bench and shoreline remain but the bench was eroded back by Nipissing wave action. Dune building occurred during or immediately after the Nipissing phase, including on the bench between Little Traverse Lake and Duck Lake, the high dunes that extend from Good Harbor south to the east end of Little Traverse Lake and at Pyramid Point. At Bufka's farm on M22, the base of the hills that lie on and near M22 mark the base of the Algonquin bluffs. The farm sits on the Algonquin bench. Immediately behind the barn to the north, the land drops off about 6-8 feet, which marks the Nipissing bluff. A few 10's of yards further are the high dunes that formed after the drop in the level of Lake Nipissing.

The most notable features along and near the Lake Michigan shoreline formed in the past 3,750 years. Like Lake Algonquin, Lake Nipissing occupied the Little Traverse Lake-Lime Lake and Bass Lake-School Lake embayments, where marl has been deposited over much of the lake bottoms. During retreat of Lake Nipissing, the water level paused at an elevation of about 595 feet (Lake Algoma) between 3,000 and 3,750 years ago. This appears to be the time when the sandy ridge formed that separates Little Traverse and Lime Lakes today. Further retreat of Lake Nipissing left Little Traverse Lake isolated behind a series of gentle lake-bottom hills and small dunes about ½ mile from the Little Traverse Lake shore line. It was probably at this time that the high dunes at the east end of Little Traverse Lake formed. These dunes probably blocked drainage of the lake into Lake Nipissing resulting in the formation of Shalda Creek, which flowed initially to the west. The direction of Shalda Creek then alternated from west to east and back again numerous times as it migrated to the north forming distinct swales and dune/beach ridges that parallel the Lake Michigan shoreline. Shalda Creek extended from the dunes at the east end of Little Traverse Lake to northwest of Shell Lake, a distance of about 7 miles. The changes in the direction of the flow of Shalda Creek were the result of changes in the prevailing winds and associated longshore current in Lake Michigan. The long shore current deposited sand where the creek exits into Lake Michigan, blocking the up-current side. This forces the creek to migrate in the direction of the long shore current. When the current reverses direction, it closes off the creeks exit point and the water level rises upstream until it overflows one or more of the ridges and finds a new exit into the lake. It then migrates in the direction of the prevailing longshore current. This process has been repeated numerous times resulting in the modern topography. Today, the creek flows northwest and around most of the dune ridges and then cuts across several ridges down to the lake. Apparently, the latest blockage of the creek's exit backed the water level up in the old channels until the creek returned to its original northwest-trending channel that it occupied after the drop in the lake level. However, the creek is again being influenced by the long shore current coming running from the northwest to the southeast down the Good Harbor Bay shoreline. Immediately after the creek crosses Lake Michigan Rd., it swings to the east and is separated from Lake Michigan by a newly formed, narrow dune ridge as the creek's exit continues to migrate to the east. This will continue until the prevailing current reverses direction back to the west.

Erosion of the hills began as soon as the ice melted and resulting in the numerous valleys that incise the glacial features. These valleys provide vehicle access to the top of the glacial plains and to the drumlin hills, e.g., Schomberg, Good Harbor, Sugar Loaf Mtn. and Basch Roads. Sediment that washes down valleys such as these usually accumulate at the bottom in fanshaped deposits but because of the fluctuating lake levels, much of it has been washed away or was buried under later sediment. The topography of the tip of Pyramid Point suggests that some of the dune sand slid directly into Lake Michigan. On steep hillsides, the soil is still moving slowly downward (soil creep) as evidenced by trees that are bent down slope at their base.

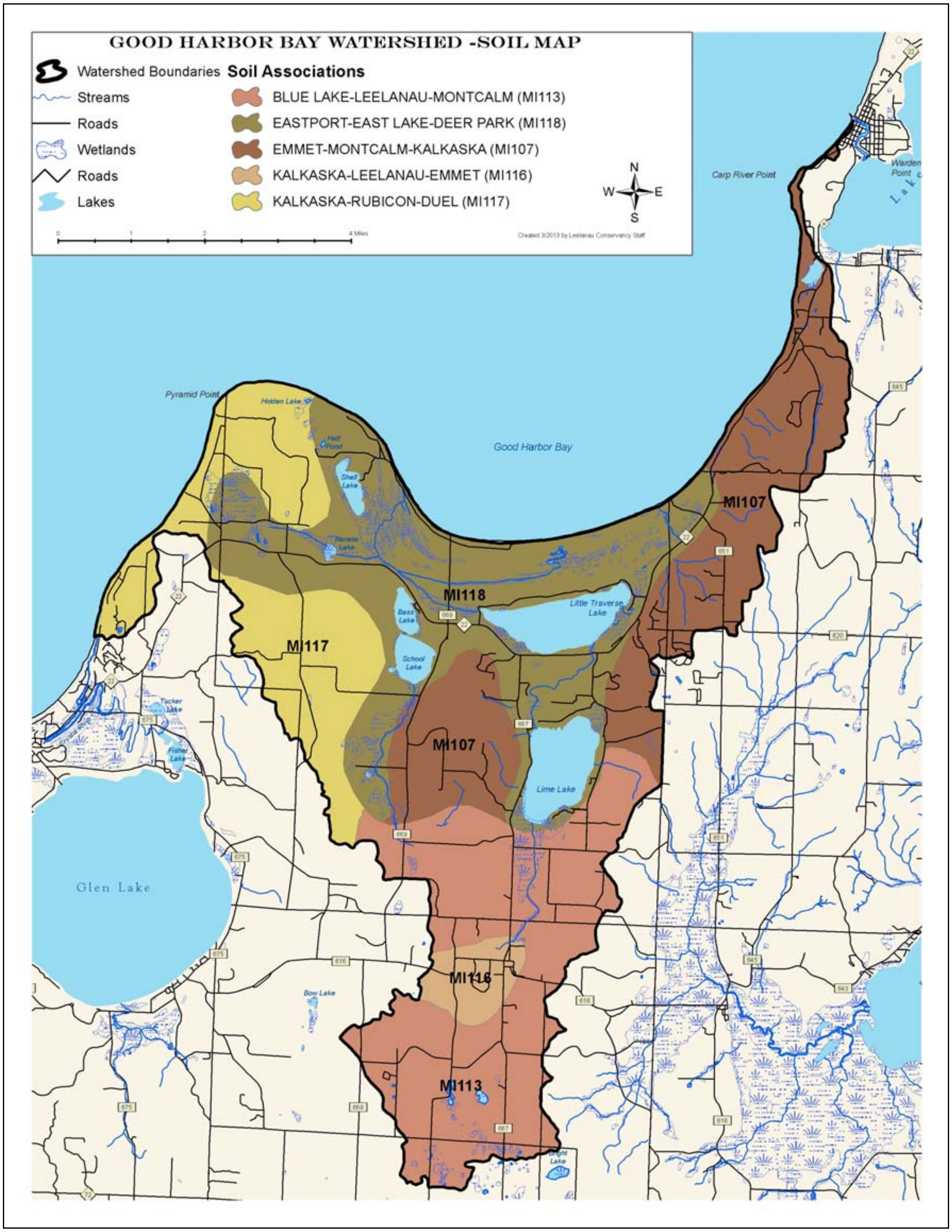
Soils and Topography

There are five main soil associations in the Good Harbor Bay watershed:

Eastport-East Lake-Deer Park association makes up the majority of the soil associations comprising 34% and the Blue Lake-Leelanau-Montcalm association comprises 25%. The Emmet-Montcalm-Kalkaska association comprises 22%, the Kalkaska-Rubicon-Duel association comprises 16%, and the Kalkaska-Leelanau-Emmet association, 3% (Figure 12).

The Blue Lake association is characterized by well-drained, nearly level to strongly sloping, gravelly, loamy and sandy soils on outwash plains. The Deer Park association is made up of sandy soils that are well drained and strongly sloping to very steep. Eastport associations are well to moderately well drained, nearly level to gently sloping, sandy soils. Nearly level to strongly sloping sandy soils on outwash plains characterize the Kalkaska-Leelanau association. In contrast, the Kalkaska-Rubicon association is found on moraines. Watershed valley floors, lakeshores and wetlands are typically composed of Lupton-Markey mucks or marl with a high pH.

Figure 12: Good Harbor Bay Watershed Soil Map



Soil Types and Origins in the Good Harbor Watershed

Soil is a natural blanket of layered, decomposed and unconsolidated rock fragments, organic material, water and air that overlies bedrock or unconsolidated material at the earth's surface (Kohnke and Franzmeier, 1995). The properties of soil depend on five factors that governed how they formed. Parent material and topography were the conditions that defined the setting when the formation of the soil began. In the Good Harbor Bay watershed the source material is glacial deposits (containing, in part, igneous, metamorphic and sedimentary rocks), water deposits and wind deposits (see the Geology Section). The glacial deposits consist of various layers of clay, silt, sand and gravel, much of which is high in calcium. The high calcium content explains the common occurrence of hard water in the watershed. The silt and sand deposits are particularly susceptible to wind erosion and often fail to develop well-developed soil horizons because of migration of the sand.

The topography at the end of the glacial periods (see Geology Section) defined the initial rates of erosion. Until plants took root and developed thin soils, wind and water were able to erode the hills producing many of the moderate-scale landforms present today. Once plants took hold and developed stable soil horizons, the rate of erosion decreased. Topography also plays an important role in the shape of the water table and of the rate of flow of subterranean water. The water table is highest under hills and lowest under low-lying areas. Flat landscapes often have water-logged soils and near stagnant subterranean water.

Further development of soil horizons relies on the three active factors: climate, organisms and time. The processes involved are physical, chemical and biological. The action of these processes results in a wide variety of soil types.

Soils are classified using a hierarchical system. Soils in the watershed belong almost entirely to the Spodosol Order marked by a spodic horizon of aluminum, organic matter and usually iron that forms on a sandy substrate under forest vegetation that is often dominated by conifers. Organic-rich Histosols may be present locally in the watershed in shallow lakes and in the wet lands around the margins of some lakes and creeks.

Some of the finer levels of the classification system are combined in the classification system shown on the detailed map. Particle size terms are a Family name and include: the smallest particles, which are clay minerals and silt that constitute 'loam'; sand; and gravel, which has a wide range of particle sizes from the smallest up to boulders. The use of the term as an adjective indicates the relative amounts of a particular particle size component. For example, ‘loamy sand’ indicates minor amounts of clay and/or silt in sand while ‘sandy loam’ indicates clay and/or silt with minor sand. It is important to note that none of the units in the watershed contain more than about 20% clay or 40% silt at the surface, although it is known that there are clay layers at depth. The highest silt content in the watershed is in ‘loam’, e.g., the Hettinger-Tonkey loams. The distribution and amount of clay and silt is important because they can reduce the porosity and permeability of the soil and, therefore, the movement of water into and through it. The percent slope is also given in the table, which gives a good indicator of the rate of runoff of rain and snow melt and, therefore, of areas of potential local flooding. The location names preceding the different soil types indicate the area where that type of soil was first described.

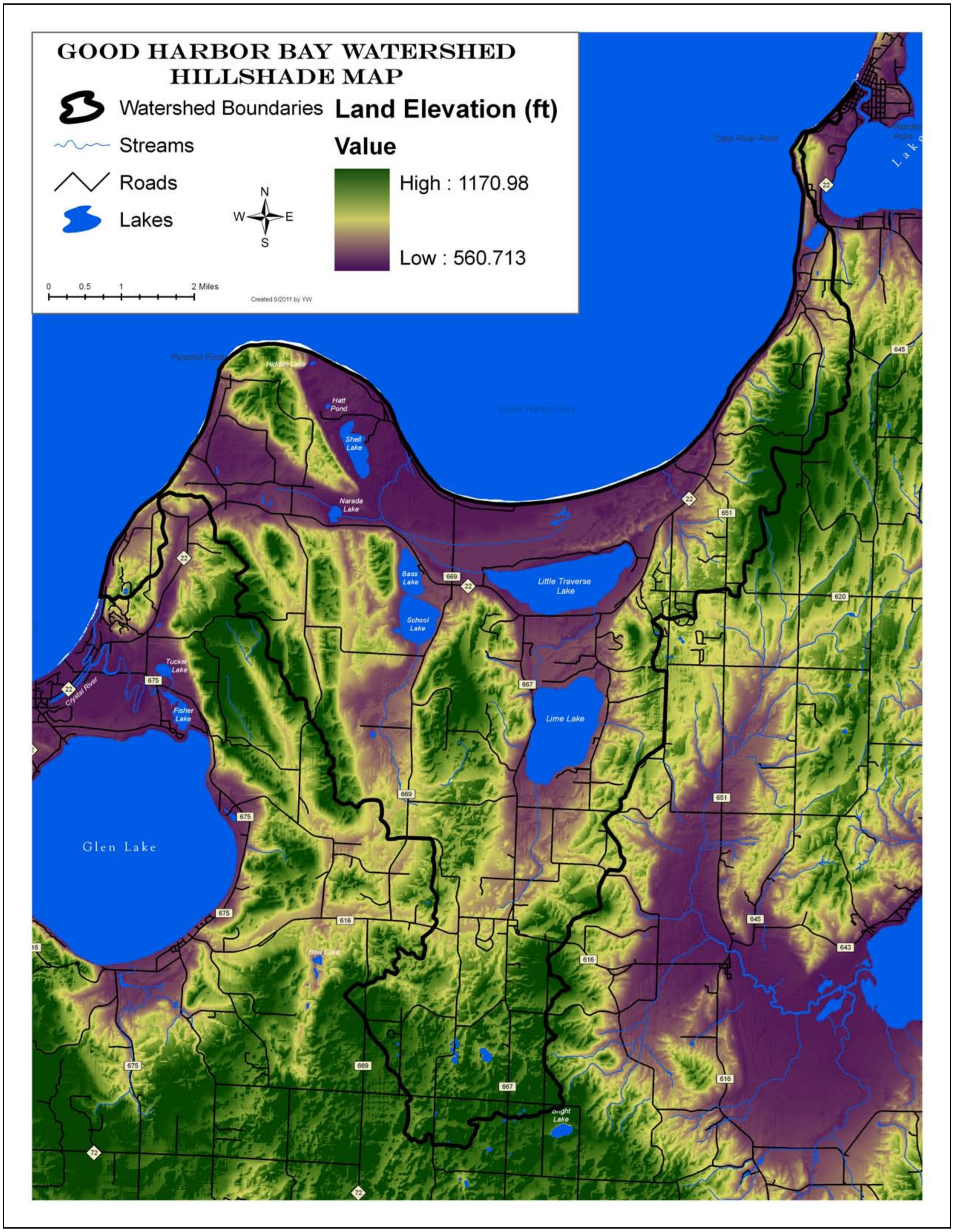
It is clear that there is a wide variety of soil types across the watershed (cf. Soil Summary Table and the detailed soil map). Loamy sands (Ll and Ea soils) form large patches from Pyramid Point and around to the south and west of M22. Gravely sandy loams (Eo and Km), sandy loams (Es) and sand (Ka soils) are also locally abundant in the same area. This overall area corresponds to the glacial tills and deposits in the watershed (see Geology section).

Mostly north of M22, Little Traverse Lake and Shell Lake are sands (D soils) and muck (R soils). These formed during retreat of the last glacial lake and the repeated eastward and westward migrations of Shalda Creek (see the Geology section). The sands are in part dune deposits, which are locally eroded, and marsh and swamp deposits.

The soil association map shows a good correlation with the parent material and eliminates much of the detail associated with the topography on the detailed soil map. Association M107 agrees quite well with the till located between Bass and School Lakes and Little Traverse and Lime Lakes and from Little Traverse Lake and Lime Lakes northeast to the mouth of the Carp River, which is all one geologic unit based. The till extending from Pyramid Point south to the watershed boundary is slightly different and is characterized by soil association M117; it also includes finer-grained silts and sands. M113 and M116 are associated with till, sand and silt south of Maple City. The Little Traverse and Lime Lake and the Bass and School Lake embayments, the area north of Little Traverse Lake and northwest to beyond Shell Lake and to the west of Navara Lake all belong to association M118. The substrate here is sand, marshes and swamps as mentioned above and in the Geology section.

Climate and time both had an important role in the formation of the soil types in the watershed but neither one varied across the watershed during soil formation and, therefore, are not responsible for the variations in soil types seen today. Source material and topography were the dominant factors that determined the different soil types on the scale of the detailed map and the associations on the association map. Biologic activity has been most important in areas of low relief where there has been extensive plant growth, but again that is tied into the topography. In other words, the early formation of soils in the watershed is largely responsible for the types of soils and their distribution that is seen today and both the source material and topography relate back to the glacial geologic events and history.

Figure 13: Good Harbor Bay Hillshade Map



2.4 JURISDICTIONS

The Good Harbor Bay watershed is comprised of portions of five townships (Centerville, Cleveland, Glen Arbor, Kasson and Leland) within Leelanau County (Table 5). Cleveland township has the most land within the Good Harbor Bay Watershed (89% of the township is in the watershed). Sleeping Bear Dunes National Lakeshore comprises 12.5% of the watershed (Figure 14, Table 6). The majority of the watershed is in private ownership (80%), which includes about 494 acres or 1.7% in private conservation easements.

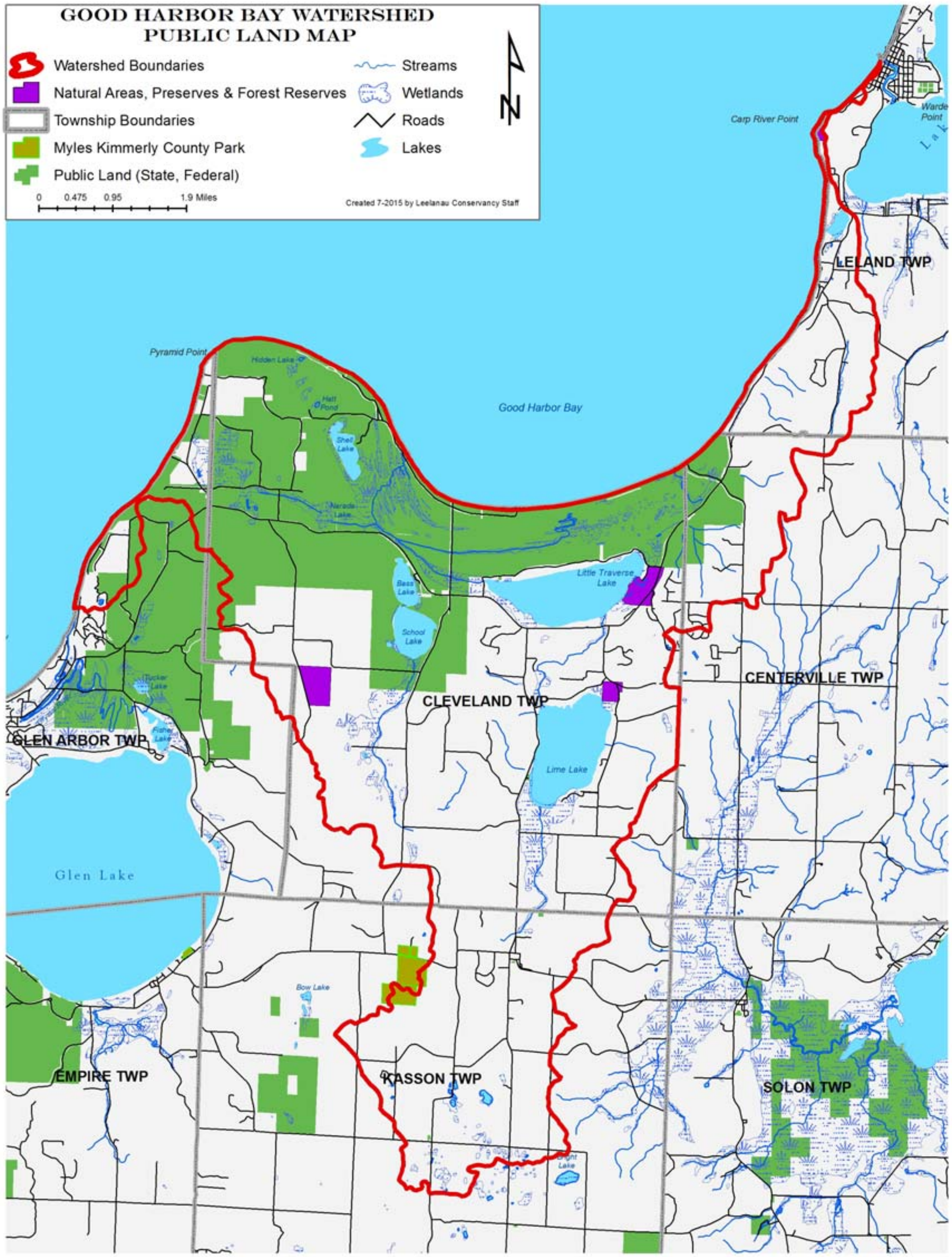
Table 5: Percent of each township within the Good Harbor Bay Watershed

Township	Acres in Watershed	% of Township in Watershed	% of Watershed
Centerville	1,893.1	10	7
Cleveland	19,008.1	89	66
Glen Arbor	1155.4	7	4
Kasson	4,907.1	21	17
Leland	2,055.9	8	7
Total	29,020		100%

Table 6: Public and Private Land in the Good Harbor Bay Watershed

Jurisdiction	Acres	% of Watershed
Privately Protected Land (conservation easements- CE's)	494	1.7
LC Natural Areas/Preserves	169	0.6
Nat'l Lakeshore	3,630	12.5
State Land	26	0.1
County Land	216	0.7
Private Land	22,763	78.4
Water (Lakes and Streams)	1,723	5.9

Figure 14: Public/Protected Lands in the Watershed



2.5 POPULATION

Rich in land and water resources, the Good Harbor Bay Watershed is home to both seasonal and year round residents living in Leelanau County and covering five Townships (Table 7). Since the Good Harbor Bay Watershed does not directly follow census boundaries, it is difficult to evaluate demographic characteristics of the exact population within the watershed boundary. According to the last census Leelanau County is one of the counties that grew at one of the fastest rates in Northwest Michigan. From 2000 to 2010 the area's population rose 10% (Table 7) and future projections indicate a steady growth rate for years to come. Leelanau County showed a percent population change of 2.8% (Table 7)

The greatest individual township population increases between 2000 and 2010 were found in Centerville and Glen Arbor Townships, with 16.3 % and 9% increases respectively. Leelanau County's population doubles during summer months to nearly 26,000 persons. These increases in population and future development have the potential to impact the entire watershed through nonpoint source pollutants, increased stormwater runoff, loss of wetlands, land fragmentation and potential degradation of important groundwater recharge areas.

Table 7: Population and Population Change

Township	1990	2000	2010*	% Change (2000-2010)
Centerville	836	1,095	1,274	16.3
Cleveland	783	1,040	1,095	5.3
Glen Arbor	644	788	859	9.0
Kasson	1,135	1,577	1,609	2.0
Leland	1,642	2,033	2,043	0.5
				Average 6.6
Total	**5,040**	**6,533**	**6,880**	**33.2**
Leelanau County	16,527	21,119	21,708	2.8

**Estimate – Population Division, U.S. Census Bureau*

2.6 LAND USE/LAND COVER

The land use within the watershed is dominated by 53.5% forested lands, (44.9% deciduous and 8.6 % coniferous), followed by 18.1 % Open shrub/Grassland and 9.6% agriculture (5.4% cropland, 3% orchards and vineyards, and 1.2 % permanent pasture or other agriculture), 6.7 % water, Urban uses comprising 5.7% and 1.4 % wetlands, (Figure 15, Tables 8 & 9).

The Good Harbor Bay watershed is blessed with more than 53% of its land in a forested condition (Table 8 & 9). Deciduous forest stands comprise the single largest land use of the watershed and, with sustainable management, provide an economic resource. At the same time, these forests have vital ecological roles. Following behind forests, Open shrub/Grassland (18.1%) and agriculture (9.6%) cover the majority of the remaining portions of the watershed (Table 8).

According to the land use layer, the major human land use of the watershed is agricultural (9.6%) along with residential homes, which comprise nearly 6% of the watershed (Table 8). Agriculture is an important part of the Good Harbor Bay Watershed, especially cherry orchards. The lack of significant industry in the watershed is a legacy of the 1950's resort era that followed the crash of the resource dependent early 1900's economy. The economy of the watershed has become more reliant seasonal tourism and summer residents that are drawn to the natural scenery found few other places. The high percentage of forested land in the watershed provides scenic beauty enjoyed by thousands of tourists while simultaneously protecting wildlife habitat, groundwater recharge and important water quality functions.

Figure 15: Land Use in the Good Harbor Bay Watershed

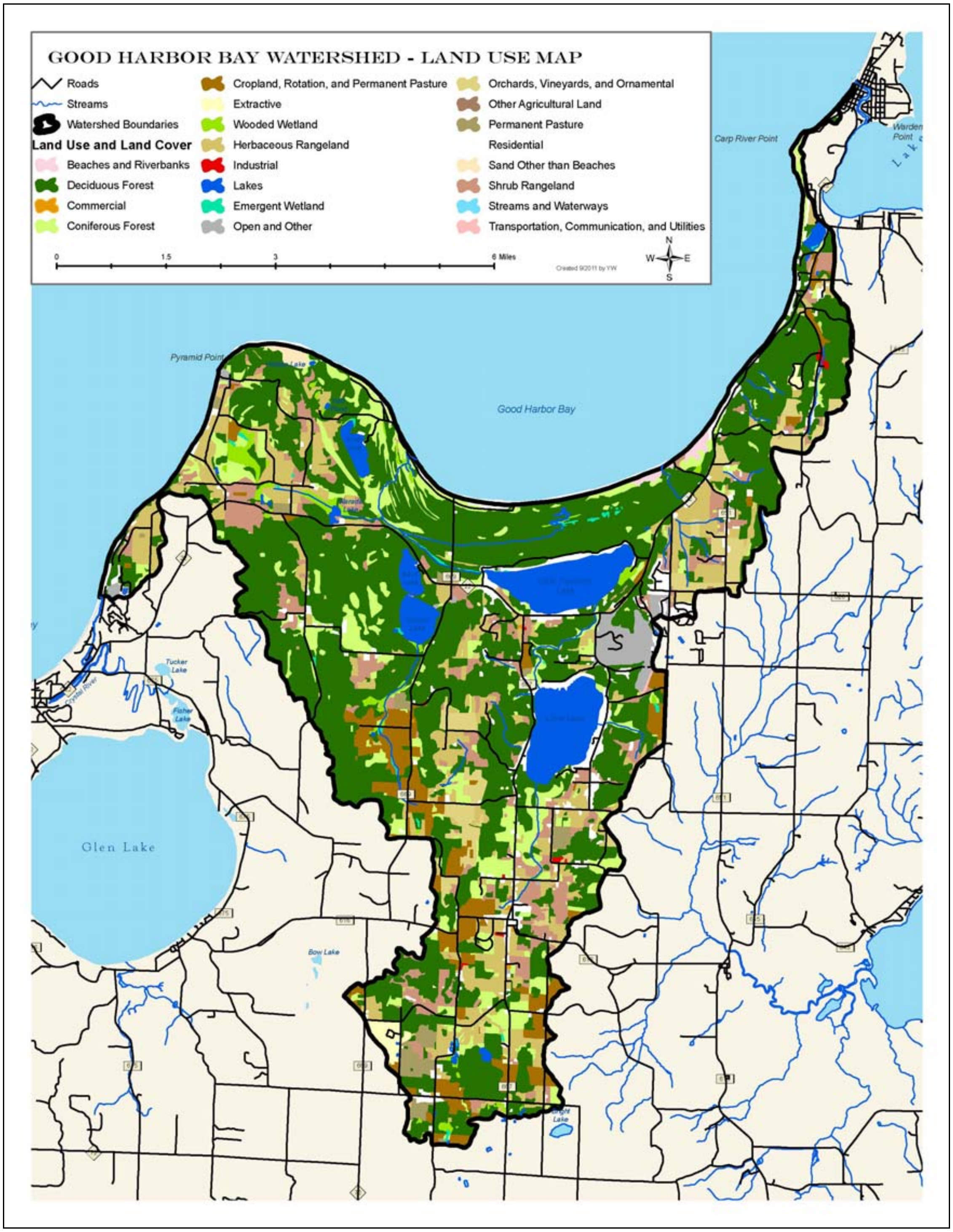


Table 8: Land Use/Cover in the Good Harbor Bay Watershed

Land Use/Cover	Acres	% Total
Commercial	29.5	0.10
Coniferous Forest	2,480.1	8.55
Cropland	1,568.1	5.40
Emergent Wetland	109.7	0.38
Extractive (Sand and gravel)	186.9	0.64
Deciduous Forest	13048.6	44.96
Herbaceous Rangeland	3289.6	11.34
Industrial	40.3	0.14
Lakes	1755.4	6.05
Open/Other	736.9	2.54
Orchards, Vineyards, and Ornamental	881.5	3.04
Other Agricultural Land	26.6	0.09
Permanent Pasture	335.1	1.15
Residential	1386.2	4.78
Scrub-Shrub Wetland	346.1	1.19
Shrub Rangeland	1969.5	6.79
Streams	6.4	0.02
Transportation/Utilities	6.3	0.02
Wooded Wetland	817.7	2.82
Total	29,020.4	100%

Table 9: Grouped Land Use/Cover

Land Use/Cover Category*	Acres	% Total
Forested (non-wetlands)	15,528.7	53.51
Agriculture	2,811.2	9.69
Open Shrub/Grassland	5,259.1	18.12
Urban	1,649.1	5.68
Water	1,761.8	6.07
Wetlands (emergent and forested)	1,273.5	4.39
Barren (beaches, dune, rock)	736.9	2.54
Total	29,020.4	100%

Land Use Groupings:

- *Forested: coniferous, deciduous*
- *Agriculture: confined feeding, cropland, orchards/vineyards, other agriculture, permanent pasture*
- *Open Shrub/Grassland: herbaceous and shrub rangeland*
- *Urban: commercial/services/institutional, extractive, industrial, residential*
- *Water: lake, streams/waterways*
- *Wetlands: emergent, shrub and wooded wetlands*
- *Barren: open/other*

2.7 THREATENED AND ENDANGERED SPECIES

This is a listing of all known occurrences of the Endangered (E), Threatened (T), and Probably Extirpated (X) plant and animal species of Michigan, and high quality natural communities occurring within the Good Harbor Bay watershed (Table 10). The species and community information is derived from the MNFI database. The watersheds are based on the 14 digit Hydraulic Unit Codes (HUC).

The species on this list are protected under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act). The current list became effective on April 9, 2009, after extensive review by technical advisors to the Michigan Department of Natural Resources and the citizenry of the state. Also included in this list are Natural Communities, plant and animal species of Special Concern. While not afforded legal protection under the Act, many of these species are of concern because of declining or relict populations in the state. Should these species continue to decline, they would be recommended for Threatened or Endangered status. Protection of Special Concern species now, before they reach dangerously low population levels, would prevent the need to list them in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Some other potentially rare species are listed as of Special Concern pending more precise information on their status in the state; when such information becomes available, they could be moved to threatened or endangered status or deleted from the list.

The listing is based on the polygon representation of the occurrences. Consequently any single occurrence may span watershed boundaries and be listed in more than one watershed. This list is based on known and verified sightings of threatened, endangered, and special concern species and represents the most complete data set available. It should not be considered a comprehensive listing of every potential species found within a watershed. Because of the inherent difficulties in surveying for threatened, endangered, and special concern species and inconsistency of inventory effort across the State species may be present in a watershed and not appear on this list.

This list was produced by the Endangered Species Program of the Michigan Department of Natural Resources and the Michigan Natural Features Inventory. English names in common usage or from published sources have been incorporated, when possible, to promote public understanding of and participation in the Endangered Species Program. To comment on the list or request additional copies, or for information on the Endangered Species Program, contact the Endangered Species Coordinator, Wildlife Division, Michigan Department of Natural Resources, P.O. Box 30028, Lansing, MI 48909 (517-373-1263). To report occurrences of these species, please contact: mnfi@msu.edu.

Source: http://mnfi.anr.msu.edu/

Table 10: Good Harbor Bay Watershed Rare Plant & Animal Species/Natural Communities List:

Scientific Name	Common Name	Federal Status	State Status
Acris crepitans blanchardi	Blanchard's cricket frog		T
Ammodramus savannarum	Grasshopper sparrow		SC
Berula erecta	Cut-leaved water parsnip		T
Botrychium campestre	Prairie Moonwort or Dunewort		T
Bromus pumpellianus	Pumpelly's bromegrass		T
Cirsium pitcheri	Pitcher's thistle	LT	T
Dendroica discolor	Prairie warbler		E
Gavia immer	Common loon		T
Great Lakes Barrens	Barrens, Upper Midwest Type		
Haliaeetus leucocephalus	Bald eagle		SC
Microtus pinetorum	Woodland vole		SC
Open Dunes	Beach/shoredunes, Great Lakes Type		
Orobanche fasciculata	Broomrape		T
Panax quinquefolius	Ginseng		T
Pterospora andromedea	Pine-drops		T
Stagnicola contracta	Deepwater pondsnail		E
Wooded Dune and Swale Complex			

Source: http://mnfi.anr.msu.edu/data/watshd_dat.cfm?id=4060104 28L 3

T= Threatened, E= Endangered, SC= Special Concern, LT= Listed Threatened

2.8 MASTER PLANS AND ZONING ORDINANCES

Master Plans and Zoning Ordinances

How communities manage their land use has a direct impact on the community's water resources. Zoning, master plans, and special regulations are a few of the more commonly used land management tools. Zoning ordinances, if enforced, establish the pattern of development, protect the environment and public health, and determine the character of communities. In 2006, PA 110, The Michigan Zoning Enabling Act was signed into law. This act codified the laws regarding local units of government regulating the development and use of land. It also provides for the adoption of zoning ordinances; to provide for the establishment in counties, townships, cities, and villages of zoning districts; prescribes the powers and duties of certain officials; to provide for the assessment and collection of fees; authorizes the issuance of bonds and notes; and prescribes penalties and provide remedies. In 2008, PA 33, titled Michigan Planning and Enabling Act, was signed into law. This law consolidated previous planning acts under one statute, creating a standard structure for all local planning commissions and one set of requirements that will apply to the preparation of all master plans. Since protecting water quality requires looking at what happens on land, zoning is an important watershed management tool.

Planners should recognize that water quality is directly impacted by adjacent land use with the amount of impervious surfaces being particularly paramount. Land use planning techniques should be applied that preserve sensitive areas, redirect development to those areas that can support it, maintain or reduce impervious surface cover, (such as roads, driveways and parking lots) and reduce or eliminate nonpoint sources of pollution.

Zoning's effectiveness depends on many factors, such as the restrictions in the language, the enforcement, and public support. Many people assume existing laws protect sensitive areas, only to find otherwise when development is proposed. Zoning can be used very effectively for managing land uses in a way that is compatible with watershed management goals. A wide variety of zoning and planning techniques can be used to manage land use and impervious cover in the watershed. Some of these techniques include: watershed based zoning, overlay zoning, impervious overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, transfer of development rights (TDRs), and limiting infrastructure extensions. Some benefits of zoning include: increased local control/autonomy over land use decision-making; communicating clear expectations with developers based on community needs; and, an opportunity for the residents of the area to design the type of community they want to live in – one that respects their unique cultural, historic, and natural resource values.

Local officials face hard choices when deciding which land use planning techniques are the most appropriate to modify current zoning. Table 10, adapted from the Center for Watershed Protection's Rapid Watershed Planning Handbook, provides further details on land use planning techniques and their utility for watershed protection (CWP 1998). While most of these techniques are for watersheds much bigger than the Good Harbor Bay watershed, it still presents a good picture of available land use planning techniques. In addition, the DEQ has published a book titled *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (Ardizone, Wyckoff, and MCMP 2003). An overview of Federal, State, and local roles in environmental protection is provided, as well as information regarding current environmental laws and regulations including wetlands, soil erosion, inland lakes and streams, natural rivers, floodplains, and more. The book also outlines regulatory options for better natural resources and environmental protection at the local level. *(A copy of this guidebook is available via the DEQ website: WWW.MICHIGAN.GOV/DEQ → Water → Surface Water → Nonpoint Source Pollution (look under Information/Education heading).*

Local governance can be a complicated issue. Generally, local governments may enact zoning laws that are more stringent than the next highest ranking form of government, but not less. In any case, all applicable State laws must be followed. Most of the townships located in the Good Harbor Bay watershed have both a Master Plan and Zoning Ordinance (Tables 12 & 13). Assisting local governments in updating and enacting strong zoning ordinances to protect water quality and secure natural areas is extremely important in the Good Harbor Bay watershed and is a high priority for implementation efforts (Chapter 8). Master plans and zoning ordinances have great potential to affect water quality. Zoning ordinances have a direct role in determining the type and density of land use allowed. They regulate permitted uses of the land, for example, setting minimum/maximum lot sizes and setback requirements (from neighbors, roads, water bodies). Overall, zoning ordinances are enacted to ensure that the use of private property does not negatively affect the public's safety, health, and welfare. Since protecting water quality requires looking at what happens on land, zoning can be an extremely important watershed management tool.

Examples of zoning to protect water quality include requiring vegetative buffer zones along bodies of water (see earlier section on Lack of Riparian Buffer), requiring greenbelt areas, protecting the integrity of soil by having filtered views along stream corridors (protects banks from erosion), or protecting wetlands.

Table 10: Land Use Planning Techniques

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Watershed-Based Zoning	Watershed and subwatershed boundaries are the foundation for land use planning.	Can be used to protect receiving water quality on the subwatershed scale by locating development out of particular subwatersheds.
Overlay Zoning	Superimposes additional regulations for specific development criteria within specific mapped	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to protect receiving water quality at both the subwatershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the	May be used to obtain proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental	Can be used to encourage development within a particular subwatershed or to obtain open space in exchange for a density bonus at the site level.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Can be used to require additional levels of performance within a subwatershed or at the site level.

Table 10: Land Use Planning Techniques (Cont'd)

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur & where agricultural or rural land is to be preserved.	Can be used in conjunction with natural watershed or subwatershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness.
Infill/ Community Redevelopment	Encourage new development and redevelopment within existing developed areas.	May be used in conjunction with watershed based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area".	May be used in conjunction with watershed based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increased densities.
Limiting Infrastructure Extensions	A conscious decision made to limit or deny extending infrastructure (e.g. public sewer, water, roads) to designated areas to avoid increased development.	May be used as a temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

Table adapted from Center for Watershed Protection's Rapid Watershed Planning Handbook – page 2.4-5 (CWP 2001)

During the process of drafting the GHBWPP a review and summary of master plans and zoning ordinances was conducted (Tables 12 and 13). For the most part, community master plans usually have good intentions when it comes to protecting natural resources. The natural resources of this area are why most people choose to live in the Good Harbor Bay region. In general however, townships and communities often lack the knowledge on how to draft and enact effective, yet enforceable, zoning requirements. The validity of a zoning ordinance, particularly those that are more restrictive is often challenged by developers, among others. Local governments may have trouble obtaining information to back up their ordinances that will stand up in court. Additionally, it is often an argument of property rights vs. the public good, with local governments trying to show and prove that a certain ordinance is important to protect water quality.

Soil Erosion and Stormwater Ordinances

It is important to note that, in addition to township zoning ordinances, Leelanau County has a separate "Soil Erosion, Sedimentation and Stormwater Runoff Control Ordinance (SESSRC). This ordinance incorporates Part 91 of Act 451, Michigan's Soil Erosion and Sedimentation Control Law, which regulates and requires a permit for earthwork within 500 feet of a lake or stream or for any soil disturbance of 1 acre or more regardless of the location of that land to water. The county ordinance goes beyond those State requirements by requiring permits for all commercial projects that disturb soil, for any project within 100 feet of a regulated wetland, for construction of a driveway with a slope of 10% or greater and for any site determined to be in an environmentally sensitive area. This ordinance is an extremely valuable tool in protecting water quality.

In Leelanau County the Leelanau Conservation District has been authorized by the County to administer the SESSRC Ordinance. Upon receiving a permit application the Soil Erosion Control Officer completes a site visit to insure that all necessary soil erosion control measures and sediment control measures are properly planned and installed prior to the start of a project. It is necessary to obtain a soil erosion permit before any soil disturbance takes place. Further information and details can be obtained by contacting Leelanau Conservation District.

Drain Commissioner

The Drain Commissioner provides assistance in the following areas: The County Drainage Plan, The Soil Erosion, Sedimentation and Stormwater Runoff Control Ordinance (SESSRC), the management and control of County Drainage Districts and County Dam inspections.

Table 11: Master Plan and Zoning Ordinance Status Summary for Local Governments in Watershed (For a map of Jurisdictions see Figure 2)

County	Township	Master Plan	Zoning
Leelanau County		Y, with updates in 2000 and 2005	N (Rely on individual
	Centerville	Y, (2005)	Y, 1971 with amendments 2007
	Cleveland	Y, 2009	Y, 1973 with 2009 amendments
	Glen Arbor	Y, (2013)	Y, 2008
	Kasson	Y (2004)	Y, 1997, updates 2011
	Leland	Y, 2009	Y, 1996 with 2014 amendments

Table 12: Good Harbor Bay Watershed 2014 Master Plan Assessments

MASTER PLAN ASSESSMENT									
Unit of government	***Plan Reviewed ("NA" indicates no plan) and "NP" indicates plan not provided by project deadline)***	***Master Plan Goals/ Narrative Address:***							
		Maintaining /Promoting Community Character	**Land use limitations for environ-mental constraints**	**Protecting Shoreline/ Lake Michigan/Inland lakes**	**Protecting Wetlands**	**Preserving and protecting Streams/ Surface Water/ Groundwater**	**Soil erosion/ Stormwater Measures**	**Protecting Dunes/ Hills/ Slopes**	**Protecting Forests/ Agriculture/ Open Space**
Leelanau County	X	X	X	X	X	X	X	X	X
Centerville	X	X		X		X		X (Soils)	X
Cleveland	X	X	X?	X	X	X	X	X	X
Glen Arbor	X		X	X	X	X	X	X	X
Kasson	X	X	X	NA		X	X		X
Leland	X	X	X	X		X	X	X	X

Table 13: Good Harbor Bay Watershed 2014 Zoning Ordinance Assessments

ZONING ORDINANCE ASSESSMENT									
Unit of government	***Ordinance Reviewed ("NA" indicates no plan and "NP" indicates plan not provided by project deadline)***	***Ordinance Regulations Include:***							
		Special Districts for Environ-mentally Sensitive Areas	**Approval or Permits for Environ-mentally Sensitive Areas or Uses**	**Requirements for Shoreline/ Riparian Areas**	**Requirements for Wetland Areas (such as for areas not regulated by DEQ or US Army Corp. of Engineers)**	**Provisions to Protect Streams/ Surface Water/ Groundwater**	**Soil Erosion/ Stormwater Provisions**	**Sewer/ Water Provisions**	**Open Space Requirements**
Leelanau Co	No Zoning	---	---	---	---	---	---	---	---
Centerville	X			X				X	X
Cleveland	X		X			X			
Glen Arbor	X			X	X	X	X	X	
Kasson	X								X
Leland	X	X?	X	X	X	X	X	X?	X

2.9 FISHERIES

The two fisheries reports for the two major lakes (Lime and Little Traverse) in the watershed written by the Michigan Department of Natural Resources are summarized below. The full reports can be found in Appendix A.

Lime Lake Fisheries (adapted from Seites/Hettinger report 2010)

Lime Lake is fed by several hillside seeps, springs, and small creeks, with the largest being Lime Creek which flows in at the southern end of the lake. Shetland Creek flows out of the north end of Lime Lake and into Little Traverse Lake, and from there Shalda Creek flows out of Little Traverse Lake and into Good Harbor Bay on Lake Michigan (Seites 2011). In years of high water migratory fish from Lake Michigan have access to Lime Lake through Shalda Creek, which flows from Little Traverse Lake to Lake Michigan. Shalda Creek is a Type 4 designated trout stream. (Seites 2011). Type 4 trout streams **are** open for the entire year. The **Possession season f**or brook trout, brown trout and Atlantic salmon is the last Saturday in April through September 30. For all other species of trout and salmon the season is open for the entire year. Artificial lures and all types of natural bait may be used. The **Daily Possession Limit is** five (5) trout and salmon in any combination, except that the daily possession limit shall not include more than three (3) trout 15 inches or greater. The size limit is 7 inches for Brook Trout and 10 inches for Brown Trout. (FO-200.15. Statewide Trout, Salmon, Whitefish, Lake Herring, and Smelt Regulations)

Lime Lake is a Type C designated trout lake that is open to trout fishing for the entire year (Seites 2011). Type C Lakes have a fishing and possession season open for the entire year. All types of natural bait and artificial lures may be used and the daily possession limit is five trout and the minimum size is 8 inches for Brook Trout, Brown Trout, Rainbow Trout, Lake Trout and Splake (FO-200.15. Statewide Trout, Salmon, Whitefish, Lake Herring, and Smelt Regulations). The lake is accessible via a Michigan Department of Natural Resources (MDNR) public boat launch. This launch is located on the southwestern shore of the lake and has one dock, two slips to launch and retrieve boats, vault toilet facilities, and approximately six gravel parking spaces. The Lime Lake Association is the only riparian association that is currently active on Lime Lake. The Cedar Rod and Gun

Club in nearby Cedar, MI is a local sportsman's group that has historically been interested in the management of Lime Lake. MDNR Fisheries Division often receives fishing reports from both local and out-of-town anglers.

According to Fisheries Division records, Lime Lake was first stocked with walleye fry in 1910. A mixture of cold and cool water species such as lake trout, walleye, bluegill, smallmouth bass, largemouth bass, yellow perch, and northern pike were stocked from 1920 until 1949. At this time the Michigan Department of Conservation (MDOC, precursor to today's MDNR) switched the focus of Lime Lake to the management of trout and began stocking rainbow trout. During the 1960's the trout fishery declined and the MDOC stocked a mix of brown trout and rainbow trout in order to determine which species would create a better fishery. In 1968 the MDOC decided to stock brown trout exclusively. With the exception of 1987 when both brown trout and rainbow trout were stocked, and 1969 and 1991 when no fish were stocked, Lime Lake has been stocked with brown trout annually from 1968 to 2011 (Fisheries Division files, Cadillac).

Lime Creek was also stocked by the MDOC for a number of years. Brook trout were first stocked in 1933, annually from 1935 to 1944, and for one final year in 1949 before this stocking was discontinued.

Current Status

The most recent Lime Lake fisheries survey was conducted in 2010 using Status and Trends protocols (Wehrly et al. 2009), and was intended to evaluate the success of brown trout stocking. During the 2010 survey a total of 1,912 fish representing 19 species were caught. Rock bass, yellow perch, and spottail shiners comprised the largest portion of the catch. A total of 1,203 rock bass made up 63% of the catch by number, ranging from 2 to 11 inches in length. Additionally rock bass represented 38% of the total catch by weight with 194 total pounds. Yellow perch represented 28% of the total catch by weight with 186 individuals collected.

Game fish caught in the 2010 fisheries survey included brown trout, smallmouth bass, largemouth bass, yellow perch, longear sunfish, bluegill, and northern pike. Although smallmouth bass only represented 3.7% of the catch by number, they represented 85.4% of the catch by weight with 71 individuals ranging in size from 3 to 20 inches. Twenty-eight brown trout ranging in size from 6 to 14 inches represented 6.9% of the total catch by number. Most species caught in May had growth rates slightly below the State average length at age. Bluegill and rock bass were the only two species with growth rates above State average. Yellow perch growth rates were significantly below State average. Not enough largemouth bass or northern pike from any one age class were collected to make statistical inferences regarding age and growth; however as individuals the northern pike were growing above State average and the largemouth were growing below State average.

Scale samples were collected in the July electro fishing survey from rock bass, yellow perch, and smallmouth bass to be aged and compared to the State average length at age. Not enough smallmouth bass or yellow perch from any one age class were collected to make statistical inferences regarding age and growth; however rock bass were growing just slightly below State average. As individuals, both the smallmouth bass and yellow perch were growing either just below or right at the State average.

Analysis and Discussion

The 2010 MDNR fisheries survey showed Lime Lake hosts a healthy fish community with abundant species diversity. Game fish species collected include brown trout, largemouth bass, northern pike, and smallmouth bass. Brown trout were represented by two year classes (ages 1 and 3), indicating that some holdover of stocked trout is occurring. Smallmouth bass were represented by 10 year classes and are growing at a fairly good (-0.1 inches) pace compared to the State average. Very few largemouth bass or northern pike were collected. It is important to note that in the time that Lime Lake has been a managed fishery, northern pike have only occurred in low densities. In Lime Lake where maintaining a trout fishery is one of the management goals it is critical to keep northern pike densities low to reduce predation on stocked trout.

Panfish species collected in the survey include bluegill, yellow perch, longear sunfish, and rock bass. Yellow perch were represented by five year classes and exhibited very slow growth rates compared to the State average (-1.2 inches), supporting angler comments reporting catching low numbers of very large perch, mostly in the winter months or early spring. Rock bass were represented by eight year classes and were growing above State average (+0.5 inches).

There are notable differences between the fish communities collected in the 2010 fisheries survey and the fish communities collected in the prior surveys. A sharp decline occurred in alewife numbers from the 1999 survey. This could partially be attributed to gear bias, as more fyke nets were used in the 1999 survey. Fyke nets could be more effective at collecting alewife than the trap nets used in the 2010 survey. It could also be due to the fact that connectivity between Lime Lake and Lake Michigan has declined over the years. Both Shalda Creek and Sheltland Creek have experienced low water, beaver activity, and other blockages which may be preventing migratory species from reaching Lime Lake as they have in the past. Species absent from the 2010 catch included pumpkinseed sunfish, green sunfish, and fathead minnows. New species collected in the 2010 survey included longear sunfish, creek chub, bowfin, Johnny darter, mimic shiner, and sand shiner. Based on the three species of sunfish that have shown up in the catch through the years, there is potential that hybridization of panfish is making identification difficult.

Management Direction

Any remaining riparian wetlands adjacent to Lime Lake and its tributaries should be protected as they are critical to the continued health of the watershed. Appropriate watershed management is necessary to sustain healthy biological communities, including fish, invertebrates, amphibians, reptiles, birds and aquatic mammals. Generally for lakes this includes maintenance of good water quality, keeping nutrients balanced, preservation of natural shorelines; especially shore contours and vegetation, and preservation of bottom contours, vegetation, and woody structure within the lake.

Additionally, dredging of the littoral zone should be avoided if possible on Lime Lake, particularly where gravel and cobble substrates are located. Most of the near shore properties that are developed on Lime Lake have gravel and cobble substrates present which is critical for a number of important Lime Lake fish species. MDNR Fisheries Division should work collaboratively with the Lime Lake

Association, MDEQ, National Park Service, and various non-profit environmental agencies to identify aquatic connectivity barriers and sustain or enhance aquatic connectivity among all the basins within the Lime Lake watershed, specifically Lime Creek, Shetland Creek, Shalda Creek, and Little Traverse Lake. Enhanced aquatic connectivity will help sustain healthy fish populations into the future.

Native species like smallmouth bass, rock bass, and yellow perch should continue to thrive in Lime Lake. The smallmouth bass population in Lime Lake is exceptional, and Lime Lake has an excellent reputation among anglers for its smallmouth bass fishery. The brown trout stocking program for Lime Lake should continue. Although the current Lime Lake northern pike densities appear low, this lake should be a candidate for a no minimum size limit classification and 5 fish per day limit for northern pike. It is recommended to have the MDNR Fisheries Division survey Lime Lake again within the next five to ten years in order to continually assess the fish community and evaluate brown trout stocking efforts (Seites 2011). Fisheries Division should also survey the major tributaries to Lime Lake to better understand their contributions to this watershed. Many of these streams have never been surveyed or have not been surveyed in many years.

Little Traverse Lake Fisheries-<u>(adapted from Seites/Hettinger report 2014)</u>

Little Traverse Lake is classified as a mesotrophic, slightly eutrophic lake. A combination of sand and marl dominates the bottom substrate. Much of the lake is less than 20 feet in depth, with good vegetative growth and areas of heavily wooded natural shoreline. Water clarity is impacted by tannic acid contribution from the watershed, as well as the marl bottom substrates. The surrounding topography of the 640 acre Little Traverse Lake is wooded, with adjacent sand dunes, rolling hillsides, and lowland cedar swamps (Hettinger 2014). While Little Traverse Lake is moderately developed with homes and cottages, much of the surrounding shoreline has been left unarmored. Numerous small seeps and creeks drain the surrounding hillsides and feed Little Traverse Lake (Hettinger 2014). Much of the shoreline is wooded or wetland area, with some areas of shore being sandy beaches or lightly armored with rock rip rap. Shallow near shore areas are predominately sand and marl, with water depths of 1-5 feet (Hettinger 2014). The remaining deep water areas are marl or a pulpy peat and marl combination. The lake has an average depth of 5-10 feet and reaches a maximum depth of about 50 feet (Hettinger 2014).

There are two public access sites that provide boat launching facilities on Little Traverse Lake. The most accessible is a Cleveland Township Park located in the northwest corner of the lake. The second site is a Leelanau County parcel on the north east corner of the lake. There is one lake association on Little Traverse Lake, the Little Traverse Lake Property Owners Association. This association was founded originally as the Little Traverse Lake Association, and throughout the years has very active in the watershed. There is one nature preserve managed by the Leelanau Conservancy that is found along the shore of Little Traverse Lake; the Swanson Preserve (Hettinger 2014).

History

The earliest recorded fish stocking in Little Traverse Lake was in 1933. Fish were stocked annually by the Michigan Department of Conservation (MDOC, pre-cursor to the present Michigan Department of Natural Resources) from 1933 to 1944. A variety of species such as yellow perch, bluegill, largemouth bass, walleye, and northern pike were stocked during this time frame (Hettinger 2014). Once the Department of Conservation stopped raising cool water species in the hatchery system, Little Traverse Lake was no longer stocked with fish. Adult panfish were transferred to the lake on three occasions in 1991, 1992, and 1993, when fish were available. These fish came from nearby Turtle Lake in Benzie County. No fish have been stocked in Little Traverse Lake since the last panfish transfer in 1993. The first known work completed by the MDOC on Little Traverse Lake, aside from stocking, started in 1949 (Hettinger 2014).

Limnology surveys were also conducted throughout the years, with the first being in August of 1949. Subsequent limnology samples were taken in 1970, 1978, 1989, and 2013. The first fisheries survey on Little Traverse Lake took place in 1965 (Hettinger 2014). At this time the fishing was described as good, with the catches being predominately bluegill. Nets were set again in August of 1970, when a combination of experimental gill nets, trap nets, fyke nets, and electroshocking was used to assess the fish community (Hettinger 2014). This was the only survey where cisco were ever collected in Little Traverse Lake. These fish may have had free movement out to Good Harbor Bay in many years of high water, but once water levels declined and fish passage began to become obstructed via undersized culverts, the movement of cisco most likely was inhibited, thus preventing new stocks from migrating into the lake (Hettinger 2014).

A request was made by the Little Traverse Lake Association in 1989 for a lake survey to be conducted after angling success reportedly declined (Hay 1989). Therefore, in June of that year the Michigan Department of Natural Resource Fisheries Division surveyed the lake using a combination of experimental gill nets and large mesh fyke nets set for three net nights (Hettinger 2014). In the summer of 1990 Fisheries Division worked with the Little Traverse Lake Association to place bundles of 12 Christmas trees at three locations in the lake to improve fish habitat (Hettinger 2014). Little Traverse Lake was surveyed again in June of 1995, using experimental gill nets, large mesh fyke nets, and small mesh fyke nets set for three net nights. The purpose of this survey was to evaluate the stocking of panfish that occurred in the early 1990's.

Current Status

In 2013, Fisheries Division conducted a Discretionary Survey in Little Traverse Lake which followed Status & Trends protocol (Wehrly et al 2009). This protocol uses the same types of collection gear and protocols in lakes of similar sizes, and allows the data collected in Little Traverse Lake to be compared with data collected from similar lakes across the state (Hettinger 2014). . Three sections of shoreline were electrofished using a boom electroshocking boat, and four beach locations were sampled with a seine net on July 23, 2013. During this survey a total of 861 fish representing 17 species and 18 turtles representing two species were collected (Hettinger 2014).

Rock bass were the most abundant species by number, with 261 individuals collected (Table 3). Rock bass also had the highest percent by number making up 30.3 % of the catch, followed by pumpkinseed which comprised 13.1% of the catch by number with 113 individuals. The biomass of the catch was predominated with 68.2 lbs. of smallmouth bass and 43.6 lbs. of northern pike. Smallmouth bass represented 23.3 % of the catch by weight, while northern pike accounted for 14.9 % of the catch by weight. Growth rates for all species aged were above the state of Michigan average length at age, with the exception of northern pike which were growing 2.2 inches below average, and yellow perch which were growing 0.1 inches below average (Table 4). While most species were only slightly above average, smallmouth bass were growing well above average with growth at 1.7 inches above the state of Michigan average length at age. Not enough largemouth bass were collected from any one year class to make statistical inferences about growth (Hettinger 2014). .

Analysis and Discussion

Overall the growth of most fish species found in the most recent survey of Little Traverse Lake is comparable to the State average, and is in the acceptable ranges for a lake with a slightly mesotrophic/eutrophic classification (Hettinger 2014). Good numbers of smaller forage fish such as shiners and minnows produce higher growth rates in species such as the smallmouth bass; however the low numbers of smaller panfish and a relatively short growing seasons result in below average growth for northern pike (Hettinger 2014).

Throughout its management history, Little Traverse Lake has been plagued with reports of a poor panfish fishery. Despite having adult panfish transferred into the lake in the early 1990's, this issue has persisted until recent times (Hettinger 2014). While numbers of bluegill still appear to be low, the numbers of longear sunfish and pumpkinseed sunfish are on the rise. One phenomenon that could be attributing to the increasing success of these panfish species is in fact the troublesome culvert located on Traverse Lake Road. Since the culvert's replacement in the late 1990's, water levels in Little Traverse Lake in the spring and the fall have been much higher than when the old culvert was in place, so high in fact that riparian owners have expressed major concerns over the flooding of their properties. However, in the spring when panfish are spawning these higher water levels and thus the increased nearshore vegetated areas may be aiding the spawning success of panfish by increasing available spawning areas and providing additional protection for newly hatched fry (Hettinger 2014).

Management Direction

Little Traverse Lake has a well preserved natural shoreline across many areas of the lake. Efforts should be made to protect remaining riparian wetlands from development in order to maintain the healthy aquatic ecosystem that currently exists (Hettinger 2014). Future unwise riparian development and wetland loss may result in deterioration of the water quality and aquatic habitat. Healthy biological communities on inland lakes and streams require suitable natural habitat (Hettinger 2014). Appropriate watershed management is necessary to sustain healthy biological communities, including fish, invertebrates, amphibians, reptiles, birds and aquatic mammals (Hettinger 2014).

Additionally, dredging of the littoral zone should be avoided on Little Traverse Lake, particularly where woody debris and cobble substrates are located (Hettinger 2014). Most of the nearshore properties that are developed on Little Traverse Lake have sand and cobble substrates present, and many have high quality woody debris. This nearshore habitat is critical for a number of important Little Traverse Lake fish species, as cobble substrates and woody debris provide spawning habitat and also host many important aquatic invertebrates that help to sustain healthy fish populations (Hettinger 2014). Currently Little Traverse Lake has excellent fisheries for multiple species, such as smallmouth bass and pumpkinseed sunfish. These are well maintained by natural reproduction, and thus no fish stocking is required at this time (Hettinger 2014). However, another Discretionary or Status & Trends fisheries netting survey should be conducted on Little Traverse Lake within the next ten years in order to continually assess the fish community (Hettinger 2014).

Fisheries Division should continue to work with the Little Traverse Lake Property Owners Association, the National Park Service, the Leelanau Conservancy, and the Grand Traverse Band of Ottawa and Chippewa Indians (GTB) to help develop and implement the Good Harbor Bay Watershed Protection Plan, as well as to help develop a solution for the poor road stream crossing at Traverse Lake Road (Hettinger 2014). These collaborations should also work to address additional aquatic connectivity barriers and sustain or enhance aquatic connectivity among all the basins within the Good Harbor Bay watershed, specifically Lime Creek, Shetland Creek, and Shalda Creek. Enhanced aquatic connectivity will help sustain healthy fish populations into the future (Hettinger 2014).

2.10 HUMAN HISTORY

Written by Dean Manikas

Humans have inhabited the Good Harbor Watershed since before recorded time. Different bands of Native Americans trapped, hunted, fished, farmed and traded in the region before a written record was made. European settlers would later appropriate their trails as the first network of roads. Initial contact between Europeans and Native Americans was along the shore of Lake Michigan trading for goods from the natural bounty of the region. A treaty in 1836 between the United States of America and local tribes opened the region to settlement by European immigrant groups.

Steam shipping around the Great Lakes required fueling stops for wood to feed the boilers. The earliest settlements (approximately 1860) in the watershed were at New Harmony and Good Harbor (Schomberg). Both were based on the cutting and selling of wood to the hundreds of steamboats navigating the lakes. The work force, all arriving by water, were German, Czech, and Polish immigrants. Carving out a living in this harsh environment required reliance on neighbors to survive in the region, especially during rough winters. All supplies came by water, often leading to shortages of essential goods in the winter months. A story from New Harmony claims how the settlement survived the first winter thanks to the migration and easy hunting of the now extinct passenger pigeon. The continuous removal of timber began to open areas for agriculture. Potatoes, cabbage, beans, a little wheat, and game from the lakes and forests became the foodstuff of the settlers. Sawmills operated in both villages. Families would work the land during growing season and shift their labor to culling wood from the forests and working the sawmills in the winter.

Sawmills and lumbering were the primary sources of income in the region. Lumbering peaked in the early 1890’s and faded quickly at the start of the 20th century. Sawmills dotted streams and lakes. Remnants of the sawmill and fueling industry can be seen at the bottom of Lime Lake and the pilings stretching into Lake Michigan at a couple of locations along the shore of Good Harbor. Gradually, as the woods were cleared, settlers moved inland, away from the lakeshore. The villages of New Harmony and Good Harbor were abandoned in the early 1900s.

Maple City was founded in 1866. Initially its name was Peg town in recognition of the primary business, the manufacture of wood pegs for shoe making. The factory burnt down in 1880 but the newly named Maple City persisted even being home to a hotel.

Cedar, founded in 1892, was the last community to develop within the interior of Leelanau County. The Railroad passed through and provided easy distribution for the cedar shingle and barrel products from the local factory. 1916 saw the demise of the wood product factory but Cedar persevered.

Agriculture has been rooted in the watershed, on small plots in the earliest of times to multiple acre orchards into the modern era. Potatoes were the first cash crop in the late 1800s. Apple and cherry orchards have been prevalent since the early 1900s and remain viable in the present. But agriculture only makes up a small portion of taxable property in the modern era. Residential property dominates the taxable rolls distantly followed by commercial property. The majority of residents make their living outside the watershed.

Within the heart of Good Harbor Watershed sits Sugar Loaf Mountain. The earliest settlers, harkening memories of the hills in their native lands, admired Sugar Loaf. During Sugar Loaf's 35 years of operation as a resort, it was the largest employer in Leelanau County. Presently, the golf courses of Sugar Loaf, the National Lake Shore, and the inland lakes and streams, attract thousands of visitors every year to the region.

2.11 ECONOMY, TOURISM, AND RECREATION

(written by Dean Manikas)

The Good Harbor Watershed is naturally beautiful; forests, wetlands and lakes compose the majority of the surface area. Township reports show that greater than 50% of local residents are employed outside Leelanau County. The population is educated (95% with a high school diploma and 32% holding a college degree) with over 30% working in professional and managerial roles, 22% in sales/office work, 17% in services, 13% construction trades, 5% agriculture and forestry occupations. The fastest growing employment sector is in the service industry. Major employers include the Grand Traverse Band, school districts, the park service, Triple D Orchards, Leelanau Fruit, and Leelanau Redi-Mix.Poverty rates hover around 16%. Taxable property value is derived from 92% residential, 3% agriculture, and 5% commercial. Residential property value had been greatly increasing for the past 20 years, just slowed by the recent recession.

The Sleeping Bear Dunes National Lakeshore, Sugar Loaf golf courses, and abundant lakes are the major recreational attractions. Seasonal and day visitors can swell the area's populations by 400%. Until its closure, Sugar Loaf Resort was the largest employer in the county. Sugar Loaf is in the heart of the Good Harbor Watershed. Townships within the watershed state the following economic goals: embrace year round employment opportunities, preserve tourist friendly qualities, and protecting farmland and agricultural enterprises.

(Sources include Cleveland and Centerville Township Plans)

SWIMMER'S ITCH SUMMARY

Ron Reimink, Lime Lake Association (LLA Biologist), wrote a summary on swimmer's itch for the LLA and will be involved in a study of Swimmer's Itch in Northern Michigan. He will work with the LLA and steering committee to help with some of the tasks identified in Chapter 8, Table 34) and will keep the lake associations and steering committee for this watershed informed on what is learned and what programs might be implemented in this watershed.

Below is an overview of Swimmer's Itch adapted from the website:

Swimmer's Itch is an infliction generated by a parasite in the water which is part of cycle involving Merganser ducks, other water fowl, and snails. The parasite burrows into one's skin and generates a 'mosquito bite' type irritation which swells into a node on the skin. Swimmer's Itch is of high concern in the inlands lakes in this watershed, particularly Lime and Little Traverse Lakes which have an increase in visitors during the swimming or summer months.

Prevention & Treatment

Until a viable, environmentally safe solution is found, here are few suggestions that many have found helpful. Obviously they are not guaranteed therapies.

- Shower and towel off with vigor and thoroughness after swimming.
- Avoid swimming at midday and in areas exposed to shore winds
- Swim in deeper water where the infecting snails are less likely to occur.
- Avoid feeding waterfowl in your swimming areas
- In case of exposure, application of topical antihistamines (such a Benadryl) or a topical hydrocortisone can help reduce inflammation and relive itching
- Some have reported success using Swimmer's Itch Guard before entering the water as a preventative.

Tracking Program

The Lime Lake Association Swimmer’s Itch Program tracks where and when anyone contracts swimmer’s itch. The LLA Board has a keen interest in keeping abreast of the latest progress in methods to alleviate swimmer's itch. Ron has been actively involved in swimmer's itch education, research, and control for the past 30 years in Michigan, Wisconsin, Indiana, and Maine and has volunteered to spearhead the efforts to keep Lime Lake on the front edge of any new control developments. Due to roadblocks at the state and national level, most control efforts involving waterfowl are limited. Anyone who decides to take control efforts into their own hands by illegally killing the ducks on Lime Lake is strongly discouraged by the LLA board. In fact, past experience has shown that such efforts actually increase the incidence of swimmer's itch. Please work within the law to maximize efforts.

To begin the assessment process, Ron is taking information from watershed users. Please contact him at his email address with any and all swimmer's itch cases from Lime Lake. Please include all of the following information for EACH PERSON INFECTED (also include repeat infections):

1. Date of contact
2. Approximate age of person infected
3. Approximate number of spots and where located
4. Approximate time of swimming (morning, afternoon, evening)
5. Approximate wind direction and speed
6. Address or location on lake most likely contacted
7. Photo of the swimmer's itch bumps (optional)

Please note: this reported data will help the LLA address this lake issue. Although he may not be able to respond to your email, please rest assured that each contact will be recorded, compiled, and shared with the LLA board and general membership. Thanks for helping in our quest to alleviate problems with swimmer's itch! Ron Reimink, Lime Lake Association (LLA Biologist), email: reiminkron@gmail.com

CHAPTER 3: EXISTING WATER QUALITY INFORMATION AND RESULTS FOR THE GOOD HARBOR BAY WATERSHED

3.1 WATER QUALITY DATA AND REPORTS

Significant data and summary reports have been produced which describe the water quality of the Good Harbor Bay watershed throughout the year. Following are information sources used in the following water quality summary:

- Leelanau County Inland Lakes Project: A Study of Development and Water Quality Within the Little Traverse and Lime Lake Watersheds, Leelanau County, MI, Steinburg et al, 1994
  - A study completed in partial fulfillment of the requirements for the degree of Master of Science and Master of Landscape Architecture University of Michigan School of Natural Resources and Environment
- Report of the Leelanau Watershed Council, Water Quality Monitoring Program (A synthesis of data from 1990 - 1995) – T. Keilty (7/1997)
- A summary of water quality parameters that were sampled from 1990-1995 in several Leelanau County lakes, including Lime and Little Traverse Lakes. Parameters included: TP, Nitrate+Nitrite Nitrogen, Chlorophyll-a, and SD.
- Report of the Leelanau Watershed Council, Nutrient Data and Budgets for Leelanau County Streams and Lakes 1990 – 1996 – R. Canale and W. Nielsen (9/1997)
  - This study summarized the nutrient budgets (inflow and outflow) of several Leelanau County lakes, including Lime and Little Traverse Lake. This study is over ten years old, but is the only study of the nutrient flux in these lakes.
- Michigan Department of Natural Resources, Historical Review and Management Prescription for Little Traverse Lake Fishery, (1/2002).
- Michigan Department of Natural Resources, Historical Review and Management Prescription for Lime Lake Fishery, (1/2002).
- Report of the Leelanau Watershed Council, Water Quality Monitoring (A Synthesis of data from 1990 through 2001) - T. Keilty and M. Woller (2/2002)

- An update (1990-2001) of a 1997 report summarizing water quality parameters sampled from several Leelanau County lakes, including Lime and Little Traverse Lakes. Parameters included: TP, TN, Chlorophyll-a, and SD.
  - While seemingly a long period of monitoring, the researchers in these studies indicate the program is just emerging from its infancy. The data have changed over this period because of the colonization of exotic zebra mussels which have affected the lake's ecology. The authors recommended more targeted studies for emerging issues.
- Predicting Blue-Green Algal Blooms & Potential Toxin Production in Zebra Mussel Infested Oligotrophic Lakes (Leelanau Watershed Council, Leelanau Conservancy for MDEQ) – M. Woller and T. Keilty (2004)
- A study of the influence of zebra mussels on the plankton populations of several Leelanau County lakes, including Lime and Little Traverse.
  - The authors cited literature sources that documented zebra mussels selectively consume green algae and reject cyanobacteria. This mechanism causes the decline in diversity of plankton and potential for cyanobacteria blooms causing a commensurate increase of microcystin (a hepatotoxin) excreted by the cyanobacteria Microcystis aeruginosa.
- Microcystin Production and Fate in Zebra Mussel Infested Oligotrophic Lakes, Prepared for Michigan Department of Environmental Quality, M. Woller and T. Keilty (3/2006)
  - This study report documented concentration and fate of microcystins generated by cyanobacterial blooms in several Leelanau County lakes, including Lime and Little Traverse Lakes. The report recorded concentration of microcystin (an hepatotoxin) in the water, sediments, macroinvertebrates and fish. The authors hypothesized potential for persistence and bioaccumulation of microcystin based on literature and results of their work.

3.2 LIME LAKE AND LITTLE TRAVERSE LAKE WATER QUALITY SUMMARY

Leelanau Conservancy Watershed Council Database – (1990-2014)

This database contains chemical and physical water sampling results of Leelanau County lakes and streams starting from 1990 through the 2014[1]. This database is available as a result of a water quality program started by Dr. Tim Keilty in 1989 and other dedicated volunteer's in 1989. The program and database is hosted and supported by the Leelanau Conservancy. Lime and Little Traverse Lakes and their tributary streams are included in the database. Parameters on the seven major lakes in Leelanau County include: TP, nitrates, nitrites, Kjeldhal nitrogen, ammonia, chlorophyll a, conductivity, oxygen reduction potential, temperature, conductivity, pH and SD. The major tributaries (streams) to each of the major lakes are also sampled for Total Phosphorus and discharge. The database provides an overview of trends over time. The stream samples include an estimate of discharge and average of phosphorous loading to Lime and Little Traverse Lakes from Shetland, Shalda and Lime Creeks. Zebra mussels were introduced to Little Traverse Lake in 1998 and showed established populations by 2002. In Lime Lake zebra mussels were introduced in 2002 (Woller-Skar 2009).

A report completed on Lime and Little Traverse Lake in partial fulfillment of the requirements for the degree of Master of Science and Master of Landscape Architecture University of Michigan School of Natural Resources and Environment in 1994 was referenced for this water quality section. It is titled: Leelanau County Inland Lakes Project: A Study of Development and Water Quality Within the Little Traverse and Lime Lake Watersheds, Leelanau County, MI, Steinburg et al, 1994. Keilty and Woller 2002 and Canale and Neilsen 1997 are also referenced.

[1] There was no data available for the Lakes in 2013.

Nutrients (Phosphorus – P and Nitrogen – N)

Total phosphorus (TP) is an essential nutrient for plant growth, but it tends to be low in northern lakes. Keilty and Woller (2002) provided information that indicated Lime and Little Traverse Lakes are oligotrophic, or high quality, clear lakes with low productivity. Oligotrophic lakes are typified by total phosphorus (TP) concentrations ranging from 3ug/L to 17ug/L, and Total nitrogen (TN) concentrations between 307ug/L and 1630ug/L. An N:P ratio of greater than 10 typically indicates that the lake is a Phosphorus limiting system. Table 14 below shows that from 1990-2014, TP concentrations for Lime and Little Traverse Lakes fell within Wetzel's oligotrophic classification (Wetzel 2001 and Keilty and Woller 2002) reported nitrate/nitrite (N) concentrations as opposed to Wetzel's classification using TN (which also includes organic and ammonia nitrogen). The ranges of the nitrate/nitrite values below show the lakes nitrogen levels also likely fall into the oligotrophic range for Lime Lake and Little Traverse Lake (Table 14).

Table 14- Lime and Little Traverse Lakes Water Quality Summary Data

Lime Lake		Little Traverse Lake	
Parameter	**Result**	**Parameter**	**Result**
TP	4.3	**TP**	5.1
N	216	**N**	125.8
N:P Ratio	50.9	**N:P Ratio**	23.6

The trophic state of lakes is indicative of their biological productivity, or the amount of living material supported within them, primarily in the form of algae. The least productive lakes are called 'oligotrophic'. These are typically cool and clear, and have relatively low nutrient concentrations. The most productive lakes are called ‘eutrophic’ and are characterized by high nutrient concentrations which result in algal growth, cloudy water, and low dissolved oxygen levels. Those lakes with a trophic status that falls along the continuum somewhere between oligotrophy and eutrophy are termed ‘mesotrophic’ (Adapted from http://www.epa.gov/greatlakes/glindicators/water/trophicb.html).

Using long term data from the water quality database, allows for monitoring the Trophic Status Index or TSI for all the lakes in Leelanau County. The Trophic Status Index (TSI) was calculated for all lakes for 2014 (Figure 16). Both Lime and Little Traverse Lake have a TSI < 35. The ratio of N/P is also an important factor in lake biology because microorganisms typically require about 10 times more nitrogen than phosphorus (Keilty and Woller 2002). Both Little Traverse Lake and Lime Lake have N/P ratios greater than 10 (see Figure 17).

Keilty and Woller (2002) also report a slight decline of TP from the water column, and attribute it to zebra mussel filtering of plankton in Little Traverse Lake, but no zebra mussels were reported in Lime Lake in 2002. Other factors they cite as possible reasons for phosphorus reduction are education efforts to riparian owners to reduce phosphorus containing substances such as fertilizer and detergents.

Figure 16: Trophic Status Index for all Lakes in Leelanau County (2014)

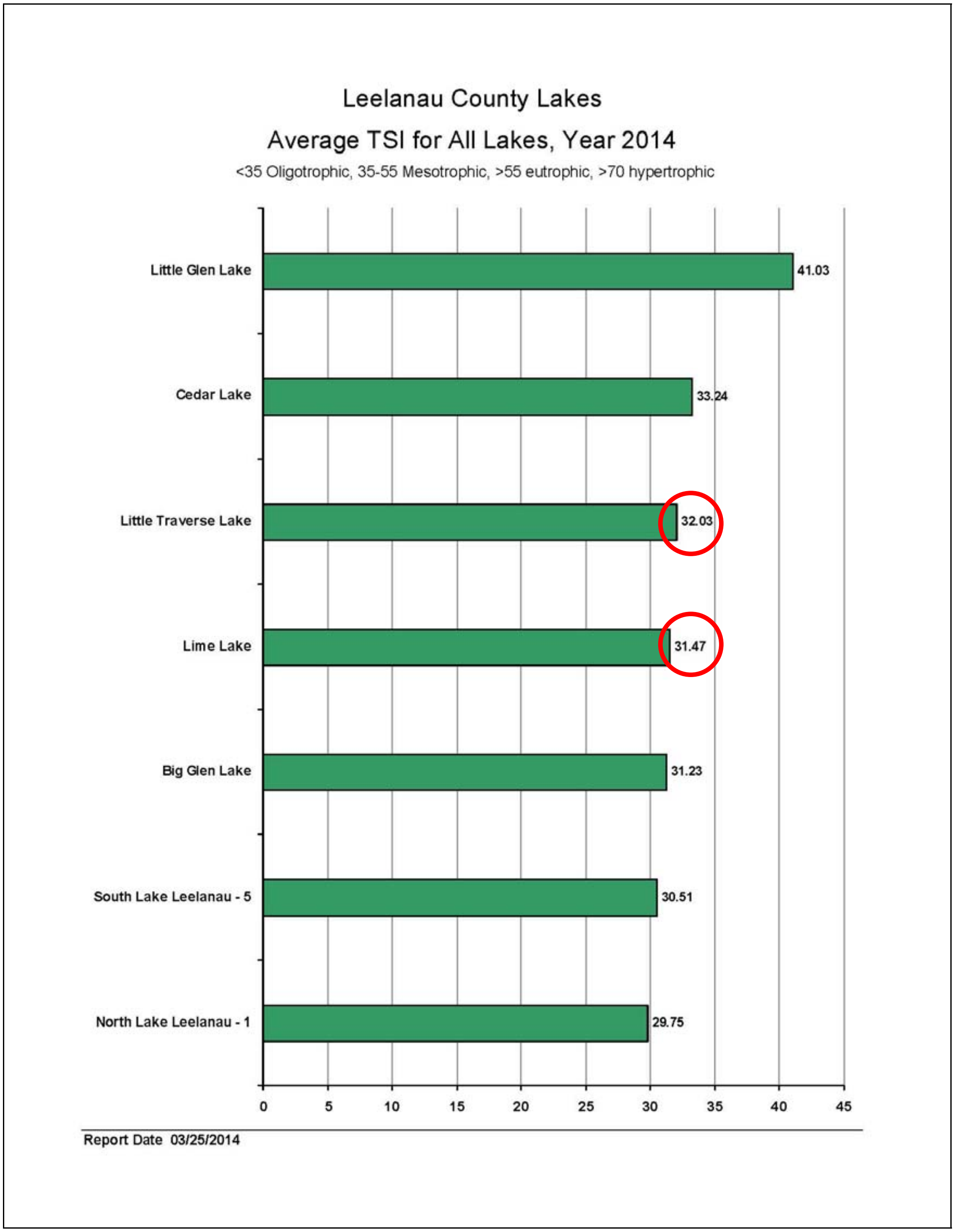
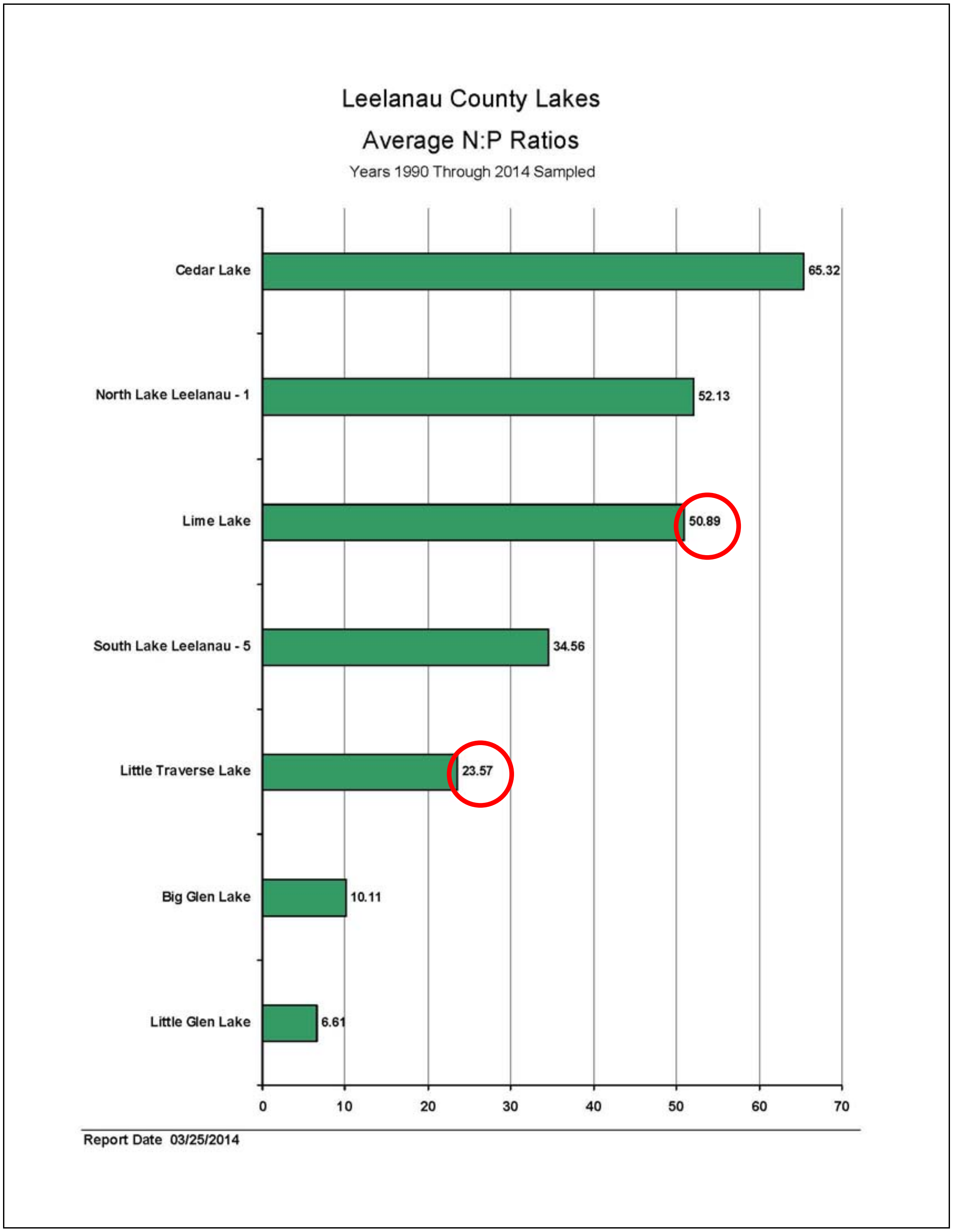


Figure 17: N:P Ratio for all Lakes in Leelanau County (1990-2014)



Lime Lake

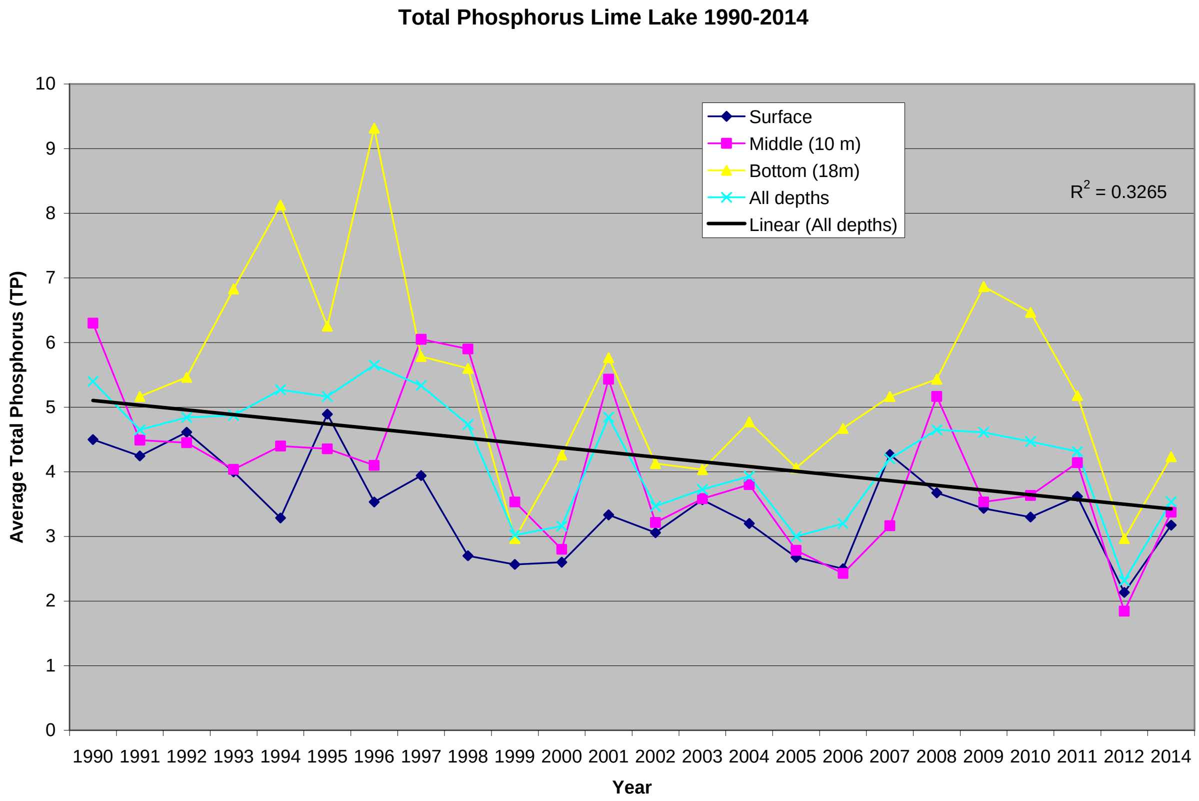
Lime lake was sampled for Total Phosphorus (TP) at three different depths 165 times for a total of 402 measurements from 1990-2014. Total Phosphorus (TP) for Lime Lake has averaged 4.3 ug/L at all depths (Table 15). This is the lowest observed average TP value for all of our lakes, placing Lime Lake in the ultra-oligotrophic range. Many who spend time in Lime Lake in the summer may notice the cloudy, lime green aspect of the water. This is due to the hard water calcareous nature of the system, and it undoubtedly results in some summertime co-precipitation of phosphorus with calcium carbonate, ultimately removing phosphorus from the system (Keilty and Woller 2002). All of the Lakes in Leelanau county experience this, but Lime Lake and nearby Glen Lake seem to be the most remarkable in this regard (Keilty and Woller 2002).

Table 15: Lime Lake Total Phosphorus (TP) and Nitrogen (NOx) results (1990-2014) at 0, 10 and the bottom (18 m), n =165

	0m	*10m*	18m	All depths
Parameter	***Result***	***Result***	***Result***	***Result***
TP (mg/L)	3.5	4.0	5.5	4.3
NOx (ug/L)	231.8	213.3	203.6	216.0

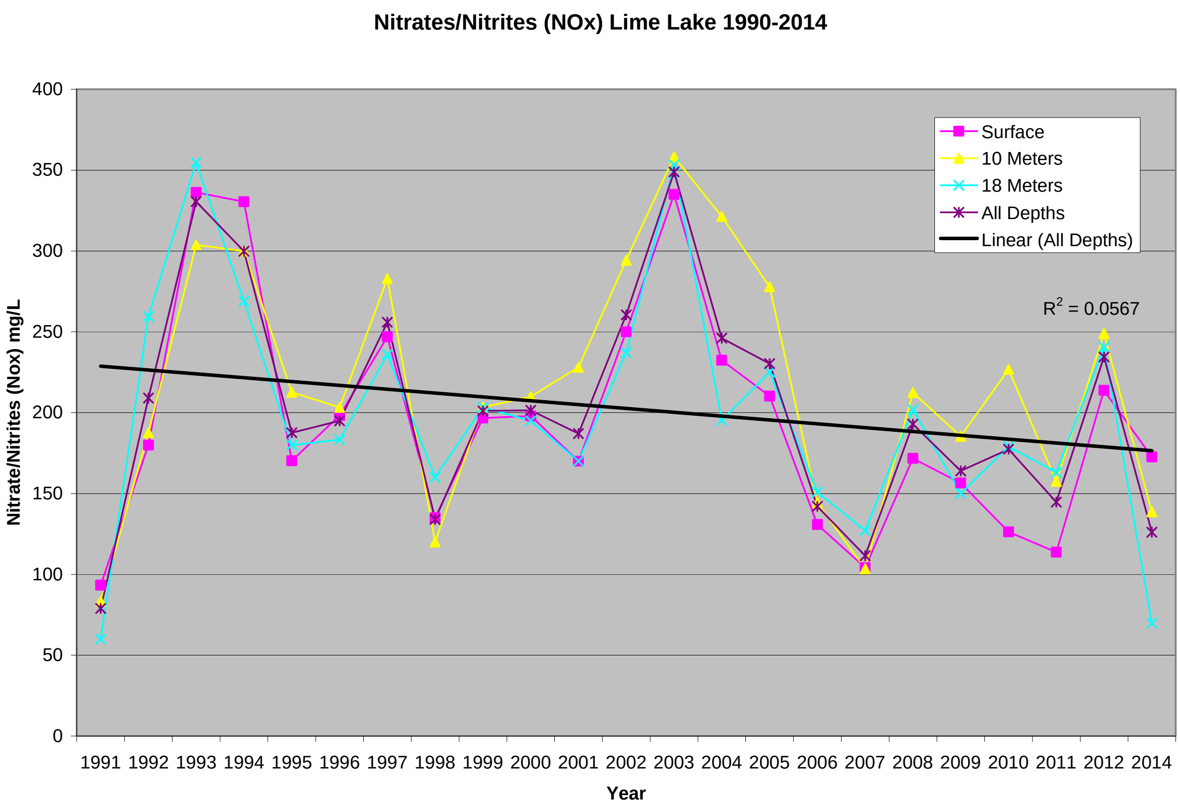
When looking at the TP values over the various depths (surface -0m, middle-10m and the bottom, 18m) from 1990-2014, there a slight decrease from 1990 (Figure 18). These levels are quite a bit higher than what was observed in Little Traverse Lake at 5.08 ug/L (Figure 20, page 90). While zebra mussel populations were observed as early as 1998 in LTL, they were not established in LTL until 2002 (Woller-Skar 2009). Efforts by riparian owners to reduce Phosphorus inputs undoubtedly have had an effect further enhanced by subsequent zebra mussel filtering.

Figure 18: Lime Lake Total Phosphorus (1990-2014)



Nitrate levels in Lime Lake averaged 215.9 ug/L for 364 observations, sampled 165 times (Table 16 above. Figure 19) resulting in an N:P ratio of 50.9. However, groundwater comprises an estimated 53% of the water coming into Lime Lake, while groundwater only comprises 16% of water coming into Little Traverse Lake (Canale and Neilsen 1997). It is believed that there are more extensive submergent weed beds in Little Traverse Lake and that these macrophytes may be assimilating much of the nitrate during the growing season (Keilty and Woller 2002).

Figure 19: Lime Lake Nitrate/Nitrites from 1990-2014



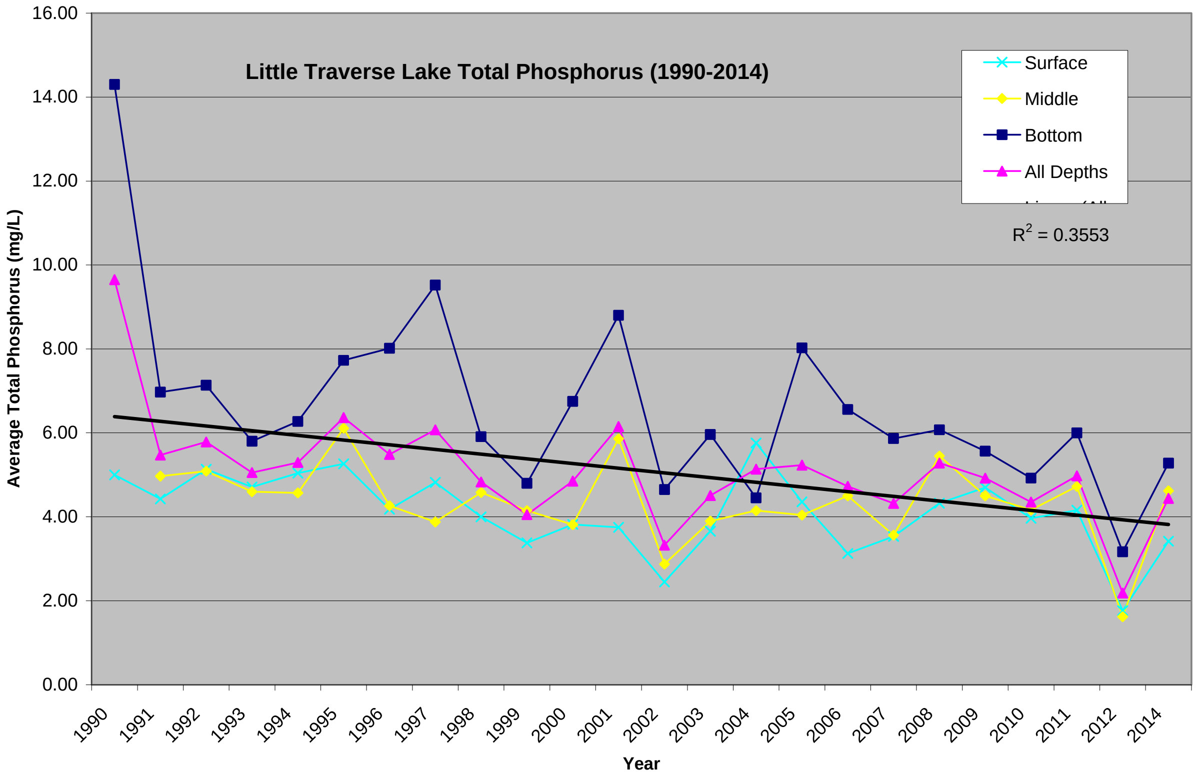
Little Traverse Lake

The Total Phosphorus (TP) in Little Traverse Lake has averaged 5.08 ug/L for 218 sampling dates for a total of 462 measurements from 1990-2014 (Table 16). By this standard, the lake would be considered oligotrophic. When looking at the average TP values over the various depths (surface -0m, middle-7m and the bottom, 12-14m) from 1990-2014, there is a slight decrease from 1990 (Figure 20).

Table 16: Little Traverse Lake TP and Nitrogen (NOx) at 0, 7 and the bottom (12-14 m) (1991-2014), n =218

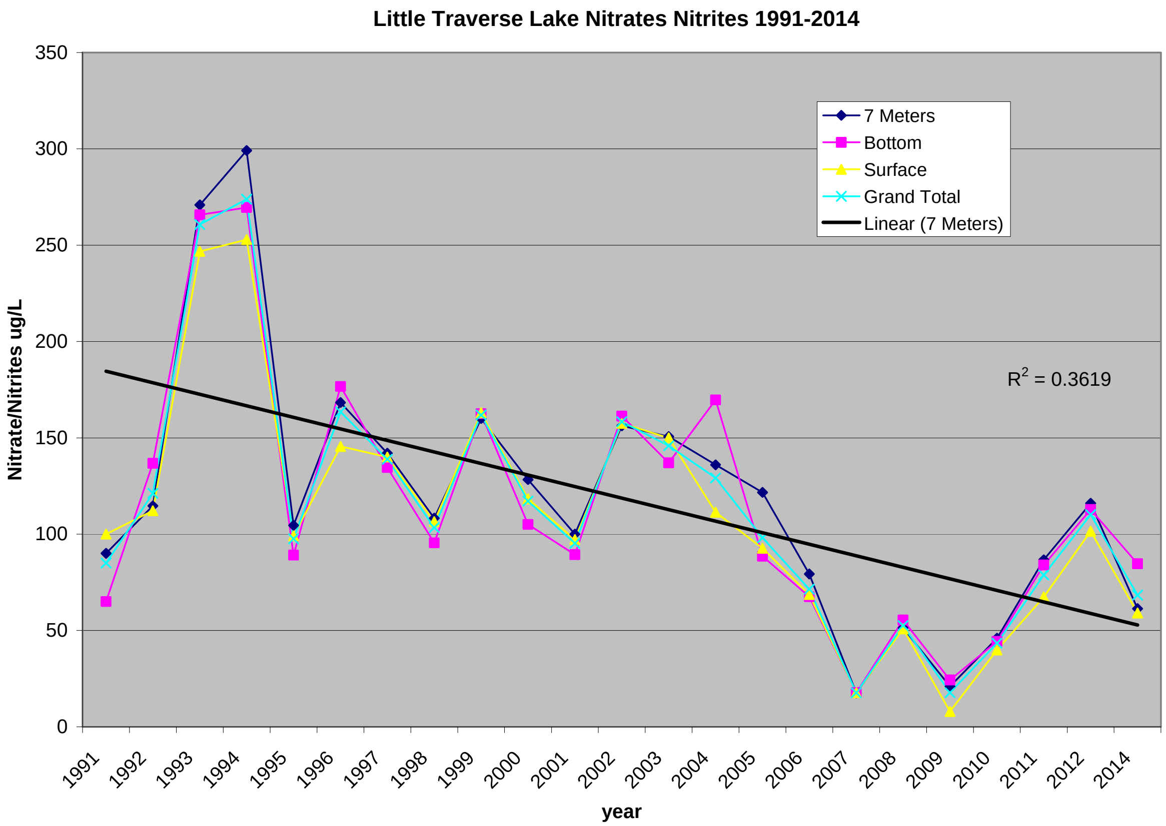
	0	7	bottom	All depths
Parameter	***Result***	***Result***	***Result***	***Result***
TP (ug/L)	6.5	4.4	4.3	5.1
NOx (ug/L)	124.7	130.0	117.6	123.8

Figure 20: Total Phosphorus Results (1990-2014) Little Traverse Lake



Nitrate nitrogen in Little Traverse Lake has average 123.8 ug/L for 218 sample dates for a total of 430 measurements from 1990-2014, resulting in an overall N:P ratio of 23.58. Levels of nitrate nitrogen have decreased with respect to time as demonstrated with the negative slope associated with the regression line (Figure 21).

Figure 21: Nitrate/Nitrites from 1990-2014 in Little Traverse Lake



Chlorophyll a

Both Lime and Little Traverse Lake are within ranges of chlorophyll a for oligotrophic lakes (0.3 – 4.5 ug/L) (Keilty and Woller, 2002) (Figures 22 & 23). The authors show decline of chlorophyll a from the water column, and attribute it to zebra mussel filtering of plankton in Little Traverse Lake, however in 2000 there was no evidence of zebra mussels in Lime Lake. By 2002 zebra mussels were noticed in Lime Lake (Woller Skar 2009).

Chlorophyll a in Lime Lake averaged 1.7 ug/L for 116 measurements from 1993-2014 (Figure 21). This is lower than the average from Keilty and Woller's data from 1990-2000 (2.58 ug/L). Chlorophyll a in Little Traverse Lake averaged 2.25 ug/L for 163 measurements from 1993-2014 (Figure 23).

Figure 22: Average Chlorophyll a for Lime Lake (1990-2014)

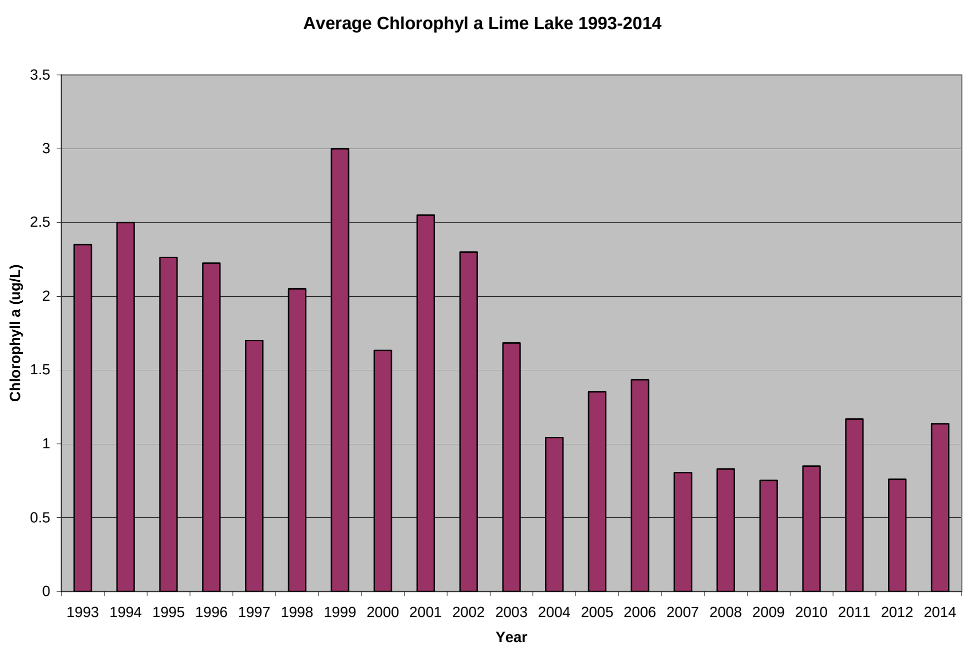
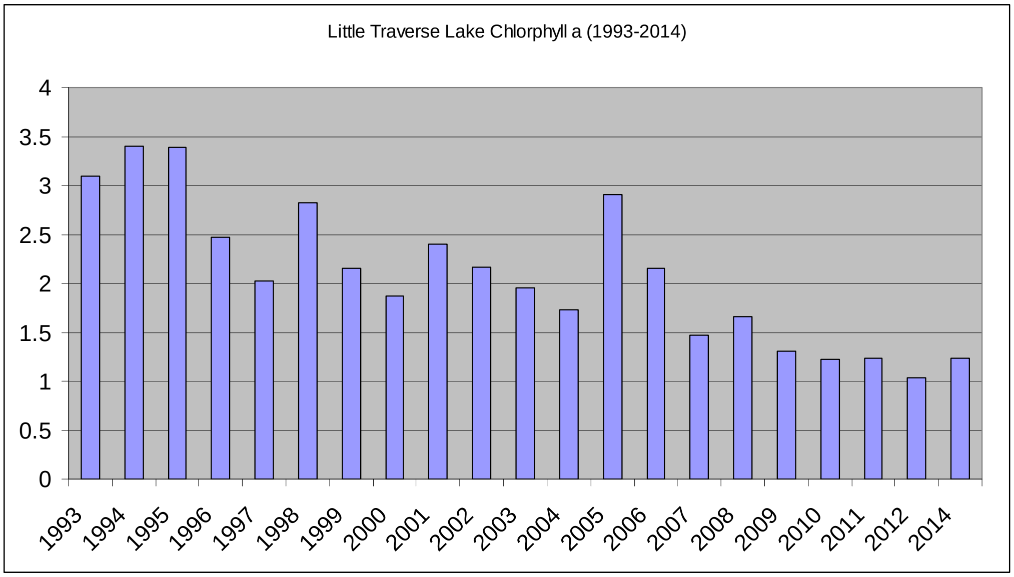


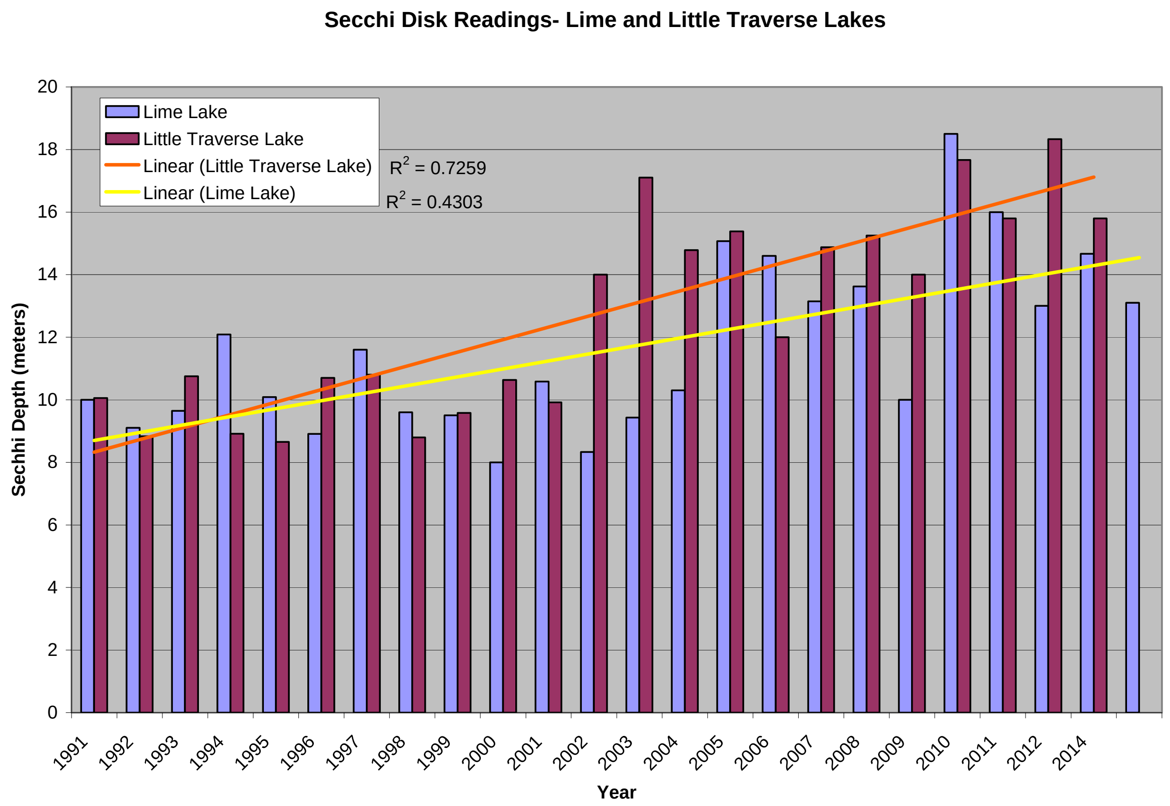
Figure 23: Average Chlorophyll a for Little Traverse Lake (1990-2014)



Secchi Disk

The Secchi disk is a measure of water transparency, which is directly linked to inorganic suspended solids and plankton abundance. Transparency and secchi disk depth measurements vary throughout year, with generally greater depths observed in spring and fall. The figure below shows average annual measurements from Lime and Little Traverse Lake from 1990-2014 which generally show an increase in secchi readings (or higher water clarity) for the averages of the two periods (Figure 24). This is mostly likely directly related to zebra mussel colonization. For example, in the spring of 2002, the secchi disc reading in Little Traverse Lake was 10m.

Figure 24: Average Secchi Disk Readings for Lime and Little Traverse Lakes (1990-2014)

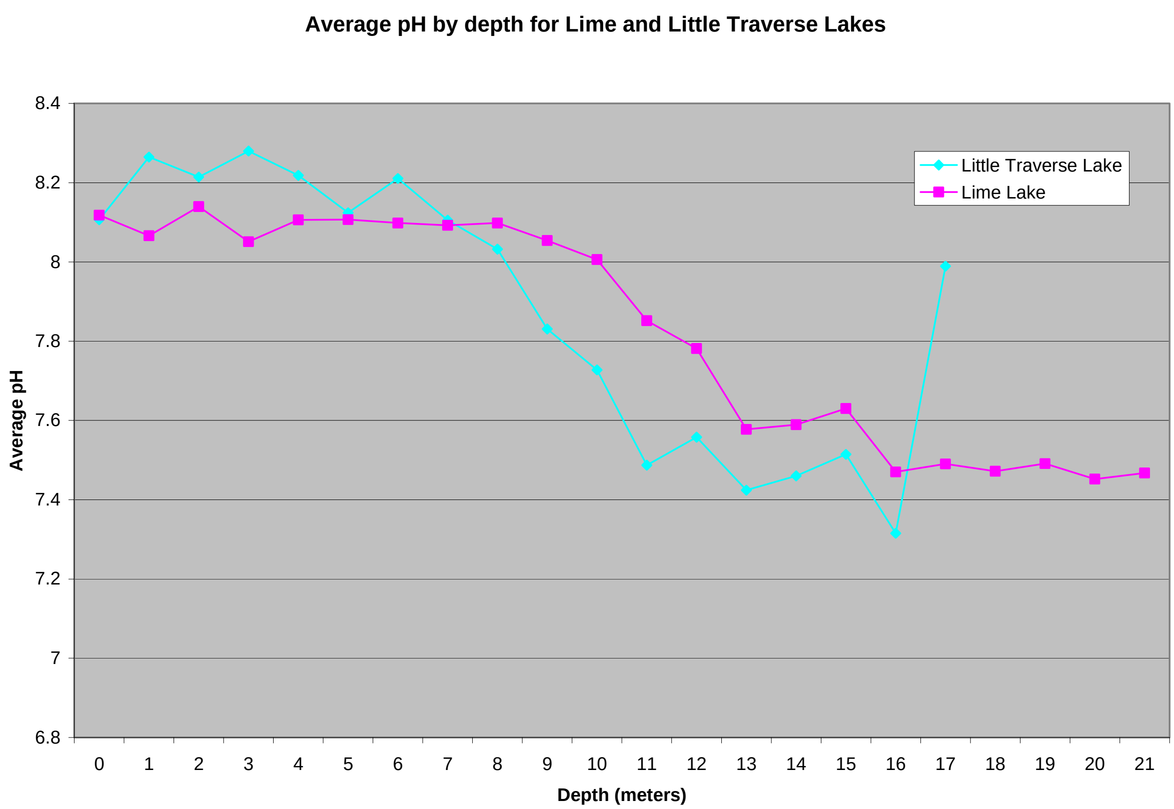


<u>General Characteristics: (Depth, Temperature, Dissolved Oxygen – DO, Conductivity, pH, Secchi Disk, Oxidation/Reduction Potential)</u>

Temperature and Dissolved Oxygen are intimately linked in northern temperate lakes such as Lime and Little Traverse Lake, because of the formation of a vertical temperature gradient during summer periods. Because cooler water is denser than warmwater it settles to the bottom of the lake. As the sun continues to heat the lake surface layer, the warm/cool water density gradient becomes too great to allow mixing of surface and bottom water. The upper layer of warmwater is called the epilimnion, the transition zone the thermocline, and the cooler bottom water the hypolimnion. This lack of vertical mixing creates environments where near-bottom oxygen can be reduced or depleted. Near bottom oxygen depletion occurs in both Lime and Little Traverse Lake. These conditions favor the release of Phosphorus from the sediments, consistent with observed data.

The pH was sampled for each of the lakes at various depths from the surface to the bottom. The pH of both Lime and Little Traverse Lake tend to stratify during the summer because of the photosynthetic activity of the plankton. The epilimnion tends to be higher, above a pH of 8.0 and the hypolimnion tends to have pH near 7.5 (Figure 25).

Figure 25: Average pH by depth (meters) for Lime and Little Traverse Lakes



Hydrolab profile data, secchi disk transparency data, and water samples have been collected 3-6 times per year on Lime Lake between 1990-2014, Water samples were collected at the surface, 10, and 18 meters, while 50 ml Chlorophyll a samples have been collected at 1 meter since 1993. Profile and water chemistry data indicate that the water quality of Lime Lake is also good and stable characteristic of a northern dimietic oligotrophic lake (Table 17) (Keilty 1997). Although consistently exhibiting oxygen depletion prior to fall overturn, the internal phosphorus input is probably small. Concentrations in the hypolimnion are elevated relative to the overlying water, particularly in the early and late summer periods and it is unlikely that a significant amount of Phosphorus precipitates when O_2 returns (Keilty 1997). The data from 1990-2014 appear as expected, normal, while higher concentrations in the early summer are more difficult to interpret.

Hydrolab profile data, secchi disk transparency data, and water samples have been collected 3-6 times per year on Little Traverse Lake between 1990-2014, Water samples were collected at the surface, 7, and 14 meters, 50 mI Chlorophyll a samples have been collected since 1993. Profile and water chemistry data indicate that the water quality of Little Traverse Lake is also good and very different from other lakes (Keilty 1997) (Table 17). Although consistently exhibiting oxygen depletion prior to fall overturn, the numbers suggest there is some internal phosphorus input from the oxygen depleted hypolimnion each summer (Keilty 1997).

Table 17: Hydrolab profile data for Little Traverse Lake and Lime Lake (1990-2012)

Lime Lake		*Little Traverse Lake*	
Parameter	Result	Parameter	Result
Depth ft (maximum)	67	Depth ft (maximum)	54
Depth ft (mean)	17.8	Depth ft (mean)	9.6
Temperature (F) Surface	63.9	Temperature (F) Surface	65.1
Temperature (F) Bottom	49.9	Temperature (F) bottom	55.4
Dissolved Oxygen (surface)	9.3	Dissolved Oxygen (surface)	9.29
Dissolved Oxygen (bottom)	5.5	Dissolved Oxygen (bottom)	4.4
Conductivity (surface)	0.289	Conductivity (surface)	0.318
Conductivity (deepest)	0.302	Conductivity (deepest)	0.359
pH (surface)	8.11	pH (surface)	8.10
pH (deepest)	7.46	pH (deepest)	7.4
Secchi Disc (range)	8m-18.5m	Secchi Disc (range)	8.7m-18.3m
Secchi Disc (average)	11.6m	Secchi Disc (average)	12.7m

Nutrient Loading for Nitrogen and Phosphorus --

A study of Leelanau County lakes, including Lime and Little Traverse Lake was completed by Canale and Nielsen (1997). The research covered the period 1992 – 1995. It quantified contributions of nitrogen and phosphorus to the lakes by atmospheric deposition, groundwater, septic systems and tributaries. Outputs included evaporation and outflows. The mass balance between inputs and outputs was assumed to remain in the sediments or ecosystem biomass. Another report by Dr. Tim Keilty and Meg Woller was written in 2002 and summarizes the water quality data for all Leelanau County Lakes from 1990-2000 (Keilty and Woller 2002). Since 2000, water quality sampling in the major lakes and tributaries has continued and a database was created in 2008. However, this data was not formally summarized in an updated report, specifically for Lime or Little Traverse Lake until the GHB watershed planning process started.

Lime Lake Nutrient Budget

Lime Lake nutrient loading is summarized in Table 18 using data from 1992-1997 (Canale and Nielsen 1997). It is estimated Lime Lake received 38,587 pounds of TN and 579 pounds of TP annually. Fourteen percent of TP input to Lime Lake is contributed by its major tributary, Lime Creek. Another 25% comes from atmospheric deposition, 18% from internal loading, 20% from groundwater, and 23% from septic systems. About 60.4% of the TN and 70% of TP are retained in the system.

Algae require about 10 times more nitrogen compared to phosphorus for growth and reproduction. The N:P ratios of both the inputs and outputs from Lime Lake are well above ten, therefore phosphorus is the limiting nutrient in Lime Lake (Neilson 1997). Approximately 70% of the phosphorus input to Lime Lake is retained in the sediments. This value is consistent with observations from other lakes with similar water quality. Approximately 74% of the phosphorus input to the lake is from either streams, groundwater, septic systems, or lake sediments. This suggests that improvements or possible future degradations in lake water quality are strongly linked to local watershed activities.

Table 18: Lime Lake Nutrient Budget

	Flow	Total Nitrogen		Total Phosphorus			N:P Ratio
	(cfs)	(ug/L)	Lb/yr	(ug/L)	Lb/yr	% Total	N:P
Lime Creek	5.31	1099	11,484	7.8	82	14	140.9
Atm Deposition	2.47		4,971		151	25	33
Septic Systems			1,670		131	23	12.7
Internal Loading			1,040		104	18	10
Groundwater	8.79	1,124	19,22	6.4	111	20	175.6
TOTAL	**16.57**		**35,587**		**579**		**66.6**
OUTPUT							
Shetland Creek	23.79	550	14,925	6.3	171		87.3
Evaporation	2.47						
Groundwater	0.31	550	336	3.6	2		152.8
TOTAL	**16.57**		**15,261**		**173**		**88.1**
NUTRIENT RETENTION			**60.4%**		**70.1%**		

Little Traverse Lake Nutrient Budget

Little Traverse Lake nutrient loading is summarized in Table 19 (Canale and Nielsen 1997). It is estimated that Little Traverse Lake received 21,024 pounds of TN and 236 pounds of TP annually. Thirty percent of TP input to Little Traverse Lake is contributed by its major tributary, Shetland Creek. Another 22% comes from atmospheric deposition, 6% from internal loading, 10% from groundwater, and 32% from septic systems.

Algae require about 10 times more nitrogen compared to phosphorus for growth and reproduction. The N:P rations of both the inputs and outputs from Little Traverse Lake are well above ten, therefore phosphorus is the limiting nutrient in Little Traverse Lake (Canale and Neilson 1997). Approximately 64% of the input to Little Traverse Lake is retained in the sediments. This value is consistent with observations from other lakes with similar water quality. Approximately 78% of the phosphorus input to the lake is from either streams, groundwater, septic systems, or lake sediments. Note that almost 1/3 of the phosphorus loading is expected from septic drain fields. This suggests that improvements or possible future degradations in lake water quality are strongly linked to local watershed activities.

Table 19: Little Traverse Lake Nutrient Budget

	Flow	Total Nitrogen		Total Phosphorus			N:P Ratio
INPUT	(cfs)	(ug/L)	Lb/yr	(ug/L)	Lb/yr	% Total	N:P
Shetland Creek	15.87	550	17,176	6.2	194	30	88.7
Atm Deposition	2.36		4,748		144	22	33
Septic Systems			2,649		208	32	12.7
Internal Loading			410		41	6	10
Groundwater	3.52	1573	10,896	10	69	10	157.3
TOTAL	**21.75**		**35,879**		**656**		**54.7**
OUTPUT							
Shalda Creek	19.13	551	20,743	6.2	233		88.9
Evaporation	2.36						
Groundwater	.26	551	282	6.2	3		88.9
TOTAL	**21.75**		**21,024**		**236**		**88.9**
NUTRIENT RETENTION			**41.4%**		**64.0%**		

(Canale and Neilsen 1997 report)

3.3 LIME LAKE AND LITTLE TRAVERSE LAKE SHORELINE SURVEY SUMMARY

Lime Lake Shoreline Greenbelt Survey Summary Report

Purpose

The purpose of the Lime Lake shoreline and greenbelt survey was to evaluate the current condition of the existing shoreline and to establish a baseline of shoreline conditions for future evaluations.

Background

The Good Harbor Bay Watershed plan is a work in progress. The shoreline greenbelt survey will serve as a point of information in determining recommendations and actions as part of water quality protection planning. Other watershed plans have established that major threats to high water quality are sediments from erosion and storm water runoff and nutrients from fertilizers, storm water runoff, and leaking septic systems.

Survey Method

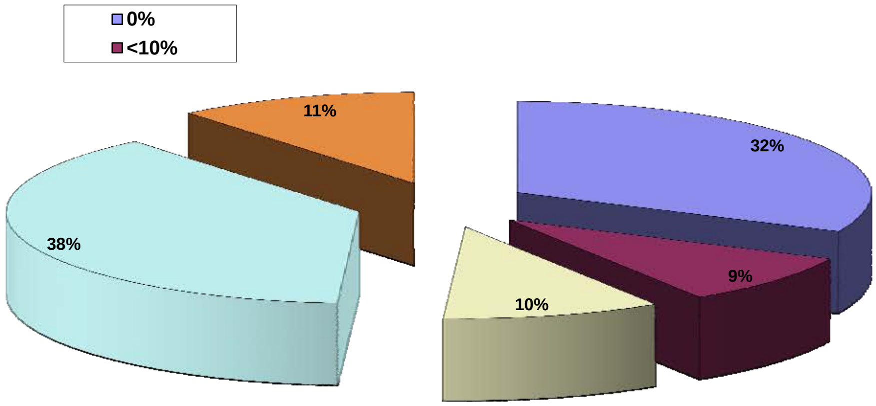
The shoreline survey of the entire Lime Lake coastline was conducted during the summer of 2013. Lime Lake is located within Cleveland Township, Leelanau County, Michigan.

All properties were surveyed with data recorded on survey sheets, including GPS readings and photos taken. Funding was provided by the Lime Lake Association.

Summary of Data

Looking at the data gathered from the Lime Lake Shoreline and Greenbelt survey, 42% of the shoreline of Lime Lake is natural and 58% is landscaped. About 66% of the shoreline of Lime Lake is developed, and only 34 % is natural. Vegetation coverage was also documented and the results show about 32% of the shoreline had no vegetation coverage (Figure 26). This could be an area of concern and where educational efforts could be focused.

Figure 26: Vegetation Coverage for Lime Lake



Little Traverse Lake Shoreline Greenbelt Survey Summary Report

The purpose of the Little Traverse Lake shoreline and greenbelt survey was to evaluate the current condition of the existing shoreline and to establish a baseline of shoreline conditions for future evaluations.

Background

The Good Harbor Bay Watershed plan is a work in progress. The shoreline greenbelt survey will serve as a point of information in determining recommendations and actions as part of water quality protection planning. Other watershed plans have established that major threats to high water quality are sediments from erosion and storm water runoff and nutrients from fertilizers, storm water runoff, and leaking septic systems.

Survey Method

The shoreline survey of the entire Little Traverse Lake coastline was conducted during the summer of 2013. Little Traverse Lake is located within Cleveland Township, Leelanau County, Michigan.

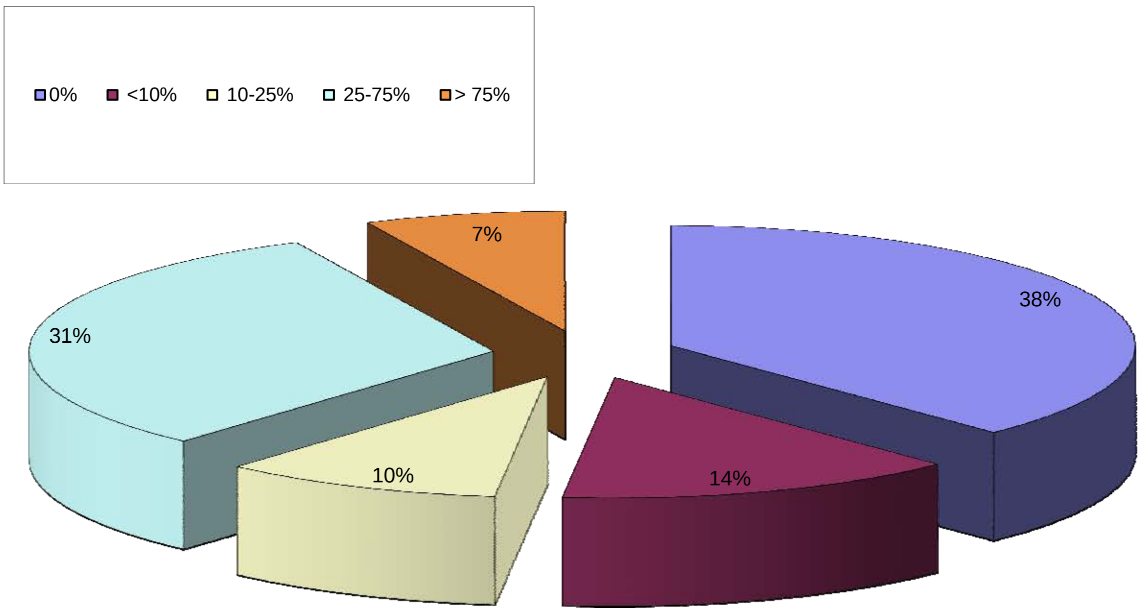
All properties were surveyed with data recorded on survey sheets, including GPS readings and photos taken. Funding was provided by the Little Traverse Lake Property Owners Association.

Summary of Data

Looking at the data gathered from the Little Traverse Lake Shoreline and Greenbelt survey, below is the summary of the study:

A) 54.5% of the shoreline of Little Traverse Lake is natural and 45.5% is landscaped
B) 51.7% of the shoreline of Little Traverse Lake is developed and 48.3% is undeveloped
C) Vegetation coverage of the shoreline of Little Traverse Lake are shown in Figure 27.

Figure 27: VEGETATION Coverage for Little Traverse Lake



3.4 SLEEPING BEAR DUNES NATIONAL LAKESHORE WATER QUALITY SUMMARY

Water resources at Sleeping Bear Dunes National Lakeshore (SLBDLNS) are abundant, diverse, and of high quality. They include 27 named inland lakes, five rivers and streams, 65 miles of Lake Michigan shoreline and nearshore waters, as well as an abundance of bogs, springs, and interdunal wetlands (see Figure 14, Page 53 for the SLDNLS boundaries within the Good Harbor Bay Watershed). Although studies of these waters precede 1940, for the purpose of this watershed management plan only the current water quality monitoring program is included. The following is a brief overview of the water quality monitoring program at SLBE.

The water quality monitoring program at SLBE is part of a larger initiative to establish consistent, scientifically sound water quality monitoring within regions of the National Park Service (NPS). Since 2007, water quality monitoring at SLBE has been done in conjunction with the NPS Great Lakes Inventory and Monitoring Network (GLKN). While developing a monitoring protocol for inland lakes a national review panel, assembled by the National Park Service – Water Resources Division, recommended a suite of five parameters be measured for all NPS monitored inland lakes. In addition to these five mandated parameters (temperature, pH, specific conductance, dissolved oxygen, and flow/water level) a measure of water clarity (Secchi depth or transparency tube depth) was added to the core suite. The core suite was ranked highest among potential vital signs for aquatic systems of GLKN parks, although it was recognized that these measurements were less diagnostic of water quality degradation than biotic communities and other water quality variables, such as nutrient concentrations.

Inputs of excess nutrients, invasion and spread of exotic species, and contaminants from atmospheric fallout and surface runoff, and how these stressors affect the chemical and biological functions of lakes are key issues of concern to the NPS. By monitoring an advanced suite of parameters (nitrogen and phosphorus species, dissolved organic carbon, major ions, dissolved silica, and chlorophyll-a), data can be collected for a more thorough understanding of changes in lakes over time. The primary objective of this monitoring program is to monitor water quality in order to describe the current status and to detect trends of common limnological parameters within sampled lakes. The hope is to be able to provide early warnings of change, work with researchers to understand the causes of change, and provide interpretation of our results to the public.

Starting in 2007, SLBDNL has focused its water quality monitoring efforts on ten inland lakes: Manitou, Florence, Shell Tucker, Narada Bass Loon, Round, Otter, and North Bar. Each lake, excluding Narada, is sampled three times during the field season by park natural resources staff. At each lake a multi-probe datasonde is used to collect depth profiles of temperature, pH, conductivity, and dissolved oxygen. Additional measurements recorded on-site include water clarity, water level relative to a benchmark, and a list of physical and environmental conditions. Additionally, water samples are collected and shipped to a contract laboratory facility for analyses of the advanced suite of parameters, including: nutrients (total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica), major ions (calcium, sodium, magnesium, potassium, sulfate, and chloride), dissolved organic carbon, alkalinity, and chlorophyll-a.

Of the 27 inland lakes at least partially within the SLBDNL boundary, very few fall within the Good Harbor Bay Watershed. In fact, Shell and Bass Lakes are the only inland lakes within the watershed that is part of the water quality monitoring program at SLBDNL. . All the information collected through SLBE’s inland lakes water quality monitoring program is submitted to the U.S. Environmental Protection Agency (EPA) and made available to the public through the EPA’s STORET database. For additional information on natural resources within the National Lakeshore, please visit the SLBE website at: www.nps.gov/slbe.

CHAPTER 4: THREATS TO WATER QUALITY IN THE GOOD HARBOR BAY WATERSHED

4.1: WATER QUALITY STANDARDS AND DESIGNATED USES

Each of Michigan's surface waters is protected by water quality standards for specific designated uses (Table 20). Designated uses as defined by the State of Michigan are recognized uses of water established by state and federal water quality laws designed to 1) protect the public's health and welfare, 2) enhance and maintain the quality of water, and 3) protect the state's natural resources. The water quality standards are found in Table 21 (page 110).

Table 20: Designated Uses for Surface Waters in the State of Michigan

All surface waters in the state of Michigan are designated for and shall be protected for all of the following uses:
1. Agriculture
2. Industrial water supply
3. Navigation
4. Warmwater fishery
5. Other indigenous aquatic life and wildlife
6. Partial body contact recreation
7. Total body contact recreation between May 1 – October 31
8. Fish Consumption

Citation: R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended

It is important to note that an additional coldwater fishery state designated use applies to Lime Creek, Shetland Creek and Shalda Creek from the outlet on Little Traverse Lake to Lake Michigan. Designated trout and salmon streams require high dissolved oxygen content and year-round temperatures below 74 degrees Fahrenheit. These are high water quality systems that depend on stable groundwater flows that are low in nutrients. The predominantly sandy loam soils of the region are highly permeable and very susceptible to the forces of erosion. Poor land use and development of land adjacent to stream corridors typically leads to excessive sediment being carried by stormwater flowing across the land into the stream channel. This can bury large woody debris and other in-stream habitat, which effectively turns the system into an aquatic desert.

Table 21: State of Michigan Water Quality Standards 3106

Pollutant	Water quality standards*	Designated Uses Affected
Dissolved solids	500 mg/L monthly average or 750 mg/L at any time	All
Chlorides	125 mg/L monthly average	Public Water Supply
pH	6.5 to 9/0	All but navigation
Taste or odor-producing	Any concentration	Public Water Supply, Industrial
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: 0.00011 µg/L ; Mercury, including methylmercury: 0.0013 µg/L ; PCBs (class): 0.00012 µg/L ; 2,3,7,8-TCDD: 0.0000000031µg/L	All but navigation
Radioactive substances	Pursuant to U.S nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1mg/L monthly average for permitted point-source discharges	All
Microorganisms	130 *Escherichia coli* per 100 ml 30-day mean of 5 or more sampling events	Total body contact recreation
	300 *E. coli* per 100 ml 30-day maximum	Total body contact recreation
	1,000 *E. coli* per 100 ml 30-day maximum	Partial body contact recreation
	Human sewage discharges (treated or untreated) 200 *E. coli* per 100 ml 30-day mean or 400 *E. coli* per 100 ml in 7 days or less	

Table 21: State of Michigan Water Quality Standards 3106 (Cont'd)

Pollutant	Water quality standards*	Designated Uses Affected
Dissolved oxygen	Minimum 7 mg/L for coldwater designated streams, inland lakes, and Great Lakes/connecting waters; minimum 5 mg/L for all other waters	Coldwater fishery
	Minimum 5 mg/L daily average	Warmwater fishery
Temperature	Natural daily and seasonal temperature fluctuations shall be preserved Monthly averages for inland lakes: J F M A M J J A S O N D 45 45 50 60 70 75 80 85 80 70 60 50 Monthly averages for inland streams in this watershed: J F M A M J J A S O N D 38 38 41 56 70 80 83 81 74 64 49 39	Coldwater fishery, other indigenous aquatic life and wildlife, warmwater fishery

*Data from Appendix B2 of DEQ's Integrated Water Quality Report – Water Quality and Pollution Control in Michigan (DEQ 2010)

4.2 IMPAIRED AND DEGRADED DESIGNATED USES

If a body of water or stream reach is impacted to the point of not meeting the water quality standards set for a specific designated use, then it is said to be in 'nonattainment'. An annually published listing of the bodies of water and stream reaches in the State of Michigan that are in nonattainment can be found in Appendix C of the DEQ's Integrated Water Quality Report – Water Quality and Pollution Control in Michigan (DEQ 2010). The DEQ uses a rotating watershed cycle for surface water quality monitoring where each of the 58 major watersheds in the state are scheduled for monitoring at least once every five years. The Good Harbor Bay watershed was last monitored in 2013 by the Surface Water Assessment Section, and results show that none of the designated uses are impaired on a watershed-wide level.

Due to widespread mercury contamination from industrial emissions occurring in other states lying upwind of Michigan (in terms of predominate weather patterns), all of Michigan's inland lakes, including lakes in the Good Harbor Bay Watershed, are not meeting water quality standards for fish consumption. Fish consumption advisories for PCBs or mercury are the primary cause of inland lakes not meeting water quality standards (DEQ 2008). For further information on mercury sources in the environment and mercury pollution prevention strategies, please refer to publications by Sills (1992) and Mehan (1996), respectively. The problem of mercury contamination and other related toxic contamination problems (i.e., PCB, chlordane, etc.) in the Good Harbor Bay watershed will not be discussed in depth in this Protection Plan, since it is caused by atmospheric deposition of industrial emissions from other states and the DEQ does not consider it to be a treatable 303 (d) impairment.

Degraded water bodies are defined as those that currently meet water quality standards, but may not in the near future. Currently, the designated uses of the Good Harbor Bay watershed are degraded from inputs of phosphorus from various sources within the watershed, increasing human development along with exotic species introduction and proliferation. The GHBWPP has identified the warmwater/coldwater fishery, other indigenous aquatic life and wildlife, and total body contact designated uses as degraded (Table 22). Degraded designated uses were ascertained through scientific research reports, water quality monitoring reports, steering committee members, and personal contact with watershed residents and scientific experts on the Good Harbor Bay watershed.

Table 22: Degraded or Impaired Designated Uses in the Good Harbor Bay River Watershed

Designated Uses	
Warmwater and Coldwater Fishery	Degraded
Other Indigenous Aquatic Life and Wildlife	Degraded
Partial/Total Body Contact Recreation (May1-Oct 31)	Degraded
Fish Consumption	Impaired

4.3 DESIRED USES

Steering committee and stakeholder input identified the need for establishing Desired Uses to address concerns particular to the watershed that are not addressed by designated uses, which are based on state water quality standards. Desired uses are defined as the ways in which people use the watershed and how they would like to manage and protect the watershed to ensure the sustainability of those uses for future generations. They may range from very general to very specific. Desired uses often help to reflect more qualitative community concerns such as poor sport fishing opportunities or deterioration of scenic viewsheds. Desired uses for the Good Harbor Bay watershed include uses for recreational, aesthetic, human health, and ecosystem preservation (Table 23).

Table 23: Desired Uses for the Good Harbor Bay Watershed

Desired Use Category	Location	Purpose
Recreational Opportunities	Entire watershed	*Sustain high quality inland lake fisheries, coldwater stream fisheries, hunting, paddling, swimming and boating. Develop and promote additional outdoor passive recreational activities such as mountain biking opportunities.
Aesthetics	Forested ridgelines, view corridors and surface water bodies	*Protect forested ridgelines from development to protect water quality and scenic view corridors. *Maintain water clarity and prevent 'whiting' events *Prevent excessive algal growth
Human Health	Lakes, rivers, groundwater	*Primarily groundwater potable water supply.
Ecosystem Preservation	Priority areas	*Promote sustainable watershed development *Protect fish & wildlife habitat *Preserve natural & intact riparian corridors

4.4 POLLUTANTS, SOURCES, AND CAUSES

There are a number of different pollutants and environmental stressors that adversely affect each of the designated and desired uses (Table 24). The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem, but are not necessarily categorized as contaminants that change water chemistry. It is meant to address the wide range of environmental degradation experienced in the watershed. This plan will refer to classic watershed pollutants such as nutrients, sediment, and toxic substances, as well as environmental stressors such as habitat and wetland loss. Environmental stressors representing activities and conditions that negatively impact the designated and/or desired uses of the Good Harbor Bay watershed include invasive species, loss of habitat, excess nutrients, and more (Table 25).

Table 24: Pollutants and Environmental Stressors Affecting Designated Uses in the Good Harbor Bay Watershed

Pollutant or Environmental Stressor	Designated Uses Affected	Desired Uses Affected
Loss of Habitat	Warmwater/Coldwater Fishery	Aesthetics
	Other Indigenous Aquatic Life	Recreation
Invasive Species	Coldwater Fishery	Aesthetics
	Other Indigenous Aquatic Life	Recreation
	Total Body Contact	Ecosystem Preservation
Nutrients	Warmwater/Coldwater Fishery	Aesthetics
	Other Indigenous Aquatic Life	Human Health
	Total Body Contact	
Fluctuation Lake Levels/Altered Hydrology	Coldwater Fishery	Aesthetics
	Other Indigenous Aquatic Life	Ecosystem Preservation
Sediment	Warmwater/Coldwater Fishery	Aesthetics
	Other Indigenous Aquatic Life	Recreation
Pathogens	Total Body Contact	Human Health
(*E. Coli*)		Recreation
Toxins (Mycrocystin, Pesticides/Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate,)	Warmwater/Coldwater Fishery	Human Health
	Other Indigenous Aquatic Life	Recreation
	Fish Consumption	Ecosystem Preservation
Thermal Pollution	Warmwater/Coldwater Fishery	Ecosystem Preservation
	Other Indigenous Aquatic Life	

Note: This is a general list that encompasses stressors and/or pollutants for the entire Good Harbor Bay watershed. Not all reaches in the watershed are impacted by all of the pollutants and/or stressors listed above.

Sources and Causes of Pollutants

A Comprehensive Watershed Protection Table was developed listing potential (p), suspected (s) and known (k) sources and causes of watershed pollutants and environmental stressors (Table 25). This table summarizes key information necessary to focus on water quality protection, provides specific targets to act upon for watershed management and forms the basis for future implementation projects to protect the quality of the watershed. Sources and causes were identified using a wide variety of methods including: road stream crossing inventories, scientific research reports, water quality monitoring reports, steering committee member local knowledge and personal contact with watershed residents. Table 26 then ranks the pollutants and stressors in the Good Harbor Bay Watershed.

The Comprehensive Watershed Protection Table (Table 25) may be used as a reference to distinguish what the major sources of pollutants and environmental stressors are on a watershed-wide scale. However, they do not distinguish between pollutants and their sources and causes at specific locations. And, as stated earlier, not all of the pollutants listed are a problem everywhere in the watershed.

Table 25: Pollutants, Sources, and Causes of Water Quality Degradation in the Good Harbor Bay Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	Impaired or Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Loss of Habitat	Warm/ Coldwater Fishery Other Indigenous Aquatic Life	Shoreline erosion (k)	Climate Change (s) Fluctuations in precipitation (k) Landscaping practices (k)
		Conversion of vegetated/forested areas to developed land uses (s)	Increasing local population w/o sufficient land use regulations in local zoning ordinances to protect high priority land protection areas (s) Improper residential lot & driveway design (s)
		Native habitat out competed by invasive species (k)	Availability and preference for invasive perennials at nursery & landscaping stores (k) Lack of awareness and/or concern (k) Lack of restrictions on boat travel (k)
Invasive Species	Warm/Coldwater Fishery Other Aquatic Life Navigation Total Body Contact	Landscaping practices (k)	Availability and preference for invasive perennials at nursery & landscaping stores (k) Lack of awareness and/or concern (s)

Table 25: Comprehensive Watershed Protection Table (Cont'd)

Environmental Stressor or Pollutant	Impaired or Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Invasive Species (Cont'd)		Anthropomorphic introduction of Invasive Species (k)	Lack of restrictions on boat travel (k) Lack of education and/or knowledge on invasive species and BMPs (k) Not properly cleaning boats between lakes (k) Direct human introduction via shoes, cars, aquariums, pets, fishing, live bait, etc (s) Migration of invasive species from Lake Michigan (s)
		Wildlife transporting invasive species (k)	Anthropomorphic introduction of invasive species that are spread by wildlife (k)
Nutrients	Warm/ Coldwater Fishery Other Indigenous Aquatic Life Total Body Contact	Residential, Agricultural Commercial Fertilizer Use (k)	Improper application (amount, timing, frequency, location, method, P content) (s)
		Septic Systems (s)	Inadequate design, sited, sized, maintained (s) High density/age of systems (s) Lack of required inspections or point of sale ordinance (s) Lack of information/education on septic system care and maintenance (s)

Table 25: Comprehensive Watershed Protection Table (Cont'd)

Environmental Stressor or Pollutant	Impaired or Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Nutrients		Soils exposed to stormwater runoff (k)	Elimination of riparian vegetation from natural shorelines (s) Poor agricultural & forestry practices, improper road construction or land use practices (s) Improper landscaping practices on private waterfront residential properties (leaving large amounts of biomass to decompose)(s)
		High water levels (k)	Climate change (s) Fluctuations in precipitation (k)
		Anthropomorphic influences(s)	Human or pets bathing in water bodies (s) Dry/Gray wells (s) Improper runoff design (s)
		Transportation (s)	Potential spills or contamination from vehicles on public roadways (s)
		Agriculture (s)	Runoff into streams/water bodies (s) Poorly managed livestock operations (s) Conversion of non-productive and/or forested land to agriculture (s)
		Atmospheric Deposition (k)	Industrial emissions (k)

Table 25: Comprehensive Watershed Protection Table (Cont'd)

Environmental Stressor or Pollutant	Impaired or Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Hydrology	Warm/ Coldwater Fishery Other Indigenous Aquatic Life	Intense precipitation periods (k)	Climate change (s) Inadequately sized culverts (s) Sedimentation (k) Stream obstructions (p)
Sediment	Warm/Cold water fishery Other indigenous Aquatic Life Navigation	Road and stream crossings (k)	Erosion of embankments (k) Road sanding (s) Inadequate design/construction/maintenance (k) Lack of erosion/surface runoff controls (k) Steep approaches (k) Reduced flow capacity at culverts, crossings or bridges (k)
		Bank/Shoreline erosion (k)	Removal of riparian and native vegetation from natural shorelines (s) Boat traffic/wakes (p) Natural forces (e.g.) wind/wave action (p) Fluctuation in water levels (s) Inadequate design, construction, and/or maintenance of culverts and road/stream crossings (s) Vulnerability of water ways to changing climate conditions (s)

Table 25: Comprehensive Watershed Protection Table (Cont'd)

Environmental Stressor or Pollutant	Impaired or Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Sediment		Residential, Commercial and/or Road Construction (k)	Inadequate soil erosion and stormwater management practices (k) Direct runoff entering water bodies from residential and developed areas (k) Impervious surfaces not allowing proper infiltration or directing water in an inappropriate direction (s)
		Soil exposed to stormwater runoff (k)	Improper landscaping or land use practices, lack of riparian vegetation (k)
		Forestry Practices (k)	Inadequate road design, management (k) Inadequate timber harvest practices (k)
		Agriculture (s)	Runoff into streams/waterbodies (k) Poorly managed livestock operations (s)
Pathogens (E. coli and Fecal Coliform indicators)	Total Body Contact	Animal Waste (p)	Improper disposal of pet waste (s) Poorly managed livestock operations adjacent to water bodies. (p)
		Septic Systems (p)	Poorly designed,sited,sized,maintained (p) High density/age of systems (p) Uninspected systems (p)

Table 25: Comprehensive Watershed Protection Table (Cont'd)

Environmental Stressor or Pollutant	Impaired or Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Microcystin, Etc.)**	Warm/ Coldwater Fishery Other Indigenous Aquatic Life Fish Consumption	Contaminated groundwater (k)	Improper maintenance septic systems (s) Improper use of chemicals and toxins (s) Inadequate disposal facilities, illegal dumping (k)
		Runoff from developed areas (p)	Direct runoff of paved surfaces to surface water (roads, parking lots, driveways) (p) Infiltration to groundwater from improper storage and over use (p)
		Atmospheric Deposition (k)	Industrial emissions (k)
		Contaminated Sediments (k)	Inadequate disposal facilities, illegal dumping (k)
		Oil, Natural Gas, Hydrocarbon, & Underground Injection Wells (k)	Improper storage and handing or gas and water craft fueling (s) Natural Gas Fracking operation (k), Inadequate Fracking fluid Storage (p) Abandoned Wells (leaking, uncapped) (p)
		Underground Storage Tanks (p)	Leaking tanks (p)

Table 25: Comprehensive Watershed Protection Table (Cont'd)

Environmental Stressor or Pollutant	Impaired or Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Thermal Pollution	Coldwater Fishery Other Indigenous Aquatic Life	Runoff from developed areas (s)	Stormwater runoff being allowed to directly enter surface water bodies (k)
		Lack of Streamside Canopy (p)	Removal of streamside vegetation (p)
		Ponds, impoundments, & other water-control devices (p)	Top draw structures (p) Poorly maintained ponds & other water control devices (p)

4.5 PRIORITY POLLUTANT RANKING

It is important to rank and prioritize pollutants and stressors in order to focus funding and implementation efforts. However this is a complex task due to the synergistic relationships of the pollutants and stressors, which creates greater impacts than any one pollutant or stressor does on its own. Thus it is important to recognize and address medium and low priority pollutants as well as high priority ones in order to help maintain the Good Harbor Bay watershed's overall good water quality. Table 26, on the next page, outlines the steering committees pollutant priorities for the watershed. Table 27 then ranks the pollutants and stressors in the Good Harbor Bay Watershed.

Table 26: Pollutant Priorities for the Good Harbor Bay Watershed

Pollutant	Priority in Watershed
Loss of Habitat	High
Invasive Species	High
Nutrients	High
Hydrology	High
Sediment	Medium
Pathogens (*E. Coli*)	Medium
Toxins (Mycrocystin, Pesticides/Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate,)	Medium
Thermal Pollution	Low

The project steering committee has decided that the specific sources for each pollutant and stressor are the most important items to rank and prioritize in this protection plan because that is where one can actually stop pollution from entering waterways (Table 27). Additionally, as noted above, because most of the pollutants and stressors are interconnected, dealing with one source and its causes could actually reduce a number of different pollutants and stressors from affecting a stream or water body. This concept is discussed more in-depth in Chapter 5.

Table 27: Pollutant Source Priority Ranking

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Loss of Habitat	Shoreline erosion (k)	HIGH
	Native habitat out competed by invasive species (k)	HIGH
	Conversion of vegetated/forested areas to developed land uses (s)	MEDIUM
Invasive Species	Landscaping practices (k)	HIGH
	Anthropomorphic introduction of Invasive Species (k)	MED
	Wildlife transporting invasive species (k)	LOW
Nutrients	Residential, Agricultural or Commercial Fertilizer Use (k)	HIGH
	Septic Systems (s)	HIGH
	Fluctuating water levels/climate change (k)	HIGH
	Soils exposed to stormwater runoff (k)	MEDIUM
	Agriculture (s)	LOW
Hydrology	Intense precipitation periods (k)	HIGH
	Runoff (k)	HIGH
Sediment	Road and stream crossings (k)	HIGH
	Bank/Shoreline erosion (k)	HIGH
	Residential, Commercial or Road Construction (k)	MEDIUM

Table 27: Pollutant Source Priority Ranking (Cont'd)

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Sediment (Cont'd)	Soil exposed to stormwater runoff (k)	MEDIUM
	Forestry Practices (k)	MEDIUM
	Agriculture (k)	LOW
Pathogens (*E. Coli* and Fecal Coliform indicators)	Septic Systems (p)	HIGH
	Animal Waste (p)	LOW
Toxins	Runoff from developed areas (p)	HIGH
(Pesticides, Herbicides, Oils, Gas, Grease, Etc.)	Contaminated groundwater (k)	MEDIUM
	Atmospheric Deposition (k)	LOW
	Contaminated Sediments (k)	LOW
	Oil, Natural Gas, Hydrocarbon, & Underground Injection Wells (p)	LOW
	Underground Storage Tanks (p)	LOW
Thermal Pollution	Runoff from developed areas (s)	LOW
	Lack of Streamside Canopy (p)	LOW
	Ponds, impoundments, & other water-control devices (p)	LOW
	Sedimentation in stream channel (s)	LOW

4.6: POLLUTANTS AND ENVIRONMENTAL STRESSORS OF CONCERN

Nutrients

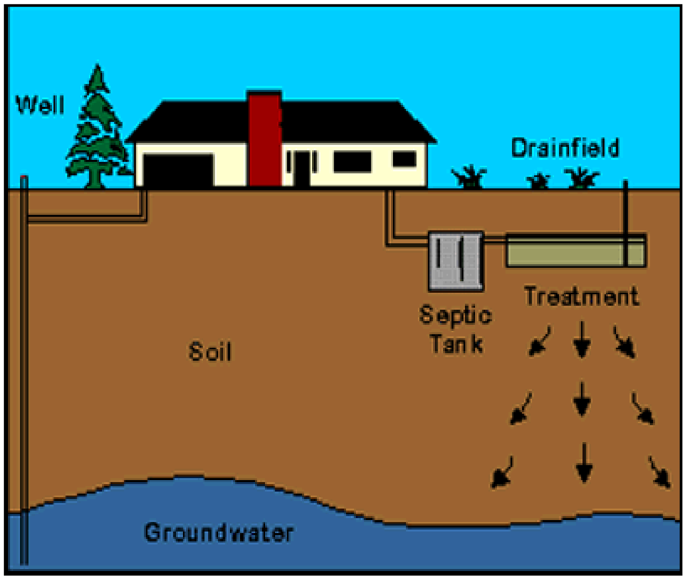
Nitrogen and phosphorus are critical nutrients for all types of plants, including aquatic species. Phosphorus has shown to contribute to excessive algae growth. Phosphorus is the primary nutrient of concern in the Good Harbor Bay watershed.

Sources of increased nutrients to the Good Harbor Bay watershed resulting from human activities include residential and commercial fertilizer use, stormwater runoff and septic system effluent.

Fertilizers

Residential and agricultural fertilizer applications can be a significant source of nutrient input to the watershed. Since phosphorus is most often the limiting nutrient in aquatic systems, phosphorus concentrations in fertilizers could have a dramatic impact on water quality in the Good Harbor Bay watershed due to the high groundwater flow and permeable soils. The Good Harbor Bay Improvement Association has advocated for years to apply phosphorus-free fertilizers anywhere near surface water bodies to help prevent excessive nutrient inputs.

Septic Systems



A septic system consists of two basic parts: a septic tank and a soil absorption field or drainfield. Wastes flow from the house into the septic tank where most solids are separated to the bottom and are partially decomposed by bacteria to form sludge. Some solids float and form a scum mat on top of the water. The liquid effluent from the septic tank, carrying disease-causing organisms and liquid waste products, is discharged into the soil absorption field. In the absorption field, the water is further purified by filtration and decomposition by microorganisms in the soil. The semi-purified wastewater then percolates to the groundwater system.

Another potential source of nutrient enrichment in the Good Harbor Bay watershed is from failing septic systems. Septic systems are the most common method of treating wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items in the Good Harbor Bay Watershed., There are no municipal water systems in the Good Harbor Bay Watershed The watershed are serviced by individual septic systems. In areas where the soil does not percolate, many residents are on holding tanks, which required frequent pumping (often every 1-2 months).

The Benzie-Leelanau District Health Department has rules and permit for septic systems (Environmental Health Regulations, Chapter II). These rules require that "all flush toilets, lavatories, bathtubs, showers, laundry drains, sinks and any other similar fixtures or devices to be used to conduct or receive water carried sewage shall be connected to a septic tank or some other device in compliance with the minimum standards and the Michigan Department of Public Health regulations and finally disposed of in a manner in compliance with these minimum standards and the Michigan Department of Public Health regulations and any other applicable law, ordinance or regulation." (Environmental Health Regulations, Chapter II) The rules require a percolation test (via an application), and require specific setbacks of septic tanks and subsurface disposal system (or drainfield) from wells, property lines and water bodies.

The best way to prevent septic system failure is to ensure that the system is sited and sized properly and to employ appropriate treatment technology and maintenance. Design requirements will vary according to local site factors such as soil percolation rate, soil composition, grain size, and depth to water table.

The effectiveness of septic systems at removing pollutants from wastewater varies depending on the type of system used and the conditions at the site. The fact is, even a properly operating septic system can release more than 10 pounds of N per year to the groundwater for each person using it (Ohrel 2000). The average pollutant removal effectiveness for a conventional septic system is as follows: total suspended solids – 72%, biological oxygen demand – 45%, total nitrogen – 28%, and total phosphorus – 57% (USEPA 1993). This shows that even properly operating conventional septic systems have relatively low nutrient removal capability, and can be a cause of an increased nutrient loading into groundwater flows.

Typical Impacts from Excessive Nutrients

Impact #1: Increased weed and algae growth impact water recreation and navigation.

Impact #2: Decomposition of algae and weeds removes oxygen from lakes, harming aquatic life and reducing the recreational and commercial fishery.

Impact #3: Exotic plant species like Eurasian Watermilfoil and Purple Loosestrife proliferate under nutrient rich conditions, which increases their competitive advantage over native species

Impact #4: Some algae (i.e., blue-green algae) are toxic to animals and humans and may cause taste and odor problems in drinking water.

Impact #5: High nitrate levels in drinking water are a known human health risk.

Sediment

Sediment is fine inorganic soil or sand particles and sedimentation is the process whereby sediment is deposited in a stream or lake bottom. Excessive sedimentation can severely degrade an entire aquatic ecosystem and has been identified as a major cause of degradation to aquatic life in many Michigan streams and rivers (DEQ 1998). Excessive sediment deposition in many of Michigan's streams also severely impacts the amount of suitable habitat needed to support healthy and diverse communities of fish and fish food organisms. When sediment enters a stream it covers gravel, rocky, and woody habitat areas, thereby leading to decreases in habitat diversity and aquatic plant production.

Sedimentation caused by streambank erosion may increase channel widening. The increased width and resulting shallower depth increases the overall water temperature of the river. Because fish and aquatic insects are sensitive to temperature changes, this sedimentation results in further degradation of habitat and animal populations.

Significant sources of sediment to Good Harbor Bay, Lime and Little Traverse Lake tributaries include activities that cause streambank erosion such as road/stream crossings, high precipitation events, residential development, and other construction events.

Excavation and earth moving or other activity in which soil is disturbed can result in sediment transport to nearby streams if proper precautions are not taken to prevent sediment transport in storm water runoff. Impervious surfaces (roads, rooftops and parking lots) create erosive storm water run-off forces that degrade water quality if allowed to directly enter surface water bodies. Properly infiltrating storm water run-off into groundwater flows through installation of retention basins, improving degraded road stream crossings and managing recreational traffic in the lower watershed will help prevent additional sedimentation of aquatic habitat.

This watershed does not have a formal road and stream crossing survey. This was identified as a high priority task in Chapter 8 (Table 32). The outlet for Little Traverse Lake is a culvert which crosses the west end of Little Traverse Lake road. It is felt to be undersized and under capacity and identified as a task in this watershed plan. The concern is over high lake levels in Little Traverse Lake caused in part by the undersized culvert, low elevation gradient and beaver activity further downstream. There are various groups around Little Traverse Lake working with the Leelanau County Road Commission, Sleeping Bear Dunes National Lakeshore (SBDNL) and Cleveland Township to address the concern over the culvert and high lake levels. A hydrology report, written by a geologist from the SBDNL, along with engineering reports are included as an appendix to this watershed plan (Appendix B-D).

Typical Impacts from Sedimentation

Impact #1: Sand and sediment harm aquatic life by covering natural stream and lake substrate, which fish and prey species rely upon for spawning and feeding.

Impact #2: Sediment also increases turbidity and decreases visibility. Excessive amounts of fine sediment can actually clogging fish and insect gills.

Impact #3: When more sand and sediment is deposited than can be moved by stream flow, water levels are raised, causing streambank erosion and potential flooding. Excessive sedimentation may also fill lakes, ponds, and wetlands.

Impact #4: Nutrients, heavy metals, and other pollutants can attach to finer sediment particles and enter the water when suspended.

Impact #5: Excess sedimentation can potentially impair navigation by making the water too shallow for boats and boat access.

Impact #6: Sediment accumulation decreases stream depth, and increases stream width, thereby causing the water temperature to rise.

Impact #7 Organically rich suspended sediments (silt) undergo aerobic respiration as they breakdown, which uses up dissolved oxygen. Excessive sedimentation with silt or other organic laiden sediments can increase Biological Oxygen Demand due to the microbial decomposition, which in turn can cause in-stream dissolved oxygen concentrations to plummet below the levels required by fish and macroinvertebrates.

Invasive and Nuisance Species

Invasive species (also called exotic or non-native species) have threatened the Great Lakes ever since Europeans settled in the region. Exotic species are organisms that are introduced into areas where they are not native. While many exotic species are introduced accidentally, others are intentionally released, often to enhance recreational opportunities such as sport fishing. The Pacific salmon, which was purposely stocked in the Great Lakes, is an exotic species, but they are not a “nuisance” species. Species are considered a nuisance when they disrupt native species populations and threaten the ecology of an ecosystem as well as causing damage to local industry and commerce. Without pressure from the competitors, parasites, and pathogens that normally keep their numbers in check, invasive species may undergo large population increases.

Stowing away on boat hulls and in bilges is the primary way many invasive species are introduced into the ecosystem. Other ways of introduction include landscaping practices and lack of awareness by homeowners of the threat (this is how purple loosestrife was introduced to Michigan) and hitching a ride on other biota like frogs and birds.

Invasive species are becoming problematic throughout many of Michigan’s inland lakes. Many of these species exhibit vast increases in numbers following their introduction, or following changes in the environment. Exotic species can affect the watershed in many ways. Zebra mussels and Eurasian watermilfoil influence the overall water quality and stability along with recreational use. Zebra mussels also alter the amount of available P by concentrating it on lake bottoms.

The most critical documented aquatic invasive species in the upper Good Harbor Bay watershed are the zebra mussel and *Eurasian Watermilfoil* infestations in the inland lakes.

In recent years, invasive plants have received more and more attention as their adverse effects on natural ecosystems becomes better understood. Within the Good Harbor Bay Watershed, invasive plants can be found in aquatic, wetland, and terrestrial habitats. Some species have been present for many years and are well established, while others are recently arrived and less common. Some of the terrestrial species of primary concern have been garlic mustard, autumn olive, Japanese barberry, Canada thistle, bull thistle, baby’s breath, Japanese knotweed, giant knotweed, and oriental bittersweet. The latter four species are early detection/rapid response (ED/RR) priorities because of their recent introduction, small population sizes and destructive potential. Wetland species of primary concern are phragmites, narrow-leaved cattail, Eurasian swamp thistle, reed canary grass, and purple loosestrife. Phragmites is present in relatively few high-density infestations in the watershed and is still an ED/RR priority. Eurasian water-milfoil is the most common aquatic species, and is present in several lakes in the watershed.

The monitoring and control of invasive plants in the Good Harbor Bay watershed is done by several different groups. First, many private landowners have become aware of the more common invasive species such as garlic mustard or phragmites, and conduct treatments on their own properties. The Northwest Michigan Invasive Species Network (ISN) is a coalition of partner organizations that covers four counties, which includes all of the Good Harbor Bay Watershed. The group has 23 partner organizations and focuses on invasive plant education, prevention, monitoring, and treatment. ISN has a full-time coordinator who divides time between the all four counties and all partner organizations along with seasonal ISN staff and crews. Sleeping Bear Dunes National Lakeshore has staff that does invasive plant treatments on park property within the watershed. The Leelanau Conservancy also treats invasive species found on their natural areas and on neighboring private and public lands within the watershed. The Leelanau Conservancy also surveys all of the Eastern Lake Michigan shoreline for ED/RR species and treats when necessary with landowner permission. The Leelanau Conservation District has begun treating invasive plants, specifically focusing on phragmites, on inland lakes and the Great Lakes Shoreline, including monitoring and treatment along Grand Traverse Bay. In addition, some lake and property associations treat invasive plants within their areas of influence.

The treatment and control of invasive plants is dependent on available funding, expertise, and awareness. It is nearly impossible to eradicate a species once it is established, so priorities must be set in control efforts based on the probability of success and the value of the ecosystem being invaded. ED/RR species such as Japanese knotweed, giant knotweed, oriental bittersweet, baby's breath and phragmites should be treated as soon as possible after they are detected in order to minimize the cost of control and maximize the potential for successful treatment. Of the species that are more common, it is best to treat them as soon as possible after they invade a new area. ISN has funded control for phragmites and knotweed species as the infestations become known, along with allocating funding to partners for other ED/RR priorities. There have been massive efforts in the past three years to locate and treat infestations of phragmites and garlic mustard, which are relatively common, yet have not taken over as they have in other parts of the state. In 2011, ISN (formerly Northwest Michigan Cooperative Weed Management Area) funded phragmites treatments at three sites in the watershed and the Leelanau Conservancy continues monitoring and treatment. The Long Lake Association has been treating Eurasian water-milfoil for more than three years. Future infestations of invasive plants will be inventoried, prioritized, and treated as they are discovered according to availability of resources.

Typical Impacts from Invasive Species

Impact #1: Invasive species often have no natural predators and can out-compete native species for food and habitat.

Impact #2: Introduction of a single key species can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions among existing species, creating ecosystems that are unstable and unpredictable. (Example: Established populations of zebra mussels can promote toxic blue-green algal blooms.)

Impact #3: In some instances invasive species can interfere with recreation in the watershed For example, rows of zebra mussel shells washed up on shore can cut beach walkers' feet, and Eurasian watermilfoil can get tangled up in boat propellers.

Loss of Habitat

The population of Leelanau increased by 10% from 2000 to 2010 (U.S. Census). As the population grows throughout the currently rural watershed, the increasing residential and road development fragments the large forested parcels and impedes wildlife movement. Areas of higher quality habitat become smaller and smaller isolated pockets of remnant habitat, many of the important natural process such as seed dispersal and movement of large mammals are lost. The remaining populations become more vulnerable to disease as well and the impact of increasingly nearby human development. Fortunately large portions of the

Good Harbor Bay watershed are already protected under State Forest or National Lakeshore management. Proper land-use practices on the remaining private land across the watershed can help focus future residential growth near existing villages and population centers to prevent hap-hazard development of high quality forested habitat into large residential lots with no nearby community infrastructure.

While the vast majority of the watershed has riparian habitats protected, and there is fairly high quality habitat along the stream, there is concern for aquatic habitat loss. Habitat along the streams and the riparian systems provides adequate coarse woody debris but flow and sedimentation is a concern. An inventory of Aquatic organism and passage issues is part of the implementation tasks as there could be issues with sedimentation relating to hydrologic impacts from inadequate road and stream crossings interrupting the flow.

Typical Impacts from Habitat Loss

Impact #1: Extinction and extirpation of native species.

Impact # 2: Habitat fragmentation, increase of edge effect

Impact #3: Loss of overall biological community stability and function.

Impact #4: Reducing the scenic magnitude of the Good Harbor Bay Watershed which is the heart of the region's attraction and draw for over a million annual tourists and residents.

Toxins

Toxic substances such as pesticides, herbicides, oils, gas, grease, salt, and metals often enter waterways unnoticed via stormwater runoff. These types of toxins are perhaps the most threatening of all the watershed pollutants because of their potential to affect human and aquatic health. Every time it rains, these toxic pollutants are washed from the roads, parking lots, driveways, and lawns into the nearest storm drain or road ditch, eventually reaching nearby lakes and streams. Additionally, farms, businesses, and homes throughout the watershed are potential sites of groundwater contamination from improperly disposed and stored pesticides, solvents, oils, and chemicals. Stormwater runoff from impervious surfaces can also carry oils directly into surface waters or wash them into groundwater recharge basins.

Traditionally speaking, toxic substances such as mercury and other heavy metals have been regarded as the most serious due to their human health impacts. As fossil fuels burn, chemicals are released into the atmosphere. When rain falls through the clouds, it carries these suspended chemicals to the surface water, via runoff that eventually flows into receiving lakes and streams. In addition to transporting airborne pollutants, surface runoff can also leach these toxic compounds that have accumulated in soil or on impervious surfaces, such as roads, into streams and lakes. The toxins bioaccumulate through the food web, and therefore the oldest higher vertebrates, in this case fish, contain the greatest concentrations. The Michigan Department of Health has issued a consumption warning for fish in all of the inland lakes to protect human health as a result of high chlordane, mercury and PCB (polychlorinated biphenyl) concentrations.

In addition to the substances noted above, another potentially toxic substances in the Good Harbor Bay watershed is sodium chloride. Sodium chloride enters the watershed primarily as a result of road salt application in the winter and subsequent runoff in the winter and spring. Higher levels of sodium chloride in streams and lakes can impair fish and macroinvertebrate communities.

Typical Impacts from Toxins

Impact #1: *Toxic chemicals entering waterbodies harm stream life, potentially causing entire reaches of a stream to be killed off if the concentrations of contaminants are high enough. Additionally, reproductive processes may be harmed.*

Impact #2: *Persistent toxic pollution in a stream may put human health and recreation at risk. Serious human health risks may include liver failure, kidney disease, and cancer.*

Impact #3: *Contaminated groundwater may pose a problem for homes and businesses throughout the watershed that rely upon groundwater wells for their drinking water. This poses a risk to human health and often requires difficult and costly cleanup measures.*

Pathogens

Pathogens are organisms that cause disease and include a variety of bacteria, viruses, protozoa and small worms. These pathogens can be present in water and may pose a hazard to human health. The US Environmental Protection Agency (EPA) recommends that freshwater recreational water quality be measured by the abundance of *Escherichia coli* (*E. coli*) or by a group of bacteria called *Enterococci*. Michigan has adopted the EPA's *E. coli* water quality standards. *E. coli* is a common intestinal organism, so the presence of *E. coli* in water indicates that fecal pollution has occurred. However, the kinds of *E. coli* measured in recreational water do not generally cause disease; rather, they are an indicator for the potential presence of other disease causing pathogens. EPA studies indicate that when the numbers of *E. coli* in fresh water exceed water quality standards, swimmers are at increased risk of developing gastroenteritis (stomach upsets) from pathogens carried in fecal material. The presence of *E. coli* in water does not indicate what kinds of pathogens may be present, if any. If more than 130 *E. coli* are present in 100mL of water in 5 samples over 30 days, or if more than 300 *E. coli* per 100mL of water are present in a single sample, the water is considered unsafe for swimming.

Fecal pollution entering the Good Harbor Bay watershed may come from stormwater runoff, animals on the land or in the water, illegal sewage discharge from boats, or leaking septic systems. Different sources of fecal pollution may carry different pathogens. Peak *E. coli* concentrations often occur during high flow periods when floodwater is washing away possible contaminants along stream banks and shorelines from waterfowl like ducks and geese.

Typical Impacts from Pathogens

Impact #1: *High levels of pathogens in the water pose a threat to human health and reduce the recreational value of the lake, thereby degrading use and enjoyment of the watershed.*

Thermal Pollution

Not normally thought of as a pollutant, increased water temperatures can potentially detrimentally affect water quality and aquatic life in a watershed system. Thermal pollution increases the temperature of a body of water, and even small increases in temperature can dramatically alter natural processes. Water's ability to hold dissolved oxygen decreases as temperature increases; thereby reducing the available amount of oxygen in the water to fish and other aquatic life. Temperature also influences the rate of physical and physiological reactions such as enzyme activity, mobility of gases, diffusion, and osmosis in aquatic organisms. For most fish, body temperature will be almost precisely the temperature of the water. Fish will seek water that is in their preferred temperature ranges so as to avoid stress from elevated water temperature. If unable to avoid the higher temperatures a fish's body temperature increases, and this then changes their metabolic rate and other physical or chemical processes as well. When thermal stress occurs, fish cannot efficiently meet their energetic demands (Diana 1995). Optimal water temperatures for trout are in the 60^{o}F range(15-20^{o}C) or below. Lethal maximum temperatures vary with different trout species, but temperatures above 76^{o}F (24.4^{o}C) can be lethal.

Other sources of thermal pollution in the Good Harbor Bay watershed are heated stormwater runoff from paved surfaces, the removal of shade vegetation along stream banks and shorelines, and undersized culverts at road stream crossings that create warm pools of retained water upstream, coupled with low flows and shallow pool depth below. Excessive inputs of sediment into streams and lakes may also contribute to thermal pollution. Sediment inputs can fill stream pools and lakes, making them shallower and wider and, consequently, more susceptible to warming from solar radiation.

Changes in climate due to global activities also may enhance the degree of thermal pollution in a watershed. Average global surface temperatures are projected to increase by 1.5^{o}C to 5.8^{o}C by the year 2100 (Houghton et al. 2001). Increases in surface temperatures may increase stream water temperatures as well, although impacts will vary by region. Overall, increases in stream water temperature will negatively affect coldwater aquatic species. For example, coldwater fish, such as trout and salmon, are projected to disappear from large portions of their current geographic range in the continental United States due to an increased warming of surface waters (Poff et al. 2002). While climate change has the potential to increase inland water temperatures, it is beyond the scope of the GHBWPP. However it will be important for Leelanau County residents to plan for alternative sources of heat to have the greatest impact on reducing climate change.

Typical Impacts from Thermal Pollution

Impact #1: Surges of heated water during rainstorms can shock and stress aquatic life, which have adapted to coldwater environments. Aquatic diversity is ultimately reduced. Constant heating of rivers and lakes ultimately changes the biological character and thus the fishery value.

Impact #2: Thermal pollution decreases the amount of oxygen available to organisms in the water, potential suffocating them.

Impact #3: Warmwater increases the metabolism of toxins in aquatic animals.

Impact #4: Algae and weeds thrive in warmer waters.

Impact #5: Human made impoundments increase stream temperatures creating lethal conditions for coldwater species such as brook trout.

Altered Hydrology

The two major natural hydrologic functions that help drive the Good Harbor Bay watershed are groundwater infiltration and discharge. As water flows out of the ground and coalesces into stream channels it carves the path of least resistance. When natural hydrologic flow patterns are altered for transportation infrastructure, large-scale water withdrawals or to create artificial lake levels, the entire hydrologic process becomes compromised. Natural sediment transport regimens become interrupted and aquatic habitat is quickly compromised. One of the main issues in the GHB watershed potentially impacting water quality is the culvert on the west end of Little Traverse Lake. This is referred to as the Little Traverse Lake Outlet System (See the priority and critical areas section below for more details on this topic). The undersized and improperly designed culvert blocks sediment transport along the stream bottom and creates a massive back-up and accumulation of very fine sands and organic silt above the dam structure. The most common altered hydrologic condition throughout the watershed is found in the myriad of un-named groundwater tributary streams that are have been compromised by the installation of undersized culverts that creates a 'choke-point' as well as creating biologically unsuitable current forces that can fragment stream segments. The undersized structures are also prone to creating 'perched' conditions, where the downstream end of the tube is actually perched above the receiving stream channel creating an impassable waterfall.

Typical Impacts from Altered Hydrology

Impact #1: Compromised sediment transport system above low-head dams or undersized culverts.

Impact #2: Biologically intolerable current forces from undersized culverts.

Impact #3: Undersized culverts can promote a 'perched' condition and further fragment the stream channel

4.7 PRIORITY AND CRITICAL AREAS

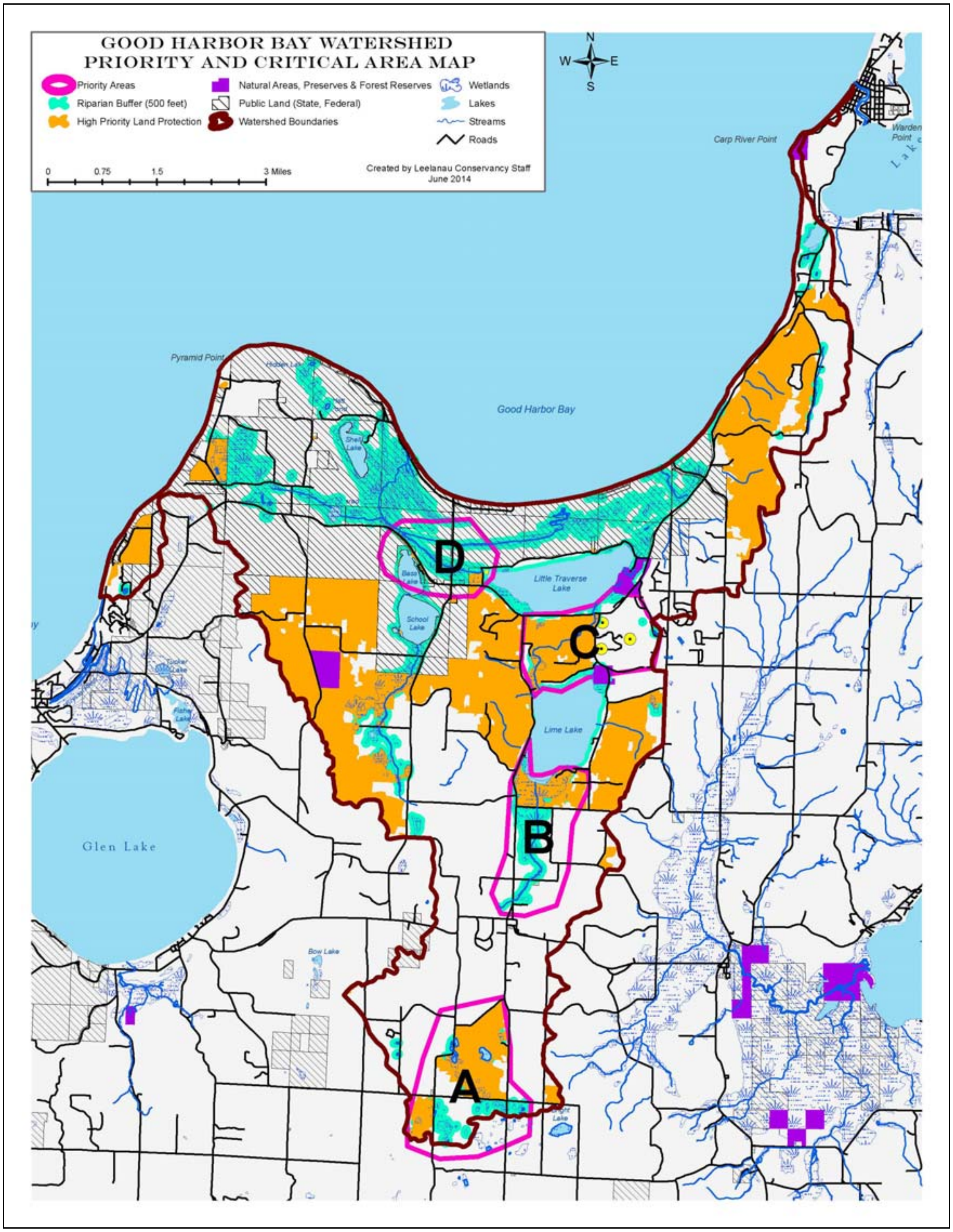
Although watershed management plans address the entire watershed, there are certain areas within the Good Harbor Bay watershed that warrant more extensive management or specific protection consideration. Areas that are most sensitive to impacts from pollutants are considered **Priority Areas.** Areas that require focused monitoring, restoration, remediation and/or rehabilitation are considered **Critical Areas**.

Priority Areas

Priority areas in the Good Harbor Bay watershed are defined as the geographic portions of the watershed that are most sensitive to impacts from pollutants and environmental stressors. The prescribed goals, objectives and tasks for these areas typically focus on preservation and protection. The priority areas were identified by analyzing the sources, causes, and prioritization of watershed pollutants (Tables 24-26). Other resources used to identify the Priority areas include; scientific research reports, the Michigan Natural Features Inventory, water quality monitoring reports, and assessment by scientific consultants to the Good Harbor Bay Watershed Steering Committee.

The priority areas for the Good Harbor Bay watershed are divided four different tiers of protection priorities that cover four geographic areas of the watershed. These tiers and areas are described below and shown in (Figure 28):

Figure 28: Priority and Critical Areas Map



Priority Area Descriptions –

Area A- This area includes the kettle lakes and wetlands in the very upper part of the watershed in Kasson Township. This area contains several isolated kettle lakes with wetland complexes and significant amounts of forested land-use that maintains groundwater recharge for the watershed.

Area B- This area focuses on the wetlands and stream corridors feeding Lime Lake and includes the wetlands, riparian corridors, along Lime Creek.

Area C- This area focuses on the outlet of Lime Lake, Shetland Creek, between Lime Lake and Little Traverse Lake. This area also contains the majority of the coldwater fishery habitat for the watershed.

Area D- This area includes the wetland complex on the western end of Little Traverse Lake (Shalda Creek), which flows through the Sleeping Bear Dunes National Lakeshore and eventually into Lake Michigan.

Tier 1:

- Habitat for or areas with threatened, endangered or species of special concern
- Existing public or protected land within the SBDNL, State, Conservancies and or natural areas and preserves
- High Risk Erosion Areas

Tier 2:

- Surface water bodies (lakes/streams), shorelines, wetlands and land within 500’ of them.
- High Priority Land Protection areas (Top two tiers of Natural Lands Inventory and 500 foot Riparian Buffer)
- Ground water recharge areas

Tier 3:

- Steep Slopes
- Wildlife Corridors

Given there is habitat for rare, endangered and/or threatened species in the Good Harbor Bay Watershed (Section 2.7), the first priority area (Tier 1) focuses efforts where these species may occur as well as within the national lakeshore, state land and other protected land. Since these areas tend to have high quality habitats and include important wetlands and shoreline, continuing to protect these ecological values will contribute to the overall watershed health. Tier 1 also includes the main wetland complexes feeding Lime and Little Traverse Lakes. These diverse wetlands contain superb ecological examples of rich conifer swamp, poor conifer swamp, and emergent and submergent wetland communities.

Tier 2 Prioritizes the protection of all undeveloped land within 500 feet of all streams, bodies of water and wetlands in the designated priority areas. In addition, conservation planning by regional land conservancies has identified large, priority parcels tied to water quality by analyzing multiple datasets. The resulting set of mostly privately owned parcels is prioritized for voluntary permanent land protection options due to their water quality protection and wildlife corridor functions. Groundwater recharge areas are critical to groundwater driven systems such as the Good Harbor Bay Watershed. Groundwater recharge and discharge areas as defined by the most acceptable groundwater mapping technology available should be prioritized for protection. Keeping these areas in a natural state facilitates natural groundwater flow and promotes high water quality.

Tier 3 includes wildlife corridors and steep slopes. While there are not a lot of steep slopes in this watershed, it is important to control erosion and protect streams and water bodies with significant buffers for wildlife and water quality. It is a priority in the Good Harbor Bay Watershed to implement best management practices that will protect the water bodies from increased sediment. It is also a priority to protect wildlife habitat and ecological diversity by connecting natural lands and promoting best management practices for wildlife enhancement.

Critical Areas

Critical Areas are specific sections of the watershed that are suspected to contribute a significant amount of pollutants or have been documented as impacted by stressors or pollutants and require restoration to achieve designated or desired uses. Critical Area designation indicates that implementation of identified tasks will be needed to achieve load reductions identified in the plan (Figure 32). The critical areas for the Good Harbor Bay watershed include the following areas:

- Little Traverse Lake outlet system
- Lime Creek Road Crossings- Narlock and Cemetery Road
- Sugar Loaf Resort and area golf courses

Descriptions of Critical Areas-

Little Traverse Lake Outlet System- by Yarrow Brown, Len Allgaier and Lou Gurthet

In the past 5 years total rainfall in Leelanau County has increased dramatically (28" to 48" annual) with intense events (3-6 inches per) challenging the outlet system on Little Traverse Lake with unprecedented volumes of surplus water (Farm log per Len Allgaier). The high water levels that Little Traverse Lake has been experiencing, specifically on the north side, has raised concerns over the culvert on the west end of the lake and continuing downstream across County Road 669. Local residents along with various organizations including the Little Traverse Lake Property Owners Association, Cleveland Township, Little Traverse Conservationists, the Michigan Department of Environmental Quality, Sleeping Bear Dunes National Lake Shore, the Leelanau County Road Commission and the Grand Traverse Band of Ottawa and Chippewa Indians, have been working together to come up with a reasonable solution. Various meetings have been held and will continue to be held to resolve this issue. Below is a summary of the studies and events leading up to the recommendation of how to address the high water and outlet system concern.

It should be noted that there are some concerns by Little Traverse Lake residents over any changes in the lake levels that could result in low water. This is taken into consideration in the reports outlined below.

In 2011, the Sleeping Bear Dunes National Lakeshore (SBDNL) commissioned a hydrologist to look at the Little Traverse Lake outlet system. A report titled: Hydraulic Assessment of Little Traverse Lake and Shalda Creek, was completed in July 2012 by Mike Martin, Hydrologist (WRD). This report is summarized below and can be found in Appendix C.

The goal of the report was to identify and describe possible causes of the observed lake levels based on site reconnaissance and provide recommendations for future management decisions. It also provided several approaches for quantifying the causes of these elevated levels. The elevated levels for Little Traverse Lake (LTL) were reported to be about 6 to 12 inches over "normal." One perceived cause of the higher-than-normal lake levels is downstream beaver activity, specifically, dam building in the downstream reaches of the creek that drains the lake. However, there are other conditions associated with the lake/stream system that could cause elevated lake levels.

The study looked at the overall setting, the flow, the physical characteristics and ecological features. They came up with five points of discussion regarding the lake levels and flow conditions on Shalda Creek:

(1) the channel of Shalda creek is very low gradient due to the surrounding terrain;

(2) extensive wetland environments exist on the margins of the creek creating broad reaches of reduced hydraulic conveyance;

(3) the culvert crossing immediately downstream from LTL represents a substantial constriction in the natural stream channel and certainly adds to elevated lake levels, especially during, times of high inflow into the lake;

(4) beaver dams create local areas of lowered channel gradient and backwater conditions for, some distance upstream; and
(5) higher than normal precipitation input may be at least part of the reason for the observed lake levels.

According to the report, the examination and site visit did not yield a conclusive explanation for the observed lake levels, stating there may be a number of contributing factors. It is not clear which elements of the stream system are having the greatest effect on observed lake levels, but it could very well be a combination of higher than average hydrologic input coupled with the physical features that reduce conveyance in the system (extensive side channel wetlands, beaver dams, and culverts, specifically the one directly downstream of LTL). To learn more about the recommendations in this report see Appendix C.

In the fall of 2013, LTLPOA convened a meeting with officials from Cleveland Township, Leelanau County Road and Drain Commission, and the Sleeping Bear Dunes National Lakeshore to discuss the need to commission a hydrology report with the purpose of learning about what influences water levels on the LTL and what actions might be taken to alleviate high water level conditions. Specific concern revolved around the culverts at Traverse Lake Road and at county road 669 on Shalda Creek and other contributing factors. After further review, LTLPOA contracted on Feb 12, 2014 with Gosling Czubak Engineering Sciences, Inc. to provide a Phase I hydrology study. The above participants contributed to assist in financing the study.

The goal of the investigation was to obtain factual data about the creek system all the way to Lake Michigan; to determine if these culverts have an impact on current lake levels; and if any other factor may be involved, including beaver dams downstream of CR 669. The investigation also analyzed possible methods to lowering lake levels, including up-sizing existing road culverts or replacing the culverts with clear span bridges. The Phase I investigation by Gosling Czubak titled "Little Traverse Lake Water Level Investigation", dated July 15, 2015 is summarized below and can be found in Appendix D.

The report looked at seven factors:

1. What are the culvert sizes and the true water surface elevation at key locations from the lake outlet to just downstream of the culvert at W. Lake Michigan Road?
2. Are all the water surface gauges on the same datum (do they correspond to each other)?
3. What is the location, size, and water level of the beaver dam downstream of CR 669?
4. What is the "normal" f low rate range through Shalda Creek?
5. What is the range of flow rate during storm events?
6. Rainfall and Water Level Gauge Readings
7. General Observations

Based on the field measurements and other information, the study performed two types of analysis on the culverts. One is an individual analysis of each culvert, without any attempt to model connectivity to other creek features. The second analysis is an attempt to evaluate how the system works as a whole and how performance at one culvert affects another. The analysis focused on the section of Shalda Creek between the beaver dam and the lake outlet.

The following questions were asked:

1. Do the calculated water surface levels at the culverts match real world observations?
Yes. Using the measured flow and water gauge readings were able to calibrate a hydraulic model of each culvert that followed real world observations very closely.

2. Does the culvert at Traverse Lake Road impede creek flow or impact Little Traverse Lake levels?
Yes. The culvert at Traverse Lake Road normally experiences a high tailwater condition that limits the capacity of the culvert. At flows lower than about 60 cfs, capacity of the culvert would be improved if the tailwater condition is lowered. However, at flows greater than 60 cfs, the culvert operates under "inlet control"

conditions. This means that no matter how low the tailwater condition is, the water can't get into the inlet fast enough, so the headwater level will be about the same, regardless of the tailwater condition.

3. Does the culvert at County Road 669 impede creek flow or impact Little Traverse Lake levels?

Yes, but to a lesser degree than the W. Traverse Lake Road culvert. This culvert also normally experiences a high tailwater condition that limits its capacity. At flows lower than about 120 cfs, capacity of the culvert would be improved if the tailwater condition is lowered. However, at flows greater than 120 cfs, the culvert operates under "inlet control" conditions. This means that the headwater level will be about the same, regardless of the tailwater condition.

4. What is the size and capacity of the culver t on West Lake Michigan Road?

The culvert on West Lake Michigan Road is actually two culverts. The capacity of this culvert system is much greater than the upper culverts due to its larger effective opening and its relatively low tailwater condition. The culvert generally operates under inlet control and has a capacity of about 140 cfs before overtopping the top of the culvert.

5. If the culvert(s) were removed or increased in size, how would lake levels change?

To effectively answer this question, additional stream cross section data is needed, along with a detailed water surface profile analysis. Based on the very preliminary stream data gathered as part of this first phase of investigation, the answer is: Yes, but the change is relatively minor and does not lower lake levels enough to eliminate the problems that have been associated with high water levels.

6. Does the beaver dam impact lake levels?

Yes, depending on the flow conditions. The way each dam affects creek flow and lake levels can vary at each dam location. A beaver dam does create a higher tailwater condition at the culverts than might naturally occur. Under higher flow conditions the culverts are under inlet control, so removing a beaver dam would have less affect on lake levels. However, removing a beaver dam could keep the “base” lake level lower so that when high flows do occur the impact from high lake levels could be of a shorter duration (lake levels could return to the base level more quickly). It was beyond the scope of this report to calculate how water levels would change if the beaver dams were removed.

The results of this study state that overall hydrologic system is quite complex. Implementation of any option requires more in depth analysis, but they offer general conclusions and options are offered for discussion. The report provided a table that includes a summary of several options considered, the advantage/disadvantage each option brings, the expected impact to lake levels, and the relative cost to implement.

In summary, replacing the existing culverts with higher capacity culverts or a clear span bridge may not produce the desired lake level reduction unless it is coupled with some form of beaver dam control. Beaver dam control without culvert modifications will continue to produce high lake levels at flows near or above 70 cfs. For more details see Appendix E.

The LTPOA voted to underwrite a report (Phase II) to study the impact of Beavers on the LTL outlet system and this will be available in Spring of 2015.

As a follow up to this Gosling Czubak Engineering (Phase I), July 15, 2014 report, Cleveland Township contracted with Gosling Czubak Engineering on November 11th, 2014 to provide preliminary engineering related to replacing culverts on Shalda Creek, downstream of Little Traverse Lake. This report is considered Phase III. The goal of this work is to provide the Cleveland Township with a Preliminary Opinion of Cost to replace the culvert at Traverse Lake Road and CR 669 with either a larger culvert system or a clear span bridge. A preliminary Phase III report was completed in March 2015 and is included in Appendix E.

The results of the Phase III Study- Culvert Replacement Preliminary Engineering Report by Gosling Czubak Engineering Sciences, Inc. include recommendations to replace the culverts both on Little Traverse Lake Road and County Road 669 and are identified as a task for the plan in Chapter 8, Category 4: Shoreline and Stream

Bank Protection (SSPB), Table 34 (Page 192). Over the spring and summer of 2015, the various groups involved in this project will be meeting to discuss funding opportunities and ways to address the situation.

Lime Creek Road Crossings- Narlock and Cemetery Road

A road and stream crossing survey would help determine the severity of these road and stream crossings, but there is concern that these crossings are in need of investigation as they are the two major roads that bisect Lime Creek, the main tributary to Lime Lake. The Leelanau Conservancy has a stream sampling location off of Narlock road and collects Total Phosphorus and discharge data.

Sugar Loaf Resort and area golf courses

Sugar Loaf Resort and area golf course are a potential concern since some of the practices used on the maintenance and upkeep of the land may input excessive nutrients into the watershed. It will be important to monitor the water and keep informed of the monitor well data to ensure excess nutrients are not entering groundwater or surface water in the GHB watershed.

4.8 UNDERSTANDING CONSERVATION EASEMENTS

One of the main goals of the Good Harbor Bay Watershed Protection Plan is to prevent increases in nutrient loading to the Good Harbor Bay and other water bodies. The nutrient loading model is grounded in the fact that natural land uses such as forest and wetlands produce far less total phosphorus loading than residential or other developed land uses. Permanent conservation easements are an important tool available to private landowners that wish to voluntarily prevent conversion of their natural lands. A conservation easement is a voluntary legal agreement between a landowner and a land trust that permanently limits a property's development potential while protecting its conservation values.

Key Advantages of Conservation Easements

- Leave the property in private ownership, and owners may continue to live on it, sell it, lease it or pass it on to heirs
- They are flexible and can be written to meet the particular needs of the landowner while protecting the property's conservation values
- They are permanent, remaining in force when the land changes hands

Land trusts are organizations that help to permanently protect land for the benefit of the public. There are more than 1,600 land trusts in the United States. These community-based institutions have protected more than 37 million acres of land. Land trusts may protect land through donation and purchase, by working with landowners who wish to donate or sell conservation easements (permanent deed restrictions that prevent harmful land uses), or by acquiring land outright to maintain working farms, forests, wilderness, or for other conservation reasons (LTA 2009).

The Leelanau Conservancy is a small non-profit accredited land trust serving Leelanau County. *Their mission is to conserve the land, water and scenic character of Leelanau County.* The Leelanau Conservancy has protected over 11, 000 acres in Leelanau County, mostly in private conservation easements. The Conservancy owns and manages about 2000 acres which are open to the public for passive recreation. The Conservancy works with interested landowners to establish permanent voluntary conservation easements over ecologically important land. They operate with the philosophy that a good conservation transaction must be good for both the land and the people involved.

How Conservation Easements Work

When a person owns land, they also "own" many rights associated with it. These property rights include the right to harvest timber, build structures, divide the property, conduct agriculture, and lease mineral rights and so on (subject to zoning or other land use restrictions). Conservation easements permanently restrict or eliminate the property rights that could degrade the documented conservation values found on the property. For example, a landowner may restrict the ability to develop more than 1 home site in the future, but retain the ability to manage the forest for sustainable timber harvest according to an approved forest management plan and maintain trails or two-track roads. These perpetual restrictions run with the land and all future owners are bound by the conservation easement's terms. Conservation easements can be used to protect a wide variety of land including farms, forests, wildlife habitat, and properties with scenic views. They are drafted in a detailed legal format that spells out the rights and restrictions on the owner's uses of the property as well as the rights and responsibilities of the land conservancy.

The Leelanau Conservancy works with interested landowner to determine if their land qualifies for permanent protection and help them determine the most appropriate conservation easement terms to protect the documented conservation values. Every conservation easement is a unique and customized to meet the desired uses of the landowner, provided they will not degrade the conservation values. Generally, limitations are made on the number and location of structures and types of land use activities that can take place. A conservation easement can serve as an important tool in generational financial planning. Conservation easements may cover all or just a portion of the property and they often allow some future construction within an approved area, if that is compatible with the easement's conservation objectives and the landowner's desires. For more information on conservation easements in Leelanau County, please contact the Leelanau Conservancy: www.leelanauconservancy.org or by calling 231-256-9665.

CHAPTER 5: BEST MANAGEMENT PRACTICES

5.1 OVERVIEW OF BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) are any structural, vegetative, or managerial practices used to protect and improve surface water and groundwater (DEQ 2001). Each treatment site must be evaluated independently, and specific BMPs can be selected to perform under given site conditions. Correct installation and maintenance are essential for optimum load reductions.

Structural BMPs are physical systems that are constructed for pollutant removal and/or reduction. This can include rip-rap along a stream bank, rock check dams along a steep roadway or biodetention basins, oil/grit separators, and porous asphalt for stormwater control.

Non-structural BMPs include managerial, educational, and vegetative practices designed to prevent or reduce pollutants from entering a watershed. These BMPs include riparian buffers and filter strips, but also include education, land use planning, natural resource protection, regulations, operation and maintenance, or any other initiative that does not involve designing and building a physical structure. Non-structural BMPs focus on source control treatments which are far more cost effective than restoration efforts after degradation has occurred (Like the common saying, "An ounce of prevention is worth a pound of cure"). Individual non-structural BMPs often address multiple pollutants or stressors simultaneously. Establishing a perpetual conservation easement over priority areas will prevent a number of different pollutants (sediment, nutrients, toxins, etc.) from entering the watershed.

Table 28 identifies possible BMPs to address common sources and causes of pollutants or stressors in the Good Harbor Bay watershed as well as where to find more information about each type of BMP. The table also notes if a potential load reduction estimate is available for a specific BMP.

Table 28: BMP Examples by Pollutant Source

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	Information Source
Bank/Shoreline Erosion	Sediment Habitat Loss	Stream bank stabilization: bank slope reduction, riprap, tree revetments, vegetative plantings, bank terracing, etc.	Varies *(see milestones in Chapter 8)*	-Conservation Resource Alliance (CRA -Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual -Michigan Ag BMP Manual
Stormwater and Impervious Surfaces	Sediment Nutrients Toxins Pathogens Increased Temperature	-Develop stormwater management plans, d other applications such as the Platte Lakes Area Management Plan overlay district - Also See Table 29	See Table 30	-The Watershed Center's Stormwater Management Guidebook -Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual -Center for Watershed Protection – Storm center website

Table 28: BMP Examples by Pollutant Source (Cont'd)

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	Information Source
Road Crossings - eroding, failing, outdated	Sediment Nutrients	-Road Crossing BMPs (vary widely – See Road Stream Crossings)	Varies *(see milestones in Chapter 8)*	-Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual
Residential/Commercial Fertilizer Use	Nutrients	-Enact local ordinances to limit fertilizers containing Phosphorus -Education on proper use of fertilizers: workshops, brochures, flyers, videos, etc.	Not available	-Public Information and Education Strategy (Chapter 9)
Septic Systems (Leaking)	Nutrients Pathogens	-Education on proper septic system maintenance -Septic system inspections -Ensure proper septic system design -Demo projects for alternative wastewater treatment systems -Chemical treatment of septic systems to reduce nutrient loading	Varies/ Not available	-Leelanau/Benzie Health Department -Public Information and Education Strategy (Chapter 9)

Table 28: BMP Examples by Source Cont'd

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	BMP Manual or Agency Contact*
Development and Construction	Sediment Habitat Loss	-Implement soil erosion control measures -Utilize proper construction BMPs like barriers, staging and scheduling, access roads, and grading) -Establishing perpetual conservation easements with voluntary landowners in priority areas	Varies/ Not available	-MI Low Impact Development Manual -Green Infrastructure Manual -Public Information and Education Strategy (Chapter 9)
Purposeful or Accidental Introduction of Invasive Species	Invasive Species	-Boat washing stations -Workshops, Brochures, Flyers, Videos, Etc. -Educational Programs	Not available	-Benzie Conservation District -Public Information and Education Strategy (Chapter 9)

* Green Infrastructure Manual: www.newdesignsforgrowth.com --> NDFG Programs; MI Low Impact Development Manual --> www.semcog.org/lowimpactdevelopmentreference.aspx; Natural Resources Protection Strategy for Michigan Golf Courses --> www.michigan.gov/documents/deq/ess-nps-golf-course-manual_209682_7.pdf

5.2 POLLUTANT LOAD REDUCTIONS

Pollutant Reduction Estimates for Land Conservation Practices

To help maintain the high water quality resources of the Good Harbor Bay watershed it is important to address known sources of pollution while at the same time preventing increases in pollutant loading overtime from emerging or currently unknown pollutant sources. Protecting Priority Areas identified in the GHBWPP with voluntary conservation easements is an excellent strategy to meet this objective. The Leelanau Conservancy is the local land conservancy using these strategies to protect high quality land in the Good Harbor Bay watershed, in addition to the rest of Leelanau County.

Land conservation BMPs are excellent ways to preserve water quality. When dealing with pollutant reduction from these specific types of BMPs the idea is to estimate the amount of pollution prevented from entering the watershed by keeping the land in its natural state. The load reduction is essentially the difference between the loading from the current land use and the loading from a more developed land use.

Table 29 represents the total pollutant loads for Total Suspended Solids, Total Nitrogen and Total Phosphorus (Lbs /yr) per land use type for the Good Harbor Bay Watershed. The numbers were calculated by multiplying the land use acreages from Table 9 (page 53) and estimated pollutant loads from Table 29 on the next page.

Table 29: Average Pollutant Loads by Land Use (Lbs/acre/yr)

Land Use	Total Suspended Solids	Total Nitrogen	Total Phosphorus
Commercial	1,040	18	1.2
Industrial	1,080	12	1.3
Institutional	790	6.5	0.8
Transportation	1,330	7.7	1.1
Multi-Family	1,050	8.6	1.1
Residential	154	3.1	0.4
Agriculture	153	2.4	0.18
Vacant	40	0.5	0.09
Open Space	20	0.2	0.13

Values obtained from EPA's Region 5 Pollutant Loading Model

Table 30: Total estimated pollutant loads for the Good Harbor Bay Watershed

Land Use	Acres	Total Suspended Solids	Total Nitrogen	Total Phosphorus
Forested (non-wetlands)	22,061.3	441,226	4412.23	2,868
Agriculture	2,811.2	430,113.6	6,746.89	506
Urban	1,649.1	253,961.4	5,112.2	659.6
Barren (beaches, dune, rock)	736.9	29,476	368.45	66.3
Total	27,258.5	115,4777	16,639.8	4,099.9

Note: Numbers are in Pounds/year. Averages were taken from Table 9 (page 53) in order to group land use categories appropriately. Water is not included in this table.

Permanent Conservation Easement Pollutant Load Reduction (lb/yr)

The total pollutant load reduction from a permanent conservation easement is determined by subtracting the total pollutant loading coefficient for the more developed land use, such as low density residential, from the total pollutant loading coefficient for a more natural land use, such as wetland or forest.

Below are the annual pollutant loading coefficients for various land uses found in the Good Harbor Bay watershed as determined by measured total phosphorus concentrations and their respective nitrogen and sediment ratios. Subtracting annual pollutant loads for forested land uses below from the annual pollutant loads for low density residential (LDR) and then multiplying by the conservation easement acreage yields an estimation of the reduction in annual pollutant load resulting from a permanent conservation easement implementation in Priority Areas.

(Low Density Residential lbs/ac/yr – Forested lbs/ac/yr) x Conservation Easement acres = Load reduction from permanent conservation easement

Annual Pollutant Loading Coefficients

Multipliers for Natural Land		
Sediment	134	(Res @ 154 - Open Space @ 20)
TN	2.9	(Res @ 3.1 - Open Space @ .2)
TP	0.27	(Res @ .4 - Open Space @ .13)
Multipliers for Agriculture		
Sediment	1	(Res @ 154-Ag @ 153)
TN	0.7	(Res @ 3.1-Ag @ 2.4)
TP	0.22	(Res @ .4-Ag @ .18)

The watershed plan goal is to permanently protect 2500 acres of land within identified Priority Areas throughout the watershed by 2024 (See Land Protection and Management Goals in Chapter 8. Successful implementation of permanent voluntary conservation easements over 2500 acres will prevent 168,750 tons of sediment, 4500 lbs N, and 602.6 lbs P from entering the Good Harbor Bay watershed each year.

Table 32: Estimation of the reduction in annual pollutant load from permanent conservation easement implementation in Priority Areas

Future Conservation Easements
(potentially protected)

Conservation Easement	Acres	Sediment (tons)	Nitrogen (lbs.)	Phos. (lbs.)
Natural Land	1250	167500	3625	337.5
Farmland	1250	1250	875	265.1
Total	**2500**	**168750**	**4500**	**602.6**

Pollutant Reduction Estimates for Stormwater BMPs

The primary stormwater source in the Good Harbor Bay watershed is direct runoff from roadways. Table 32 lists the total percent removal of phosphorus, nitrogen, sediment (total suspended solids), and metals and bacteria for selected stormwater BMPs that could be used for stormwater pollution particular to this watershed.

Listing BMP effectiveness by percentage is often a more useful way of conveying the data to the general public rather than using specific concentration values, which can be difficult to comprehend for the average person.

It should be noted that the percent removal values in Table 32 are comparative numbers that approximate how much pollutant is removed as compared to no BMP implementation. For example, it is assumed that porous pavement values approximate the percentage of pollutants removed compared to regular pavement storm water runoff; or that Riparian Buffer values approximate the percentage of pollutants removed as compared to runoff from a landscaped, fertilized lawn. For more specific information on these stormwater BMPs, please see the Center for Watershed Protection's Stormwater Center website at www.stormwatercenter.net.

Additionally, keep in mind that not every BMP may be the best selection for every site. Some places are better suited for specific kinds of BMPs. There are other factors to consider besides pollutant removal efficiency when deciding which BMP to use at a site. Other factors include the size of site, money available for implementation, and the purpose of the land (i.e., what the site will be used for).

Table 32: Pollutant Removal Effectiveness of Selected Potential Stormwater BMPs

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Riparian Buffer*	Grass: 39-88 Forest: 23-42	Grass: 17-87 Forest: 85	Grass: 63-89 Forest: N/A	n/a	- Increase in property value - Public education necessary
Porous Pavement	65	82	95	Metals: 98	$2-3/ft^2 (traditional, non-porous asphalt is $0.50-1.00/ft^2)
Infiltration Basin	60-70	55-60	75	Metals: 85-90 Bacteria: 90	$2/ft^3 of storage for a ¼-acre basin - Maintenance is essential for proper function
Infiltration Trench	100	42.3	n/a	n/a	$5/ft^3 (expensive compared to other options)
Bioretention **(Rain Gardens, etc.)**	29	49	81	Metals: 51-71 Bacteria: -58	$6.80/ft^3 of water treated - Landscaped area anyway - Low maintenance cost - Note possible export of bacteria
Grassed Filter Strip (150 ft)	40	20	84	n/a	- Cost of seed or sod

Table 32: Pollutant Removal Effectiveness of Selected Potential Stormwater BMPs (Cont'd)

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Sand and Organic Filter Strip	Sand: 59 +/-38 Organic: 61 +/-61	Sand: 38 +/-16 Organic: 41	Sand: 86 +/-23 Organic: 88 +/-18	Sand: Metals: 49-88 Bacteria: 37 +/-61 Organic:Metals: 53-85	Not much information, but typical costs ranged from $2.50 - $7.50/ft of treated stormwater
Grassed Channel/Swale	34 +/-33	31 +/-49	81 +/-14	Metals: 42-71 Bacteria: -25	$0.25/ft^2 + design costs - Poorer removal rates than wet and dry swales
Constructed Wetlands** **1) Shallow Marsh** **2) Extended Detention Wetland** **3) Pond/Wetland** **4) Submerged Gravel Wetland**	1) 43 +/-40 2) 39 3) 56 +/-35 4) 64	1) 26 +/-49 2) 56 3) 19 +/-29 4) 19	1) 83 +/-51 2) 69 3) 71 +/-35 4) 83	1) Metals: 36-85; Bacteria: 76 2) Metals: (-80)-63 3) Metals: 0-57 4) Metals: 21-83; Bacteria: 78	- Relatively inexpensive; $57,100 for a 1 acre-foot facility - Data for 1 and 2 based on fewer than five data points

**Pollutant removal efficiencies will increase as buffer width increases. Grasses in this case mean native grasses -not regular lawn or turf grass.*

*** Wetlands are among the most effective stormwater practices in terms of pollutant removal, and also offer aesthetic value. While natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands. There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.*

Values obtained from Center for Watershed Protection's Stormwater Center website (www.stormwatercenter.net) and Practice of Watershed Protection Manual (Schueler and Holland 2000).

It should be noted that information regarding the pollutant removal efficiency, costs, and designs of structural stormwater BMPs is constantly evolving and improving. As a result, information contained in Tables 28 and 29 is dynamic and may be updated to reflect new information and data as it is available.

CHAPTER 6: WATERSHED PLANNING EFFORTS

6.1 STEERING COMMITTEE, STAKEHOLDER AND PARTNER OUTREACH

Survey Results

(with contributions by Ann Mason and Jerry Leanderson)

The GHBWPP Steering committee conducted a paper (Appendix D) and on-line survey (http://www.surveymonkey.com/s/N7VXX55) during the course of the watershed planning process. There were two versions of the survey. The first survey was created in April of 2011 did not include information about the various locations (lakes, streams or national park) in the watershed, but received 80 responses. The second version of the survey (appendix D), which was updated a few months later, was mailed to riparian owners in the watershed (lake residents, and those who lived along streams, wetlands and the lake MI shoreline) in spring of 2014. This survey was more comprehensive and received 80 responses. The results below include comparisons from both surveys. Below is a summary of those results and the details can be found in Appendix D.

Within the watershed, inland lake/stream residents, Lake Michigan residents, full-time and seasonal residents have different perceptions of what's important to the watershed and how it should be used and protected. Inland lake/stream residents, both year round and seasonal are more concerned with natural habitat and the effects of development than are seasonal/visitor residents or Lake Michigan residents, either seasonal or year-round. The timing of the survey was a factor. If the survey had been done in August/September instead of April/May, the importance of lake levels might have been seen differently, at least on Little Traverse Lake!

There are also major areas of agreement among these groups. In response to the question "how would you like to see the Watershed 50 years from now", almost all of the respondents said things like "I hope it will remain as it is", "same as today", "beautiful as it is now".

Clean water without algae is a universal high priority.

Invasive species were of concern to nearly every survey respondent. They may not have opinions or knowledge about nutrient infusion, sediment, pathogens, toxins and thermal pollution, but they definitely are aware of the effects of invasive species, whether zebra mussels, Asian carp, dumping from ocean-going vessels, phragmites, humans, etc.

The majority of the responses were from Full Time/Year Round Residents (35%) with seasonal or part-time residents coming in at 29.4% for responses. When asked what part of the watershed survey respondents were most familiar with, most stated Lake Michigan (41%). Respondents were also mostly familiar with Little Traverse Lake (33%) and Sleeping Bear Dunes National Lakeshore (14%). Survey respondents were asked about the types of activities they enjoy in the watershed and where they enjoy these activities. Swimming was most popular on the Lake Michigan Shoreline while motor boating was most popular on the inlands lakes (Lime and Little Traverse). Fishing was most popular on Lake Michigan, but also on the inland lakes.

When asked what the highest priority threat was in the watershed, Invasive Species, Loss of Habitat and Toxins where all ranked high (Figure 29). When asked what the lowest threats were in the watershed, Fluctuations in Lake Levels and thermal pollution where all ranked low (Figure 30).

Figure 29: Survey results- Threats in the GHB watershed considered a HIGH priority

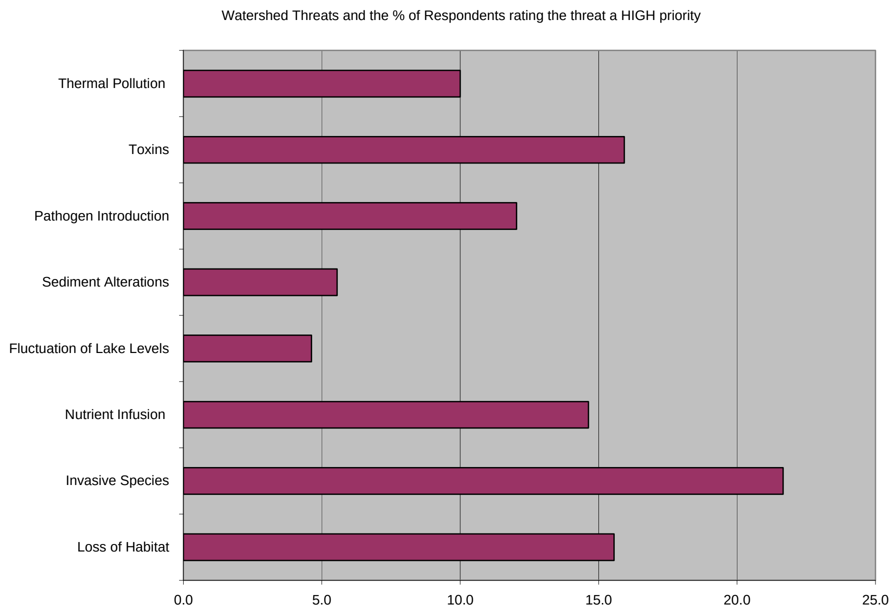
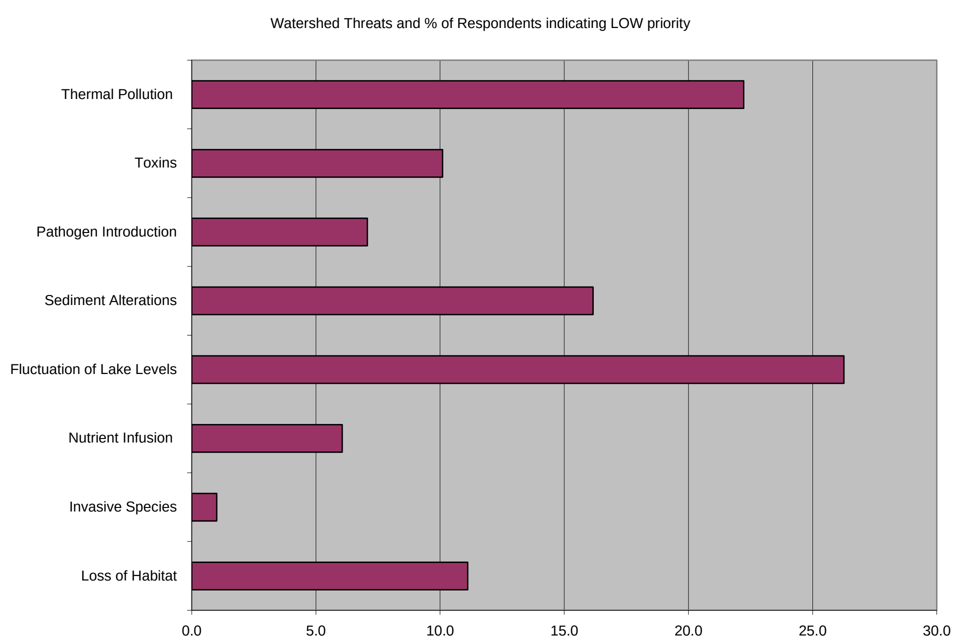


Figure 30: Survey results- Threats in the GHB watershed considered a LOW priority



When asked if there are any specific sites in the watershed that deserve special attention and/or management, over 72% of respondents said YES. Of the comments relating to this question, about 13% stated the Lake Michigan Shoreline and 13% mentioned the Tributaries to the lakes. About 6.5% mentioned sugarloaf resort. When asked: “What do you feel is the greatest threat to the Good Harbor Bay Watershed?” the majority of the responses were: Invasive Species (30%), Pollution (15%) and Development (11%).

When asked “What changes specifically, if any, have you noticed since you've lived in the watershed in and WHERE you have noticed these changes?” The majority of respondents noticed changes along the Lake Michigan Shoreline (71%). The comments indicated low lake levels being a the change (19%) along with algae (19%) and invasive species (17%). High lake levels and zebra mussels were mentioned specifically as a change in Little Traverse Lake. On Lime Lake, the comments mentioned zebra mussels, development and algae as changes. Increased beaver activity was mentioned as a change on Shetland, Shalda and Lime Creeks. The increased use and traffic was mentioned as a change in the Sleeping Bear Dunes National Lakeshore.

To share a few quotes:

"Many huge 'cottages' and the water resources required by them" are a concern.

"This area is not only the best in Michigan but all the USA. And usually not overflowing with people!"

"The greatest threat to the watershed is loss of natural habitat".

"The greatest threat is increased human footprint".

"cannot walk on the shore (of Good Harbor Bay) because of the buildup of algae and dead birds"

"No great loss of beach and natural trees. Very limited development"

6.2 GOOD HARBOR BAY WATERSHED PLAN ACCOMPLISHMENTS TO DATE

Lime Lake Association

- Newsletters put out 2x/year and the majority of the newsletters include information about watershed plan
- Put up boat washing/invasive sign at boat launch
- Shoreline Erosion study- set up in 2013 and ongoing (2014 +)
- Hosted annual meeting with Yarrow Brown to present on watershed plan and accomplishments
- Partner/initiator in watershed plan
- Support of water sampling program

Little Traverse Lake Property Owners Association

- 2newsletters per year including information about watershed plan
- Put up boat washing/invasive sign at boat launch
- Shoreline Erosion study- set up in 2013 and ongoing (2014 +)
- Hosted annual meeting with Yarrow Brown to present on watershed plan and accomplishments
- Partner/initiator in watershed plan
- Volunteers help with stream sampling in watershed
- Support of water sampling program

Little Traverse Conservationists

- Research on LTL water levels and culvert design
- Shoreline Erosion study- set up in 2013 and ongoing (2014 +)

Leelanau Conservation District

- Supported mailing to Riparian landowners- Spring 2014 and stakeholder mailing (7/2014)
- Phragmites and other invasive species surveys
- Working with landowners and producers in the watershed
- District Forester hired in 2013 and hosting workshop

- Partner in shoreline workshops

Leelanau Clean Water

- Host shoreline and septic workshops

Leelanau Conservancy

- Host water sampling program and water quality database
- Facilitated the watershed planning process
- Protected 735 acres of private land and 189.3 acres of public land in the watershed from 1988-2014 (Total = 924.3)

Sleeping Bear Dunes National Lakeshore

- Water sampling on beaches, lakes and streams in SBDNL
- Support for culvert project on outlet of Little Traverse Lake
- Participation in GHB steering committee

Michigan DNR Fisheries Division-

- Lime Lake Fisheries Survey conducted in 2010
- Lime Lake Status of the Fishery Report completed in 2011
- Little Traverse Lake Fisheries Survey conducted in 2013
- Little Traverse Lake Status of the Fishery Report completed in 2014
- Tributaries to Little Traverse Lake and Lime Lake are scheduled to be electrofished in July of 2014

CHAPTER 7 WATERSHED GOALS AND OBJECTIVES

The overall mission for the Good Harbor Bay Watershed Protection Plan is to identify actions, or protection measures, and provide guidance for the implementation of those actions, which will reduce the potential negative impacts that pollutants and environmental stressors could have on the designated watershed uses. The overall goal for the Good Harbor Bay Watershed Protection Plan is to support and protect all identified, designated and desired watershed uses while maintaining the distinctive environmental characteristics and high water quality of the Good Harbor Bay Watershed.

After reviewing the pollutant priorities, stakeholder survey and discussing the priorities in the watershed, the project steering committee developed six broad goals for the Good Harbor Bay Watershed (Table 33). Working to attain these goals will ensure that the designated and desired uses described in Chapter 4 are maintained or improved.

Watershed Goals:

1. Protect aquatic and terrestrial ecosystems.
2. Protect the quality and quantity of water resources.
3. Preserve high quality of recreational opportunities.
4. Ensure that all property owners, visitors, users and other stakeholders understand stewardship and are able to support and promote watershed protection activities.
5. Protect the health and safety of watershed users, residents and stakeholders.
6. Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected.

Table 33: Good Harbor Bay Watershed Goals

Goal	Designated or Desired Use Addressed	Pollutant/Environmental Stressor Addressed
#1-Protect aquatic and terrestrial ecosystems.	Warm/Coldwater Fishery, Other Aquatic Life, Navigation Desired Use: Aesthetics, *Ecosystem Preservation*	Loss of habitat, invasive species, nutrients, thermal pollution
#2-Protect and improve the quality of water resources.	ALL	Nutrients, hydrology, sediment, pathogens, toxins
#3-Preserve high quality of recreational opportunities.	Warm/Coldwater Fishery, Total Body Contact, Navigation Desired Use: *Recreation*	Loss of habitat, pathogens, toxins, thermal pollution, nutrients
#4-Implement/promote educational programs that support stewardship and watershed planning goals, activities, and programs.	All	Loss of habitat, nutrients, pathogens, invasive species, toxins
#5- Protect the health and safety of watershed users, residents and stakeholders	Warm/Coldwater Fishery, Partial/Total Body Contact, Navigation, Fish consumption Desired Use: Human Health	Nutrients, Sediment, pathogens, toxins, thermal pollution
#6- Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected	Warm/Coldwater Fishery, Habitat, Partial and Total Body Contact, Agriculture Desired Use: *Recreation, Ecosystem Preservation*	Hydrology, Loss of habitat, Sediment, pathogens, toxins

Goal #1

Protect aquatic and terrestrial ecosystems

Designated uses: warm/coldwater fishery, other aquatic life

Desired uses: ecosystem preservation

Pollutants or stressors addressed: Loss of habitat, invasive species, nutrients, thermal pollution

Objective 1.1	Inventory and evaluate the constituents, resources and conditions of our natural systems.
Objective 1.2	Establish land and water management practices that conserve and protect the natural resources of the watershed and consider the influences driven by climate change.
Objective 1.3	Preserve the biodiversity of the watershed.
Objective 1.4	Protect and restore critical habitat areas for aquatic life and fish.
Objective 1.5	Protect shoreline habitats and promote the wise use of shorelines.
Objective 1.6	Preserve the distinctive character and aesthetic qualities of the watershed including viewsheds and scenic hillsides.
Objective 1.7	Manage and control existing invasive species and minimize the spread of new invasive species.
Objective 1.8	Maintain and enhance ecosystem functions of the wetland and riparian areas in the watershed.

Goal #2

Protect the quality and quantity of water resources.

Designated Uses: Warm/Coldwater Fishery, Other Aquatic Life, Total Body Contact

Desired Use: Human Health

Pollutants or Stressors Addressed: Nutrients, hydrology, sediment, pathogens, toxins, thermal pollution

Objective 2.1 Identify threats to high quality water and surrounding ecosystems that are likely influences within watershed.

Objective 2.2 Control and reduce the amount of pollutants in stormwater, stormwater runoff entering surface waterbodies.

Objective 2.3 Identify verifying tests, best practices and action strategies to deal with threats.

Objective 2.4 Maintain and enhance existing long term water quality testing program and procedures.

Objective 2.5 Prioritize, stabilize and/or improve road-stream crossing embankments and approaches.

Objective 2.6 Control and/or minimize the input of pollutants, pathogens and toxic compounds into surface water and groundwater.

Objective 2.7 Prioritize, stabilize and/or improve shoreline, stream and banks to prevent erosion.

Objective 2.8 Assure plans and actions reflect the expected influences tied to climate change.

Objective 2.9 Understand existing hydrology and strive for hydrologic practices that will enhance, expand and support water quality.

Goal #3

Preserve high quality recreational opportunities in the watershed

Designated Uses: Warm/Coldwater Fishery, Total Body Contact, Navigation

Desired Use: Recreation

Pollutants or Stressors Addressed: Loss of habitat, pathogens, toxins, thermal pollution, nutrients

Objective 3.1 Support desired recreational uses while maintaining distinctive environmental characteristics and aquatic biological communities throughout the watershed.

Objective 3.2 Maintain and promote high quality and diverse fishing opportunities throughout the Good Harbor Bay Watershed.

Objective 3.3 Maintain and promote high water quality to ensure safe and clean areas for public swimming and other types of water recreation.

Objective 3.4 Maintain and protect un-fragmented large tracts of wetlands, wildlife corridors and forested habitat on public and private lands across the watershed.

Goal #4

Ensure that all watershed property owners, visitors, users and other stakeholders understand stewardship and are able to support and promote watershed protection activities.

Public I/E Campaign

Designated Uses: All

Desired Uses: All

Pollutants or Stressors Addressed: Loss of habitat, nutrients, pathogens, invasive species, toxins

Objective 4.1 Implement Information and Education Strategy outlined in Chapter 9.

Objective 4.2 Raise awareness, understanding, commitment and action within the Good Harbor Bay Watershed so that private practices and public policy enhance attainment of the watershed goals.

Objective 4.3 Involve the citizens, public agencies, user groups and landowners in implementation of the watershed protection plan through meetings, events and workshops with individuals or groups.

Objective 4.4 Measure effectiveness of outreach activities in increasing awareness and reduction of Non-Point Source (NPS) pollution, including shoreline erosion.

Objective 4.6 Increase awareness of proper septic system maintenance, fertilizer use and storage of organic wastes and fertilizers.

Objective 4.7 Encourage appropriate provisions for site plan development and review for water quality and natural resources protection.

Goal #5

Protect the health and safety of watershed users, residents and stakeholders

Designated Uses: Warm/Coldwater Fishery, Partial/Total Body Contact, Navigation, Fish consumption

Desired Uses: Human Health

Pollutants or Stressors Addressed: Nutrients, Sediment, pathogens, toxins, thermal pollution

Objective 5.1 Identify and address threats to groundwater and surface water to ensure public drinking water is protected.

Objective 5.2 Monitor swimmers itch and develop a program to address swimmers itch concerns in the watershed.

Objective 5.3 Monitor water bodies, including the Lake Michigan shoreline and interface areas, for E. coli (fecal coliform), botulism, and fish die offs and address areas of concern.

Objective 5.4 Partner with the health department, county and townships to promote proper septic system maintenance and replacement.

Goal #6

Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected

Designated Uses: Warm/Coldwater Fishery, Habitat, Partial and Total Body Contact, Agriculture

Desired Uses: Recreation, Ecosystem Preservation

Pollutants or Stressors Addressed: Hydrology, Loss of habitat, Sediment, pathogens, toxins

Objective 6.1 Promote developments and land use activities that work in harmony with watershed protection

Objective 6.2 Adopt the most economically sound approaches to ecologically sound watershed practices

Objective 6.3 When developing watershed protection policies give consideration to the property values, local business and tourism.

CHAPTER 8 IMPLEMENTATION TASKS AND ACTIONS

8.1 IMPLEMENTATION TASK CHART FOR EACH GOAL AND OBJECTIVE

Objectives and Tasks

The goals detailed in Chapter 7 for the Good Harbor Bay watershed were developed by the Steering Committee to protect the designated and desired uses of the watershed. The goals are recommendations for implementation efforts within the watershed. Each goal has multiple objectives that outline how the goal can be reached. Tasks were then assigned to address the individual goals and multiple objectives. The detailed task implementation chart (Table 34) has broken the tasks into nine (9) major categories: Water quality, Fish & Wildlife habitat, shoreline and stream bank protection, invasive species, best management practices, outreach and education, land protection, public health/safety, and economy. This table (Table 34) describes the task by category, provides interim milestones, approximates projected costs and assigns a plausible timeline for completion. The chart also identifies possible project partners, however, this does not imply any sort of commitment on behalf of these organizations to accomplish these task criteria. These were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority and critical areas in the watershed (Tables 22 & 23, Figures 33 & 34). The implementation tasks in Table 34 are designed to address individual watershed objectives under each main goal. Some of the tasks utilize are designed to address multiple objectives under one treatment.

Priority Level

Each task has been given a priority level based on the following criteria:

1. High-
2. Medium-
3. Low-

Unit Cost/Cost Estimate

An estimated cost is provided when available and applicable. An estimated total cost is provided when it is able to be calculated. Table 32 summarizes the Goals by Designated and Desired uses.

Milestones

Milestones are identified, when possible, to establish a measurable benchmark for determining the progress of a specific task or action.

Timeframe

A timeframe of 10 years was used to determine the scope of activities and the estimated costs for implementing the tasks. The year in which the task or action is to begin or end is noted. When a task or action is ongoing, it is noted as spanning the ten years.

Funding Sources

Likely funding sources for task implementation include State and Federal grant sources (DEQ: CMI, CWA Sec. 319, GLRI, NAWCA, GLFT, MDNR), private foundations, private fundraising from the Platte Lake Improvement Association and other lake associations, local land conservancies and volunteer time.

Potential Partners

Potential partners and target audiences are outlined on the next page with acronyms. These include anyone who have the interest or capacity to implement a task or action. However, they are not obligated to fulfill the task or action. It is anticipated they will consider pursuing funds to implement the task or action, work with other identified potential partners and communicate any progress with the Good Harbor Bay Watershed Protection Plan Steering Committee or project partners.

Targeted Audiences

These are audiences are those groups and individuals that would be appropriate for information and educational outreach.

Potential Project Partner Acronyms:

BCD- Benzie Conservation District

BCRC – Benzie County Road Commission

BCPRC-Benzie County Parks & Recreation Commission

BLHD – Benzie-Leelanau Health Department

CRA – Conservation Resource Alliance

EPA – Environmental Protection Agency

GTBOCI – Grand Traverse Band of Ottawa and Chippewa Indians

GTRLC- Grand Traverse Regional Land Conservancy

GTCNC- Grand Traverse County Nature Center

ISEA – Inland Seas Education Association

LeeCty – Leelanau County

LC – Leelanau Conservancy

L-CD – Leelanau Conservation District

LCRC – Leelanau County Road Commission

LCW – Leelanau Clean Water

LCHR-Leelanau Scenic Heritage Route

LGOV – Local Governments

LA- Lake Associations

MDNR – Michigan Department of Natural Resources

MDEQ- Michigan Department of Environmental Quality

M-DOT – Michigan Department of Transportation

MNSP-Michigan Natural Shoreline Partnership

MSU-E – Michigan State University Extension

NRCS – USDA Natural Resources Conservation

PLIA – Good Harbor Bay Improvement Association

NWMCOG – Northwest Michigan Council of

Governments

NWMSBF-Northwest Michigan Sustainable Business Forum

OWTTF – Onsite Wastewater Treatment Task Force

SBDNL- Sleeping Bear Dunes National Lakeshore

USFWS – United States Fish & Wildlife Service

Others:

Area Libraries, Boat/Marine Retailers, Garden Centers and Nurseries, Solid waste management entities, Schools, Leelanau County Chamber of Commerce, Architects and Engineers, Local Realtors, Businesses, Landscaping Companies

Target Audiences Include:

Builder/Developer/Realtor

Education

Households

Local Governments

Riparian Landowners

Tourists

General

Funding Sources:

DEQ: CMI- Department of Environmental Quality, Clean Michigan Initiative

CWA Sec. 319- Clean Water Act

GLRI- Great Lakes Restoration Initiative

NAWCA- National

GLFT- Great Lakes Fisheries Trust

MDNR- Michigan Department of Natural Resources

The tables on the following pages (Table 34) include the tasks for implementing the watershed plan. The evaluation strategy and the information and education strategy are presented in the next two chapters (Chapters 9 and 10).

Table 34: Tasks for Implementing the Good Harbor Bay Watershed Plan

Category 1: Water Quality (WQ)

Categories/Tasks	*Priority:* *HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
WQ1- Maintain current water quality program	HIGH	$11,000/year (analysis and report)	Annual review of water quality monitoring results. Reported in Lake Association publications and on Leelanau Conservancy website	X	X	X	X	X	X	X	X	X	X	Leelanau Conservancy	2.4
WQ2-Establish a water quality monitoring program for water quality threats and hot spots, including E. coli and appropriate training for water quality testing and sources for hot spots	HIGH	$10,000 initial and $5,000/year	Start sampling program and training in 2016 and continue yearly as funding is available.		X	X	X	X	X	X	X			LTC, LLA, LTLPOA, LCD, SBDNL, CRA	2.1,2.4
WQ3-Stay current with ongoing research on swimmer's itch in Northern Michigan	HIGH	$0.00	LLA biologist will keep the steering committee and lake associations informed annually or research progress	X	X	X	X	X	X	X	X	X	X	LLA, LTPOA	2.1
WQ4- Assess the need for & feasibility of instituting a new swimmer's itch control program using new technology on Lime and Little Traverse Lakes	HIGH	$20,000/year	Once research is complete, inform lake associations and develop a control program 2020		X	X	X	X	X					LLA, LTPOA, LTC	2.1

Category 1: Water Quality (WQ) (Continued)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
WQ5- Implement swimmer's itch control measure on Lime and Little Traverse Lakes	HIGH	$40,000/year	Pending funding and research results, implement control measures by 2017, assess annually			X	X	X	X	X	X	X	X	LLA, LTPOA, LTC	2.1
WQ6- Investigate public health effects in the watershed including well water quality, swimmers itch and *E. coli* testing	MEDIUM	$1000/year	Lake Association will develop a task force by 2015. Plan by 2018.		X			X						LCD, LLA, LTC, LTLPOA, Conservancy	2.1
WQ7- Establish watershed wide central database for water quality data.	MEDIUM	$12,000 to start $6,000 annual	Raise funding and do research on feasibility by 2015. Launch central database by 2018.			X	X	X	X	X	X	X	X	LCD, LLA, LTC, LTLPOA, Leelanau Conservancy	2.4
WQ8-Conduct data analysis and investigate impacts to living organisms and impact of threats on water quality and use this information to establish limits on the watershed threats	MEDIUM	$1000/year	Develop a summary report of water quality testing and investigating every 3 years. First report in 2015.			X			X			X		LCD, LLA, LTC, LTLPOA, Conservancy	1.3,1.4,3.3, 2.6,2.1,2.4

Category 1: Water Quality (WQ) (Continued)

Categories/Tasks	***Priority:*** ***HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***	***2024***	***Potential Project Partners***	***Objective(s) Addressed***
WQ9- Develop a plan for threat reduction and mitigation strategies in the watershed	MEDIUM	$1000/year	Lake Association will develop a task force by 2018 and implement plan by 2020		X			X	X	X	X	X	X	LCD, LLA, LTC, LTLPOA, Leelanau Conservan	2.2,2.1,1.2,1.1
WQ 10-Develop a lake nutrient loading model for the major lakes in the watershed.	LOW	$60K sampling, $30K development of model	Develop a lake nutrient loading model for the major lakes in the watershed by 2018 as funding is available.						X					LCD, LTC, LLA, LTLPOA, Leelanau Conservan cy	2.3, 2.4

Category 2: Fish and Wildlife Habitat (FWH)

Categories/Tasks	***<u>Priority:</u> HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***	***2024***	***Potential Project Partners***	***Objective(s) Addressed***
FWH1-Maintain high quality inland lake fisheries	HIGH	$9,782 annually	Receiving positive angler comments	X	X	X	X	X	X	X	X	X	X	MDNR, GTBOCI, NFWS	1.1,1.4,1.3, 2.2, 3.2
FWH2-Work with interested landowners to promote placement of large woody debris in near-shore zones of lakes through-out the watershed for fish habitat.	MEDIUM	$1500/year over ten years	1. Develop literature for property owners. 2. Create a “demo site” of a natural shoreline property	X	X	X	X	X	X	X	X	X	X	MDNR, PLIA, BCD, SBDNL, CRA	1.2,1.3,1.4
FWH3- Monitor fisheries population on inland lakes and streams, draft subsequent status reports	MEDIUM	Lake surveys are conducted once every ten years. Stream surveys are conducted once every five-ten years. $5500 per lake	Completion of survey write-ups (available to the public) within one year of the surveys completion. Lime Lake surveyed in 2009/ LT Lake surveyed in 2013					X				X		MDNR, GTBOCI, NFWS	3.2, 3.1, 1.1
FWH4- Implement BMP’s and habitat restoration as needed and as funding is available. Compile list of priority areas.	MEDIUM	<u>Estimate</u> $80/foot for 1000 feet = $8,000	Initiate projects as funding available, ongoing			X	X	X	X	X	X	X	X	CRA, GTBOCI LLA, LTC, MDNR, LTLPOA, LCD	1.1, 1.2, 1.5, 2.7

Category 2: Fish and Wildlife Habitat (FWH) (Cont'd)

Categories/Tasks	*Priority:* HIGH, MED, LOW	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
FWH6- Implement Wild-Link program to identify, protect and enhance fish and wildlife habitat on private property within ecological corridors throughout the watershed.	MEDIUM	$15,000/year ever other year	Four projects by 2015, ongoing as funding is available			X		X		X		X		CRA, LCD, GTRLC, LC	3.4,1.2,1.3,2.7

Category 3: Invasive Species (IS)

Categories/Tasks	***<u>Priority:</u>*** ***HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***	***2024***	***Potential Project Partners***	***Objective(s) Addressed***
IS 1- Continue to implement invasive species treatment program, including monitoring for new and the spread of existing aquatic and terrestrial invasive species in watershed	HIGH	$10,000/year for 9 years	2016- begin treatment program for highest priority species and establish index of existing populations to prioritize treatment; 2018-address medium priority species. Review		X	X	X	X	X	X	X	X	X	LCD, LA's, Leelanau Conservancy, CRA, GTBOCI, MDNR	1.2, 1.6, 1.7
IS2- Implement an education program to inform watershed users about invasive species and create a yearly status report on the current conditions of invasive species	HIGH	$5000/year	Grant funding dependent. Hire watershed coordinator by 2018.					X	X	X	X	X	X	LCD, LA's	1.7, 4.1
IS3- Establish boat washing stations on Lime and Little Traverse Lakes to help control the introduction of invasive species	MEDIUM	$6000/start up per lake and $1000/year maintenance	Apply for funding to install a boat washing station by 2018 on Lime Lake and Little Traverse Lakes				X	X	X	X	X	X	X	LCD, LA's, MDNR	1.7

Category 4: Shoreline and Stream Bank Protection (SSPB)

Categories/Tasks	*Priority:* *HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
SSBP 1- Evaluate and address the culvert and road/stream crossings in the watershed for shoreline erosion, high water levels, potential contamination from septic systems, and other concerns, particularly on the west end of Little Traverse Lake and along County Road 669 and along Cemetery Rd, Narlock Rd.	HIGH	$20,000 for survey (see task SSBP2 below)	Grant dependent. Conduct road and stream crossing survey by 2018 and implement projects by 2020				X		X					NRCS, GTBOCI , CRA, LA's, LCD, DC, LCRC, NPS, Cleveland Twp	1.5,1.7, 1.1, 2.2, 2.6, 2.5
SSBP2-Restore adequate storm water handling and stream conditions to the Little Traverse Lake outlet, Shalda Creek, and its passage under County Road 669 taking into consideration the LTL Lake levels.	HIGH	$900,000 for LTL and 669 culverts (Gosling Report)	Grant dependent. Obtain funding for a replacement of culverts on LTL road and Co Road 669 in 2016-2017.		X	X								NRCS, GTBOCI , CRA, LA's, LCD, DC, LCRC	2.9
SSBP 3- Evaluate and understand water level fluctuations and seasonal changes in water levels in the watershed and how to accept the conditions without negative shoreline impacts	HIGH	$10, 000 initial survey	Conduct initial hydrologic and engineering survey to come up with future plan in 2016.		X									LTLPOA, LTC, GTBOCI, LCRC	2.9, 3.3, 2.2, 2.5
SSBP 4- Inventory the shoreline, streams and lakes in the watershed for erosion, development, invasive species, etc and develop a restoration plan for high priority sites.	MEDIUM	$1000/year	Volunteers from Lake Associations to conduct survey yearly starting in 2014. Update LA's yearly on findings	X	X	X	X	X	X	X	X	X	X	LA's, LCD	1.5,1.7, 1.1

Category 4: Shoreline and Stream Bank Protection (SSPB) (Cont'd)

Categories/Tasks	***Priority:*** ***HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***	***2024***	***Potential Project Partners***	***Objective(s) Addressed***
SSBP 5 - Work with interested landowners to remove invasive species, improve riparian corridors and restore degraded habitat along the shorelines of Lake Michigan, Inland Lakes and tributary streams in the watershed	MEDIUM	$50,000/site for 3 sites	Identify priority sites and obtain cost-share funds by 2017. Complete treatment on 3 priority sites by 2021			X				X				CRA, MDNR, LCD, LA's	2.1,1.2, 1.7, 1.5
SSBP 6- Conduct workshops on natural shoreline management for shoreline property owners promoting native plants, soft engineering, and natural landscaping to improve fish/wildlife habitat, reduce nutrient runoff into lakes, and decrease erosion.	MEDIUM	$2000/year for 10 years	2 workshops/yr.	X	X	X	X	X	X	X	X	X	X	LCD, LA, NRCS, LA	1.5, 1.7
SSBP 7-Inventory the status of aquatic habitats in portions of the watershed	LOW	$5000 for inventory	Complete inventory by 2018				X							CRA, BCD, LA's	1.1, 1.5, 1.7

Category 5: Best Management Practices

Categories/Tasks	*<u>Priority:</u> HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
BMP 1- Work with project partners to develop a road and stream crossing survey	HIGH	$10K for inventory	Road and Stream crossing completed by 2018,				X							CRA, LCD, LA, NRCS, GTBOCI	1.2, 2.5
BMP 2- Implement road and stream crossing BMP projects on high and medium priority sites	HIGH	200,000/year for duration of plan- Total = $1.4M	Road and Stream crossing completed by 2015, Four projects by 2018, ongoing as funding is available					X	X	X	X	X	X	CRA, LCD, LA, NRCS, GTBOCI	1.2, 2.5
BMP 3-Conduct *Cladophora* and other surveys to determine failing septic systems yearly	HIGH	$0	Start survey in 2015	X	X	X	X	X	X	X	X	X	X	LA's,	2.1,2.6,1.1
BMP4-Implement a cost share program to replaced outdated or failing septic systems around lakeshores, wetlands or streams.		$50,000/year for five years depending on funding	Implement cost share program as funding is available- within 5 years						X	X	X	X	X	LCD, BLDHD	2.1,2.6,1.1

Category 5: Best Management Practices (BMP) (Cont'd)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
BMP 5-Inventory abandoned and poorly capped wells and correct properly to prevent contaminants from moving into and among groundwater aquifers via this route.	MEDIUM	$10,000 for inventory and $2000 for report	Start inventory by 2015 work with partners to distribute a report on findings by 2016, Inventory every 10 years			X		X						MDA-Wellhead Stewardship Program, BLDHD	1.1,2.1, 2.2
BMP 6-Work with landowners to promote forest management practices that are in compliance with current BMPs, as outlined in "Quality Management Practices on Forest Land," (1994) MDNR	MEDIUM	$30,000/year for 10 years	Establish relationships with private forestland owners and managers. Adoption of 5 management plans/ yr. on private forest land.	X	X	X	X	X	X	X	X	X	X	MDNR, NRCS, LCD, CRA	3.4, 1.7, 1.3

Category 6: Information, Outreach and Education (IOE)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Potential Project Partners	Objective(s) Addressed
IOE 1- Partner with Glen Lake Schools and other organizations to provide information, programs and education on watershed planning, water quality monitoring and watershed protection	HIGH	$5000/year for 10 years	Establish contacts with Glen Lake School, launch educational program by 2015	X	X	X	X	X	X	X	X	X	X	Schools, LCD, LLA, LTPOA	4.2
IOE 2- Develop communication strategy for watershed users on topics such as invasive species, shoreline/stream bank protection and other watershed best management practices.	HIGH	$1000/year	Develop strategy with steering committee and implement strategy by 2016		X	X	X	X	X	X	X	X	X	LCD, LLA, LTPOA	4.2,4.3
IOE 3- Develop an education program for watershed users on topics such as invasive species, shoreline/stream bank protection and other watershed best management practices.	HIGH	$1000/year	Develop implement education program by 2016		X	X	X	X	X	X	X	X	X	LCD, LLA, LTPOA	4.2,4.3
IOE 4- Encourage appropriate provisions during or before site plan review for water quality and natural resources in the approval process.	HIGH	$1000/yr. for 10 years	Attend planning commission meetings regularly	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA, BWC	4.7, 4.3

Category 6: Information, Outreach and Education (Continued)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
IOE5- Find resources for a watershed coordinator position to work county-wide on watershed issues, including the Good Harbor bay Watershed	HIGH	$20,000/year for a part-time position	Obtain grant funding and work with local groups to find position by 2016			X	X	X	X	X	X	X	X	LCD, LA's	4.1, 4.2, 1.1,
IOE 6- Provide water quality information and news about implementation tasks progress to local and regional media.	MEDIUM	$1000/year for ten years	Publicize watershed planning progress, updates to the watershed plan in lake association annual reports, in newspaper and on websites.	X	X	X	X	X	X	X	X	X	X	LCD, LA,	4.2, 4.3, 4.4
IOE 7- Advocate for zoning, master plans and ordinances that protect water quality, human health and natural resources	MEDIUM	$1000/year (staff time) for ten years	Attend at least 2 meetin annually	X	X	X	X	X	X	X	X	X	X	BLDHD, LA, LCD	4.3, 4.7
IOE 8-Promote adoption of Leelanau County Point of Sale Septic Ordinance and encourage enforcement of the ordinance and addressing failing septic	MEDIUM	$10,000 for staff time	Passage of ordinance in 2017		X									BLDHD, LA, LCD	4.3, 4.6

Category 6: Information, Outreach and Education (Continued)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
IOE 9- Continue publication of water quality monitoring and survey results to Lake Association members and the public	MEDIUM	$1000/year for 10 years	Update website and put information in newsletters. 2 publications	X	X	X	X	X	X	X	X	X	X	LCD, LA, Leelanau Conservancy	4.2, 4.3, 1.1,
IOE 10-Work with agricultural producers to obtain an approved Conservation Plan	MEDIUM	$25,000/year for 10 years	3 plans/year	X	X	X	X	X	X	X	X	X	X	USDA-NRCS, BCD	1.7, 4.3
IOE 11- implement USDA-NRCS conservation practices on agricultural producers land with approved conservation plans	MEDIUM	$50,000/year for 10 years	3 projects/year	X	X	X	X	X	X	X	X	X	X	USDA-NRCS, BCD	1.7, 4.3
IOE 12- Create applications for mobile devices to link outreach and education materials to more watershed users	LOW	$5,000/5 years	Create QR code for GHBWPP progress updates and display at access sites by 2019.					X						SBDNL	4.2, 4.3, 4.5
IOE 13- Inventory stairs or barriers where needed to facilitate safe human access to high quality recreation resources	LOW	$2,500 for inventory	Inventory priority sites by 2017. .			X								SBDNL, CRA, MDNR, BCD	4.2, 2.2, 3.1, 3.3
IOE 14- Install signage, stairs or barriers where needed to facilitate safe human access to high quality recreation resources and prevent impacts to wetlands, shorelines and steep banks.	LOW	$20,000 for treatments	Inventory priority sites by 2017. Install treatments at 3 sites by 2020.			X			X					SBDNL, CRA, MDNR, BCD	4.2, 2.2, 3.1, 3.3

Category 7: Land Protection (LP)

Categories/Tasks	***Priority:*** ***HIGH, MED, LOW***	***Estimated Cost***	***Milestone***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***	***2024***	***Potential Project Partners***	***Objective(s) Addressed***
LP 1- Establish voluntary conservation easements to protect identified Priority Areas	HIGH	$150,000/year as funding is available for 8 years	Permanent protection of 2500 acres by 2024 (1250 natural land and 1250 farmland). Goal to protect 1000 acres (total) by 2018.			X	X	X	X	X	X	X	X	Conservancy	1.8, 1.1, 1.3, 3.4
LP 2-Acquire and develop additional public access sites on public land, lakes and rivers in the watershed.	LOW	$200,000	Secure at least one parcel for additional or continued public access within the next five years						X					MDNR, SBDNL	3.4, 3.1

Category 8: Public Health and Safety (PHS)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Potential Project Partners	Objective(s) Addressed
PHS 1- Develop a sampling program for E. coli (fecal coliform bacteria) on inland lakes	HIGH	$5000/year	Work with SBNDL and LA's to expand sampling program for e. coli bacteria on inland lakes by 2018				X	X	X	X	X	X	X	LCD, LLA,SBNDL, LTLPOA	5.3
PHS-2: Develop a watershed level plan to address swimmer's itch in inland lakes	MEDIUM	$2,000/year	Work with area biologists to come up with a plan for swimmer's itch by 2018			X	X	X	X	X	X	X	X	LTLPOA, LLA	5.2
PHS-2: Implement a watershed level plan to address swimmer's itch in inland lakes	MEDIUM	$1,000/year	Implement plan for swimmer's itch by 2018				X	X	X	X	X	X	X	LTLPOA, LLA	5.2

Category 9: Economy

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Potential Project Partners	Objective(s) Addressed
E1-Ensure that zoning ordinances in all watershed communities include provisions to protect scenic vistas, agricultural lands, and historic or cultural sites.	MEDIUM	$0	Assemble a group to attend township meetings by 2016. Work with Township officials during annual zoning ordinance reviews		X	X	X	X	X	X	X	X	X	LCD, LLA, LTPOA, Townships	6.3
E2-Provide economic and community development incentives to entrepreneurial business efforts that help protect and/or allow people to experience the region's high-quality natural resources	MEDIUM	$50,000	Pending grant funding						X	X	X	X	X	Townships/ County	6.3
E3-Improve and expand existing fishing access by providing new or updated piers, platforms, and developed access points, including infrastructure to create opportunities for anglers with physical limitations	LOW	$750,000	Pending grant funding or budget funds to MDNR				X	X	X	X	X	X	X	MDNR. LLA, LTLPOA	6.3

Table 35: Summary Task Table

Categories/Tasks	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
WQ1- Maintain current water quality program	X	X	X	X	X	X	X	X	X	X
WQ2-Establish a water quality monitoring program for water quality threats and hot spots.		X	X	X	X	X	X	X		
WQ3-Stay current with ongoing research on swimmer's itch in Northern Michigan	X	X	X	X	X	X	X	X	X	X
WQ4- Assess the need for & feasibility of instituting a new swimmer's itch control program on Lime and Little Traverse Lakes		X	X	X	X	X				
WQ5- Implement swimmer's itch control measures			X	X	X	X	X	X	X	X
WQ6- Investigate public health effects in the watershed including well water quality, swimmers itch and *E. coli* testing		X			X					
WQ7- Establish central database for water quality data.			X	X	X	X	X	X	X	X
WQ8-Conduct data analysis and investigate impacts to living organisms and impact of threats on water quality			X			X			X	
WQ9- Develop a plan for threat reduction and mitigation strategies in the watershed		X			X	X	X	X	X	X
WQ 10-Develop a lake nutrient loading model for the major lakes in the watershed.						X				
FWH1-Maintain high quality inland lake fisheries	X	X	X	X	X	X	X	X	X	X
FWH2-Work with interested landowners to promote placement of large woody debris in near-shore zones of lakes for fish habitat.	X	X	X	X	X	X	X	X	X	X
FWH3- Monitor fisheries population on inland lakes and streams, draft subsequent status reports					X				X	
FWH4- Implement BMP's and habitat restoration projects			X	X	X	X	X	X	X	X
FWH6- Implement Wild-Link program to identify, protect and enhance fish and wildlife habitat on private property			X		X		X		X	
IS 1- Continue to implement invasive species treatment program		X	X	X	X	X	X	X	X	X
IS2- Implement an education program to inform watershed users about invasive species					X	X	X	X	X	X

Categories/Tasks	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
IS3- Establish boat washing stations-Lime &Little Traverse Lakes				X	X	X	X	X	X	X
SSBP 1- Evaluate and address the culvert and road/stream crossings on priority sites				X		X				
SSBP2-Restore adequate storm water handling and stream conditions to the Little Traverse Lake outlet, Shalda Creek, and		X	X							
SSBP 3- Evaluate and understand water level fluctuations and seasonal changes in water levels		X								
SSBP 4- Inventory the shoreline, streams and lakes	X	X	X	X	X	X	X	X	X	X
SSBP 5 - Work with interested landowners to remove invasive species, improve riparian corridors and restore degraded habitat			X				X			
SSBP 6- Conduct workshops on natural shoreline management for shoreline property owners	X	X	X	X	X	X	X	X	X	X
SSBP 7-Inventory the status of aquatic habitats in portions of the watershed				X						
BMP 1- Develop a road and stream crossing survey				X						
BMP 2- Implement road and stream crossing BMP projects on high and medium priority sites					X	X	X	X	X	X
BMP 3-Conduct *Cladophora* and other surveys to determine failing septic systems yearly	X	X	X	X	X	X	X	X	X	X
BMP4-Implement a cost share program to replaced outdated or failing septic systems around lakeshores, wetlands or streams.						X	X	X	X	X
BMP 5-Inventory abandoned & poorly capped wells & correct properly.			X		X					
BMP 6-Work with landowners to promote forest management practices that are in compliance with current BMPs	X	X	X	X	X	X	X	X	X	X
IOE 1- Partner with Glen Lake Schools and other organizations to provide information, programs and education	X	X	X	X	X	X	X	X	X	X
IOE 2- Develop communication strategy for watershed users		X	X	X	X	X	X	X	X	X
IOE 3- Develop an education program for watershed users		X	X	X	X	X	X	X	X	X
IOE 4- Encourage appropriate provisions during or before site plan review for water quality.	X	X	X	X	X	X	X	X	X	X

Summary Task Table (Cont'd)

Categories/Tasks	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
IOE5- Find resources for a watershed coordinator position			X	X	X	X	X	X	X	X
IOE 6- Provide water quality information and news about implementation tasks progress to local and regional media.	X	X	X	X	X	X	X	X	X	X
IOE 7- Advocate for zoning, master plans and ordinances that protect water quality, human health and natural resources	X	X	X	X	X	X	X	X	X	X
IOE 8-Promote adoption of Point of Sale Septic Ordinance		X								
IOE 9- Continue publication of water quality monitoring and survey results to the public	X	X	X	X	X	X	X	X	X	X
IOE 10-Work with agricultural producers to obtain an approved Conservation Plan	X	X	X	X	X	X	X	X	X	X
IOE 11- implement USDA-NRCS conservation practices on agricultural producers land with approved conservation plans	X	X	X	X	X	X	X	X	X	X
IOE 12- Create applications for mobile devices to link outreach and education materials to more watershed users					X					
IOE 13- Inventory stairs or barriers where needed to facilitate safe human access to high quality recreation resources			X							
IOE 14- Install signage, stairs or barriers where needed to facilitate safe human access to high quality recreation resources			X			X				
LP 1- Establish voluntary conservation easements to protect identified Priority Areas			X	X	X	X	X	X	X	X
LP 2-Acquire and develop additional public access sites on public land, lakes and rivers in the watershed.						X				
PHS 1- Develop a sampling program for E. coli on inland lakes				X	X	X	X	X	X	X
PHS-2: Develop a watershed level plan to address swimmer's itch			X	X	X	X	X	X	X	X
PHS-2: Implement watershed plan to address swimmer's itch				X	X	X	X	X	X	X
E1-Ensure that zoning ordinances include provisions to protect scenic vistas, agricultural lands, and historic or cultural sites.		X	X	X	X	X	X	X	X	X
E2-Provide economic & community development incentives to help protect natural resources						X	X	X	X	X
E3-Improve and expand existing fishing access				X	X	X	X	X	X	X

Category Costs

The total cost for implementation efforts for all categories was determined using some of the information in Table 32 above, but also from individual stakeholders and organizations who will be doing the work. The total cost for implementation of the Good Harbor Bay Watershed Plan (excluding outreach activities) is **$7,026,320** (Table 36).

Table 36: Summary of Implementation Task Costs by Goal

Category	Cost
#1-Water quality (WQ)	$726,000
#2- Fish and Wildlife Habitat (FWH)	$202,820
#3- Invasive Species (IS)	$132,000
#4-Shoreline and Stream Bank Protection (SSBP)	$1,115,000
#5- Best Management Practices (BMP)	$1,972,000
#6- Information, Outreach and Education (IOE)	$1,095,500
#7- Land Protection (LP)	$1,400,000
#8- Public Health and Safety (PHS)	$58,000
#9- Economy	$325,000
Grand Total	**$7,026,320**

Summary

The lake associations, Leelanau Conservancy and the Leelanau Conservation District and other project partners will continue to build partnerships with various groups throughout the watershed for future projects involving the implementation of recommendations made in this watershed protection plan. Continued support and participation from key partner groups, along with the availability of monies for implementation of the plan is necessary to keep the momentum generated by planning efforts. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

The GHB Steering Committee has identified several priority projects to undertake in the future, in addition to maintaining their current robust water quality and modeling efforts. One of the highest priority tasks is to learn more about the lake levels and outlet in Little Traverse Lake, maintain the water quality monitoring program and establish funding for a watershed coordinator to help implement the information and education task

The Leelanau Conservancy will continue to evaluate the extent of development on parcels in priority areas deemed important to protecting high water quality and fish and wildlife habitat, along with the region's scenic and natural character. Voluntary conservation easements established with interested landowners will prevent conversion of natural lands in priority areas to prevent additional pollutants from entering the watershed. Over the next five years, the Leelanau Conservancy has a goal of protecting 500 acres of land within identified Priority Areas, which will prevent 33.45 tons of sediment (or 66,900 lbs/yr), 4215 lbs N, and 91.5 lbs P from entering the Good Harbor Bay watershed each year.

It is expected that the implementation phase will last more than 10 years, with some efforts expected to be conducted on a yearly basis indefinitely (i.e., monitoring). Grant funds and other financial sources will be used to implement tasks outlined in Chapter 8, including the continuation of water quality assessment and monitoring, installation and adoption of various Best Management Practices (Chapter 5), and educational tasks outlined in the IE Strategy (Chapter 9) In general, funding for short-term tasks (1-5 years) will be attained through state and/or Federal grants, other non-profit grant programs, partner organizations' budgets, fundraising efforts, and private foundations. Funding for long-term tasks will be addressed as needed. The Good Harbor Bay Watershed Steering Committee should continue to meet annually during the implementation period to discuss and evaluate progress.

Important issues facing the Good Harbor Bay watershed include: increasing development and its associated increase in nutrient loading, invasive species and aging septic systems. Priority will be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the impacts from these pollutants or stressors.

CHAPTER 9: INFORMATION AND EDUCATION STRATEGY

The Information and Education Strategy highlights the actions needed to successfully maintain and improve watershed education, awareness, and stewardship for the Good Harbor Bay watershed. It lays the foundation for the collaborative development of natural resource programs and educational activities for target audiences, community members, and residents. Environmental awareness, education, and action from the public will grow as the IE Strategy is implemented and resident awareness of the watershed is increased. Implementing the IE Strategy is a critical and important long-term task to accomplish.

Initial IE efforts began a long time ago by the Lake Associations, but more work is needed. Both organizations publish newsletters and host educational events. These outreach activities should be continued and paired with additional ones outlined in this management plan. Considerable time and effort should also continue to be put into introducing stakeholders to the watershed protection plan and its various findings and conclusions, as well as providing general information about the Good Harbor Bay watershed and its beautiful and unique qualities.

During the implementation phase of the IE Strategy, the critical first steps are to build awareness of basic watershed issues and sources of pollution, as well as how individual behaviors impact the health of the watershed. It will also be necessary to continue to introduce stakeholders to results and information provided in the revised management plan and show them how they can use the plan to protect water quality in the region.

Information and Education is one of the overall goals of the plan described on page 180. One of the most important tools to use when implementing watershed protection is an effective outreach and education campaign. Watershed residents, businesses, local leaders, seasonal residents, and tourists alike are often unfamiliar with watershed issues. This Information and Education (IE) Strategy addresses the communication needs associated with implementing the Good Harbor Bay Watershed Protection Plan.

A variety of means have already been used by the Lime Lake Association, Little Traverse Lake Property Owners Association, Little Traverse Lake Conservationists, GTB, Leelanau Conservation District, Sleeping Bear Dunes National Lakeshore (SBDNL) and other organizations to inform the public regarding water quality issues for both Good Harbor Bay and its tributaries.

Some of these methods/publications include holding annual meetings/picnics, publishing newsletters and handouts, updating individual websites, participating in Leelanau Clean Water and collaborating with project partners.

Local Research Findings

The Good Harbor Bay watershed is unique in character. Many riparian landowners are not permanent residents, which provides a dilemma on how best to educate this important segment of watershed residents that are only here part time.

There has not been any local research regarding public knowledge of watersheds and water quality issues, but a survey completed in adjacent Grand Traverse Bay watershed by The Watershed Center Grand Traverse Bay in 2002 identified a major gap in knowledge amongst watershed residents. 60% of the respondents answered “don’t know” when asked which watershed they lived in (TWC 2005). This basic fact indicates that watershed organizations have a long way to go in informing and engaging the public in watershed issues.

The same study pointed out that though many area residents routinely express concern about environmental issues, there is a lack of understanding of the key issues that face the watershed. Residents in the Grand Traverse Bay watershed perceive that business and industry (17%) and sewage treatment plants (16%) are the main causes of water pollution to the bay. In truth, the Grand Traverse Region is dominated by non-smokestack industries and comparatively few discharge permit holders. Additionally, when asked what they believe to be the least cause of water pollution in the Bay, and area lakes, streams and rivers, respondents indicated the “day to day actions of individuals” as the second least likely pollutant. These two findings would seem to indicate that the general public sees sources outside their individual control to be more responsible for existing and potential water quality problems (TWC 2005).

Other key findings relevant from the Grand Traverse survey point out that most people get their information about the environment and water quality from newspapers and television (Table 37) When this question was cross-tabulated with the respondents' age, more detail was revealed about where specific age demographic groups obtain their information about the environment (TWC 2005) (Table 38). It is worthy to note that since 2002, we have seen a boom in the use of the internet as a source of information, especially for the younger generation (specifically on social networking sites).

Table 37: Results from Grand Traverse Bay Watershed Survey- Information Sources

Information Source	Percent
Newspaper	46.6%
TV News	13.7%
Environmental organization newsletters	7.3%
Friends, neighbors, coworkers	5.2%
Other organizations (churches, clubs, etc)	2.6
Magazines	2.3
Radio	1.6
Schools	1.3

Table 38: Results from Grand Traverse Bay Watershed Survey- Demographics

Age Range	Preferred Source	Education Level	Preferred Source
18-25	Schools	Graduate Degree	Environmental newsletters or friends, neighbors and relatives
26-35	TV News	Some post grad	Environmental newsletters, newspapers
36-55	Newspapers	College degree	Environmental newsletters, newspapers
56-65	Environmental Newsletters	Some college, high school or some high school	Television news
66+	Newspapers		

Summary of Regional Environmental Education and Outreach Research

Note: *The following is an excerpt from the IE Strategy outlined in Chapter 7.3 in the Grand Traverse Bay Watershed Protection Plan (TWC 2005). Even though the two watersheds differ immensely in size, the summary of research findings is relevant to the Good Harbor Bay watershed and will be helpful when implementing the outreach plan. When it comes to watershed education in Northern Michigan, most of the issues and attitudes are the same across watershed and municipal boundaries.*

Recent regional and national research surveys regarding the environment confirm the basic findings of the Grand Traverse Bay surveys. A recent Roper study (Roper 2001) indicates that while there is increasing public concern about the environment, the majority of the public still does not know the leading causes of such problems as water pollution, air pollution and solid waste. This finding was also confirmed in work done by The Biodiversity Project (2003) as part of their Great Lakes Public Education Initiative. Their research involved both a public opinion poll and a survey of organizations, agencies and institutions engaged in public education efforts on Great Lakes topics. An excerpt follows:

> "...organizations are making a concerted effort to provide reliable information to people who can make a difference when it comes to improving the environmental conditions in the Great Lakes Basin. However, the public opinion poll shows that, for the most part, people are just not grasping the importance of the issues facing the Great Lakes in three important ways: the seriousness of the threats, the need for urgency in taking action to address the threats, and ways that individuals can make a difference. This led us to examine the discrepancy between the level and focus of current communications and public education efforts and the gaps in public awareness. Because of this discrepancy, it was concluded that the public knowledge gaps are likely to be attributed to other factors besides the content and volume of materials. Likely factors include the following three points.
>
> - Limited use of targeting (tailoring messages and delivery strategies to specific audiences).
> - Heavy reliance on printed materials and the Web – reaching already interested knowledge seekers; limited use of television and other communication tools that reach broader audiences.
> - Multiple, complex, detailed information as opposed to broad, consistent unifying themes."

The report goes on to conclude that educators need "to pay attention to a full spectrum of factors that act as barriers to the success and impact of public outreach." Factors to be considered include:

- **Targeting** – Avoid the one-size-fits-all approach.
- **Delivery** – As resources allow, use the mediums and venues that best reach the target audience. Brochures are easy, the web is cheap, but television is the most used source of information about the environment.
- **Content** – Facts and figures are important to validate a point, but it is important to address the emotional connection needed to address why people should care, why the issue is relevant, effective solutions and what your audience can do about it.
- **Context** – Many environmental threats are viewed by the public as long term issues. Issues need to be communicated in a way that makes them more tangible. Beach closings, toxic pollution, sewage spills and water exports tend to feel more immediate than loss of habitat, land use planning and other big picture issues that citizens feel more disconnected from.

The study identified a list of educational needs and actions that should be incorporated consistently in educational efforts:

- Promote understanding of the system.
- Make the connection to individuals.
- Be local and specific.
- Include a reality check on "real threats." (For example, industrial pollution was a hot topic ten years ago but, many organizations have shifted their education focus to other current and emerging threats, such as stormwater runoff, biodiversity, etc, but the public has not caught up with this shift.)

- Emphasis on "why is this important to you" messages.
- Make the connection to policy.

Both local and regional research indicates that there are considerable gaps in the public's knowledge and understanding of current environmental issues. But, this knowledge gap is tempered by keen public interest and concern for the environment. Watershed organizations need to do a better job of making issues of concern relevant to their audiences. There is a need for ongoing, consistent and coordinated education efforts targeted at specific groups, addressing specific threats.

The Good Harbor Bay watershed IE strategy addresses some of these concerns. Both local and regional opinion research findings should be considered carefully when developing messages and delivery mechanisms for IE strategy implementation.

Goals and Objectives

The goal of the IE strategy is to ***"Establish and promote educational programs that support effective watershed preservation and increase stewardship."*** Fixing an erosion problem at a road stream crossing does not involve a high degree of public involvement. But, developing and carrying out a regional vision for stewardship of water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes.

The objectives of this Implementation and Education strategy focus on building awareness, educating target audiences, and inspiring action. In order to accomplish many of these I & E tasks, a part time position is needed such as a watershed coordinator. This position will be dependent on funding availability and the group does have a strategy in place to work on this project.

Five major objectives have been identified within Goal 4, which is to "**Ensure that all watershed property owners, visitors, users and other stakeholders understand stewardship and are able to support and promote watershed protection activities**". These include:

1. Raise awareness, understanding, commitment and action within the Good Harbor Bay Watershed so that private practices and public policy enhance attainment of the watershed goals.
2. Involve the citizens, public agencies, user groups and landowners in implementation of the watershed protection plan through meetings, events and workshops with individuals or groups.
3. Measure effectiveness of outreach activities in increasing awareness and reduction of Non-Point Source (NPS) pollution, including shoreline erosion.
4. Increase awareness of proper septic system maintenance, fertilizer use and storage of organic wastes and fertilizers.
5. Encourage appropriate provisions for site plan development and review for water quality and natural resources protection.

Target Audiences

A number of diverse regional audiences have been identified as key targets for IE strategy implementation. The targets are divided into user groups and decision-making groups.

User Groups

Households – The general public throughout the watershed.

Riparian Landowners – Due to their proximity to a specific water body, the education needs of riparian landowners are different.

Tourists – This area is known for its scenic beauty and recreational opportunities. This seasonal influx of people puts a noticeable strain on area infrastructure and often the environment. There is a growing concern that this important economic segment could eventually destroy the very reason why it exists, and that the region's tourism "carrying capacity" may soon be reached. There is clearly a growing need to educate tourists about their role in protecting the Good Harbor Bay environment.

Builders/Developers/Real Estate – This region is one of the fasting growing areas in Michigan in terms of population and land use. Increasingly, homes around and near Good Harbor Bay are being converted from small seasonal cottages to larger year round homes. Additionally, new developments are popping up all over the watershed. Members of the development industry segment play a crucial role in this growth and providing ongoing education opportunities about their role in protecting water quality and environmental health is critical.

Agriculture - Certain streams and wetland in the Good Harbor Bay watershed are still prone to less than adequate agriculture practices, runoff into streams or water bodies. Educating farmers using this practice would benefit the watershed by reducing erosion, protecting wetlands, and reducing nutrients and pathogens entering streams.

Education – Area educators and students, primarily K-12.

Special Target Audiences – In addition to the above, certain user groups such as recreational boaters, other sports enthusiasts, garden clubs, churches, or smaller audience segments may be targeted for specific issues.

Local Government Decision Makers

Elected/Appointed Officials – Township, village, city, and county commissioners; planning commissions; zoning board of appeals; road and drain commissioners; etc.

Staff – Planners, managers, township supervisors, zoning administrators, etc.

Message Development

General message outlines have been established for each target audience (Table 39). These messages will be refined as implementation moves forward. They may also be modified or customized depending on the message vehicle.

Table 39: Target audience Messages

Target Audience	Messages
Households	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Water quality-friendly lawn and garden practices • Housekeeping practices and the disposal of toxic substances • Septic maintenance • Managing stormwater on your property
Riparian Landowners	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Riparian land management including the importance of riparian buffers • Water quality-friendly lawn and garden practices • Septic system maintenance • Housekeeping practices and the disposal of toxic substances • Clean boating practices
Tourists	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Help us protect the beauty that you enjoy when you are a guest • Clean boating practices • Role in controlling the spread of aquatic invasive species
Local Government Decision Makers	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • The leadership role that local governments must play in protecting the watershed • The importance of establishing sound, enforceable natural resource protection ordinances • Economic impact and advantages of environmental protection

Table 39: Target audience Messages (Cont'd)

Builders, Developers, Real Estate	• Monetary advantages of and opportunities for Low Impact Development • Identification and protection of key habitats and natural features: aquatic buffers, woodlands, wetlands, steep slopes, etc. • Advantages of and opportunities for open space protection and financial incentives for conservation • Minimize the cutting of trees and vegetation • Impact of earthmoving activities, importance of soil erosion and sedimentation control practices, construction BMPs • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Educate about and encourage wetland mitigation where landowners will cooperate
Agriculture	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Riparian land management including the importance of riparian buffers and BMPs • Water quality friendly types of agricultural practices • Disposal of toxic substances and pesticides should be done responsibly • NRCS recommended Conservation Practices
Education	• Adoption and promotion of a state-approved watershed curriculum in K-12 schools. • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Connection between watershed organizations' programs and school activities • Active participation in watershed protection activities and stewardship

**Table adapted from Grand Traverse Bay Watershed Protection Plan (TWC 2005)*

Action Plan to Implement Strategies

A complete list of tasks by category follows this narrative (Table 37); the categories are the same as those used to outline the implementation tasks in Chapter 8 from the Information and Education category, but also include some other categories that specifically relate to I & E efforts. Several priority areas for the Good Harbor Bay watershed have been identified and the plan for rolling out the IE Strategy will correspond to these priority areas (Chapter 4, Section 4.7, Figure 28). Additionally, the IE Strategy will support other implementation efforts to control nutrient loading, loss of habitat, input of harmful toxins, and the impacts of invasive species in the watershed, and other pollutants outlined in Chapter 4, Section 4.6.

The IE Strategy tasks use a diverse set of methods and delivery mechanisms. Workshops, presentations, demonstration projects, brochures, public and media relations, web sites and other communications tools will be used for the different tasks and target audiences. Broadcast media, most importantly television, is beyond the reach of most area partner organizations – at least at a level of reach, frequency and timing that can be expected to have any impact on awareness and behavior. This is a barrier to utilizing this effective medium, but effort should be placed on building coalitions that can pool resources to address larger picture issues through broader-based, more long-term communications efforts. Additionally, the use of social networking websites such as Facebook and Twitter has increased exponentially over the past few years. These sites offer advantages to reaching out to a broader segment of individuals that might not be reached via other means.

Partnerships

Due to the large amount of public land under State and Federal control combined with the long history of active fisheries management within the Good Harbor Bay watershed, several important and significant partnerships have developed to address issues that impact multiple management agencies. The MDNR fisheries division is also an important partner with the general public in the Good Harbor Bay Watershed through their management of inland and anadromous fisheries in the watershed.

The Leelanau Clean Water group was formed in 2008 and includes several additional organizations in partnership with the Leelanau Conservation District to address water quality issues in Leelanau County. These are examples of the many partnerships that have formed and will continue forming as the project partners attempt to implement their respective tasks.

The total cost for implementation efforts for all categories is detailed in Chapter 8, Section 8.1. The total costs for I & E efforts, which includes Goals 1, 2, 4 and 6 from Tables 40 and 41 below is $1,145,000.

Table 40: Information and Education Tasks

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
IOE 1- Partner with Glen Lake Schools and other organizations to provide information, programs and education on watershed planning, water quality monitoring and watershed protection	HIGH	$5000/year for 10 years	Establish contacts with Glen Lake School, launch educational program by 2015	X	X	X	X	X	X	X	X	X	X	Schools, LCD, LLA, LTPOA	4.2
IOE 2- Develop communication strategy for watershed users on topics such as invasive species, shoreline/stream bank protection and other watershed best management practices.	HIGH	$1000/year	Develop strategy with steering committee and implement strategy by 2016		X	X	X	X	X	X	X	X	X	LCD, LLA, LTPOA	4.2,4.3
IOE 3- Develop an education program for watershed users on topics such as invasive species, shoreline/stream bank protection and other watershed best management practices.	HIGH	$1000/year	Develop implement education program by 2016		X	X	X	X	X	X	X	X	X	LCD, LLA, LTPOA	4.2,4.3
IOE 4- Encourage appropriate provisions during or before site plan review for water quality and natural resources in the approval process.	HIGH	$1000/yr. for 10 years	Attend planning commission meetings regularly	X	X	X	X	X	X	X	X	X	X	BCD, PLIA, LA, BWC	4.7, 4.3

Table 40: Information, Outreach and Education Tasks (Continued)

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Potential Project Partners	Objective(s) Addressed
IOE5- Find resources for a watershed coordinator position to work county-wide on watershed issues, including the Good Harbor bay Watershed	HIGH	$20,000/year for a part-time position	Obtain grant funding and work with local groups to find position by 2016			X	X	X	X	X	X	X	X	LCD, LA's	4.1, 4.2, 1.1,
IOE 6- Provide water quality information and news about implementation tasks progress to local and regional media.	MEDIUM	$1000/year for ten years	Publicize watershed planning progress, updates to the watershed plan in lake association annual reports, in newspaper and on websites.	X	X	X	X	X	X	X	X	X	X	LCD, LA,	4.2, 4.3, 4.4
IOE 7- Advocate for zoning, master plans and ordinances that protect water quality, human health and natural resources	MEDIUM	$1000/year (staff time) for ten years	Attend at least 2 meetin annually	X	X	X	X	X	X	X	X	X	X	BLDHD, LA, LCD	4.3, 4.7
IOE 8-Promote adoption of Leelanau County Point of Sale Septic Ordinance and encourage enforcement of the ordinance and addressing failing septic	MEDIUM	$10,000 for staff time	Passage of ordinance in 2017		X									BLDHD, LA, LCD	4.3, 4.6

Table 40: Information, Outreach and Education Tasks (Continued)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*Potential Project Partners*	*Objective(s) Addressed*
IOE 9- Continue publication of water quality monitoring and survey results to Lake Association members and the public	MEDIUM	$1000/year for 10 years	Update website and put information in newsletters. 2 publications	X	X	X	X	X	X	X	X	X	X	LCD, LA, Leelanau Conservancy	4.2, 4.3, 1.1,
IOE 10-Work with agricultural producers to obtain an approved Conservation Plan	MEDIUM	$25,000/year for 10 years	3 plans/year	X	X	X	X	X	X	X	X	X	X	USDA-NRCS, BCD	1.7, 4.3
IOE 11- implement USDA-NRCS conservation practices on agricultural producers land with approved conservation plans	MEDIUM	$50,000/year for 10 years	3 projects/year	X	X	X	X	X	X	X	X	X	X	USDA-NRCS, BCD	1.7, 4.3
IOE 12- Create applications for mobile devices to link outreach and education materials to more watershed users	LOW	$5,000/5 years	Create QR code for GHBWPP progress updates and display at access sites by 2019.					X						SBDNL	4.2, 4.3, 4.5
IOE 13- Inventory stairs or barriers where needed to facilitate safe human access to high quality recreation resources	LOW	$2,500 for inventory	Inventory priority sites by 2017. .			X								SBDNL, CRA, MDNR, BCD	4.2, 2.2, 3.1, 3.3
IOE 14- Install signage, stairs or barriers where needed to facilitate safe human access to high quality recreation resources and prevent impacts to wetlands, shorelines and steep banks.	LOW	$20,000 for treatments	Inventory priority sites by 2017. Install treatments at 3 sites by 2020.			X			X					SBDNL, CRA, MDNR, BCD	4.2, 2.2, 3.1, 3.3

Table 41: Other Information and Education Related Tasks

Categories/Tasks	Priority: HIGH, MED, LOW	Estimated Cost	Milestone	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Potential Project Partners	Objective(s) Addressed
IS2- Implement an education program to inform watershed users about invasive species and create a yearly status report on the current conditions of invasive species	HIGH	$5000/year	Grant funding dependent. Hire watershed coordinator by 2018.					X	X	X	X	X	X	LCD, LA's	1.7, 4.1,
FWH 2-Work with interested landowners to promote placement of large woody debris in near-shore zones of lakes through-out the watershed for fish habitat.	MEDIUM	$1500/year over ten years	1. Develop literature for property owners. 2. Create a "demo site" of a natural shoreline property	X	X	X	X	X	X	X	X	X	X	MDNR, PLIA, BCD, SBDNL, CRA	1.2,1.3,1.4
SSBP 6- Conduct workshops on natural shoreline management for shoreline property owners promoting native plants, soft engineering, and natural landscaping to improve fish/wildlife habitat, reduce nutrient runoff into lakes, and decrease	MEDIUM	$2000/year for 10 years	2 workshops/yr.	X	X	X	X	X	X	X	X	X	X	LCD, LA, NRCS, LA	1.5, 1.7
BMP 4-Work with landowners to promote forest management practices that are in compliance with current BMPs, as outlined in "Quality Management Practices on Forest Land," (1994) MDNR	MEDIUM	$30,000/year for 10 years	Establish relationships with private forestland owners and managers. Adoption of 5 management plans/ yr. on private forest land.	X	X	X	X	X	X	X	X	X	X	MDNR, NRCS, LCD, CRA	3.4, 1.7, 1.3

CHAPTER 10: EVALUATION PROCEDURES

An evaluation strategy will be used to measure progress during the GHB Watershed Plan's implementation phase and to determine the degree to which water quality is being protected or impacted. The Steering Committee will meet two times/year to go over the watershed plan evaluate the progress.

The evaluation strategy for the GHB Watershed Plan includes:

- Continuation of the GHB Watershed Steering Committee
- Evaluation of GHB Watershed Plan Implementation
- Measuring and Evaluating Social Milestones
- Evaluation Strategy for Determining Water Quality Improvement
- GHB Watershed Plan Update

The following sections address each of these aspects of the evaluation strategy.

Continuation of the GHB Watershed Steering Committee

The GHB Watershed Steering Committee has been active in the implementation of the GHB Watershed Plan. The Steering Committee will continue to include at least one representative from the Lime Lake Associations (LLA), the Little Traverse Lake Property Owners Association (LTLPOA) and the Little Traverse Lake Conservationists (TLC). Representatives from organizations currently active on the Steering Committee, such as the Leelanau Conservation District, The Leelanau Conservancy, the Michigan Department of Environmental Quality, Michigan Department of Natural Resources (MDNR), Leelanau County Road Commission, township officials and representatives from the M-22 residents in Glen Arbor Township will be invited to all meeting and will be asked to provide input.

Other planning partners, including but not limited to Conservation Resource Alliance (CRA), Grand Traverse Band of Ottawa and Chippewa Indians (GTB), Grand Traverse Regional Land Conservancy (GTRLC), Natural Resources Conservation Service, NW Michigan Council of Governments, Benzie Leelanau Health Department, Sleeping Bear Dunes National Lakeshore (SBDNL), and The Homestead Resort owners will also be invited and asked for input.

Evaluation Strategy for Plan Implementation

This aspect of the evaluation strategy was developed to measure progress during the implementation phase of the watershed management plan and to provide feedback during implementation. The evaluation will be ongoing and will be conducted through the existing Steering Committee. The Steering Committee will meet two times a year to assess progress on plan implementation and to learn and share information about existing projects throughout the watershed. In addition, plan tasks, priorities, and milestones will be assessed every five years to ensure that the plan remains current and relevant to the region and that implementation is proceeding as scheduled and is moving in the right direction.

The evaluation will be conducted by analyzing the existing watershed plan goals and objectives, as well as the implementation tasks and 'milestones' in Chapter 8 to determine progress. Key milestones include conducting necessary research and water quality monitoring, protecting priority land areas, and assisting townships with enacting ordinances to protect water quality. The proposed timeline for each task will also be reviewed to determine if it is on schedule. Other anecdotal evidence (not attached to specific plan milestones) also will be noted that indicates the protection plan is being successfully implemented, such as an increase in the number of updated or new zoning ordinances adopted that deal with water quality and natural resource protections in watershed townships and municipalities.

Additionally, a number of other evaluation tasks will be completed due to the variety of tasks involved in the watershed plan. They will include but not be limited to the following:

- Use the Steering Committee to evaluate specific projects throughout plan implementation as needed.
- Conduct targeted surveys of project partners by direct mail, phone or by website to assist in information gathering.
- Maintain a current list of future target projects, the status of ongoing projects, and completed projects, along with their accomplishments. Keep track of the number of grants received and the money committed in the watershed region to implement aspects of the plan.

- Document the effectiveness of BMP implementation by taking photographs, completing site data sheets and gathering physical, chemical and/or biological site data.

The purpose of the evaluation strategy is to provide a mechanism to the Steering Committee to track how well the plan is being implemented and what can be done to improve the implementation process. Additional development of the strategy will occur as the implementation phase unwinds.

Measuring and Evaluating Social Milestones

Chapter 9 outlines an Information and Education Strategy that addresses the communication needs associated with implementing the watershed protection plan. The strategy is important because developing and carrying out a vision for stewardship of the region’s water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes. Residents, local officials, homeowners, and the like must be educated and motivated to adopt behaviors and implement practices that result in water quality improvements.

In this respect, it is important to measure and keep track of the social impacts of the Good Harbor Bay Watershed Protection Plan. The LLA,LTLPOA, TLC, LCD and other organizations conducting outreach must find out what types of outreach are working in the community and what types are not, along with how people’s attitudes and behaviors are impacted. Just how much is social behavior changing because of the plan implementation? To answer this question, social impacts must be included when evaluating the progress of plan implementation.

Key social evaluation techniques that will be used to assess the implementation of the IE Strategy, as well as other watershed BMPs, include:

- Continued cooperation between area organizations submitting proposals to implement aspects of management plan.
- Social surveys (and follow up surveys) for homeowners, local officials, etc. to determine watershed and water quality awareness.
- Determining any increases in ‘watershed friendly’ design and construction (anecdotal evidence will be used).

- Increased awareness (from both the general public and local government officials) regarding the necessity of water quality protection.
- Increase in the number of townships implementing water quality protection related ordinances.
- Incorporating feedback forms into educational and public events and posting them on the Lake Association and Conservation District websites.
- Maintaining a list of ongoing and completed projects protecting water quality, along with their accomplishments and who is completing/completed the project.

Evaluation Strategy for Determining Water Quality Improvement

The EPA dictates that watershed management plans must outline a set of criteria to determine whether proposed load reductions in the watershed are being achieved over time and that substantial progress is being made towards attaining water quality standards. The evaluation strategy is based on comparing established criteria with future monitoring results. The evaluation strategy will help identify whether water quality monitoring strategies are effectively documenting the progress of implementation tasks toward achieving measurable water quality improvement. The following criteria were developed to determine if the proposed pollutant reductions in the Good Harbor Bay watershed are being achieved and that water quality is being maintained or improved:

1. **Total phosphorus concentrations in Lime and Little Traverse Lake remain below 10.0** mg/m^3
   Assuming constant rates of phosphorus release from anaerobic bottom sediments, atmospheric deposition and direct shoreline input, achieving annual average concentrations of 10.0 mg/m^3 for the Lime and Little Traverse Lakes will be important to maintain the oligotrophic status of the lake.

2. **Total Nitrogen concentration in Lime Lake, Little Traverse Lake and their tributaries remain above 80 mg/m^3**
   The annual average nitrogen concentration of Lime and Little Traverse should remain above 80 mg/m^3 to discourage the growth of nitrogen fixing

blue green algae such as *Anabeana sp* and *Microcystis sp.* Nitrogen levels are not regulated in surface waters by the State of Michigan or USEPA the maximum levels should remain within statewide averages for inland lakes with a similar trophic status index as Lime and Little Traverse Lakes.

3. **Maintain high dissolved oxygen levels in the Lime Lake, Little Traverse Lake and their tributaries.**
   Dissolved oxygen concentrations in Lime and Little Traverse Lake and their tributaries are typically above the 7 mg/L standard that is required by the State of Michigan for water bodies that support coldwater fisheries. Thus, it should be considered that water quality throughout the watershed is being maintained if annual average dissolved oxygen concentrations in Lime and Little Traverse Lakes are above 7 mg/L.

4. **Reduce nutrient inputs from stormwater**
   Depending on numerous factors, such as drainage area, land-cover type, and time period between rain events, nutrient loads in stormwater can vary widely.

5. **Reduce stormwater sediment loads draining into the Lime and Little Traverse Lake and their tributaries.**

6. **Maintain pH levels within range of 6.5 to 9.0 in Lime and Little Traverse Lake and tributaries as required by the State of Michigan.**
   Data from the Conservancy Water Quality Monitoring program show that pH levels consistently fall within this range.

7. **Maintain coldwater ecosystems in all water bodies in the Good Harbor Watershed that are designated coldwater fisheries.**
   The major tributaries to Lime Lake, Little Traverse Lake and Lake Michigan (Lime Creek, Shetland Creek and Shalda Creek) must maintain water temperatures below 24° Celsius to sustain their coldwater fisheries. Water temperatures below the thermocline in Lime and Little Traverse Lakes should generally not exceed 18° Celsius throughout summer months.

8. **Reduce *Cladophora* algae growth on the Lime and Little Traverse Lake shoreline associated with human induced nutrient loading.** *Cladophora* algae occurs naturally in small amounts along the shorelines of Northern Michigan lakes, but grows more extensively and densely as nutrient availability increases. Surveys should be completed on Lime and Little Traverse Lake periodically. The most recent completed in 2014 on Little Traverse Lake, has documented the location of specific *Cladophora* colonies along the shoreline, as well as the density of growth. Thus, the same information generated during future surveys can be used to determine if there were reductions in the density or size of *Cladophora* growth as a result of water quality improvement projects.

9. **Maintain chlorophyll-a concentrations in surface waters typical for lakes in Northern Michigan.** Chlorophyll-a concentrations should be maintained within normal ranges for similar lakes in Northern Michigan to prevent problems associated with large phytoplanktonic algae blooms that can cause water quality problems (e.g., low dissolved oxygen levels). Typical peak chlorophyll-a concentrations for Lime and Little Traverse Lake should remain below 3 mg/m3.

10. **Maintain or improve water clarity for Lime and Little Traverse Lakes** Minimum summertime Secchi depth should be greater than 10 feet.

The tasks outlined on pages 188-190 for water quality outline the monitoring work that will be done to measure the majority of the above mentioned criteria. Much of the proposed tasks are dependent on future grant funding.

GHB Watershed Plan Update

The frequency for a complete evaluation of the GHB Watershed Plan will be approximately every 5 years. If updates to the Plan are needed prior to five years, the Steering Committee will coordinate with the DEQ and collect public input on any proposed changes.

CHAPTER 11: CONCLUSIONS

The Good Harbor Bay Watershed Protection Plan was developed to help guide efforts to protect water quality of Lime Lake, Little Traverse Lake, other inland lakes, Good Harbor Bay and its surrounding watershed. The watershed planning process was initiated in 2011 and allowed key decision-makers, organizations, resource management agencies and the public to learn about the watershed, what issues confront it and what they can do to protect it. The watershed plan was prepared by the Leelanau Conservancy and Good Harbor Bay Watershed Steering Committee with collaboration and input from major watershed stakeholders including the Good Harbor Bay Improvement Association and local units of government.

In 2011 these committed partners initiated a watershed planning process and formed a steering committee. This 2015 watershed plan includes significant information on the watershed, pollutant concentrations, pollutant sources, and load reduction estimates of various BMPs, measurable task milestones to guide plan implementation progress, and a set of criteria to evaluate the effectiveness of implementation efforts. The Good Harbor Bay Watershed Protection Plan is meant to assist decision-makers, resource managers, landowners, residents and visitors in the watershed in making sustainable decisions to help maintain, improve and protect water quality.

The success of the Good Harbor Bay Watershed Protection Plan will depend on continued support and participation from key partner groups, along with the availability of monies for implementation of the identified tasks. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

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