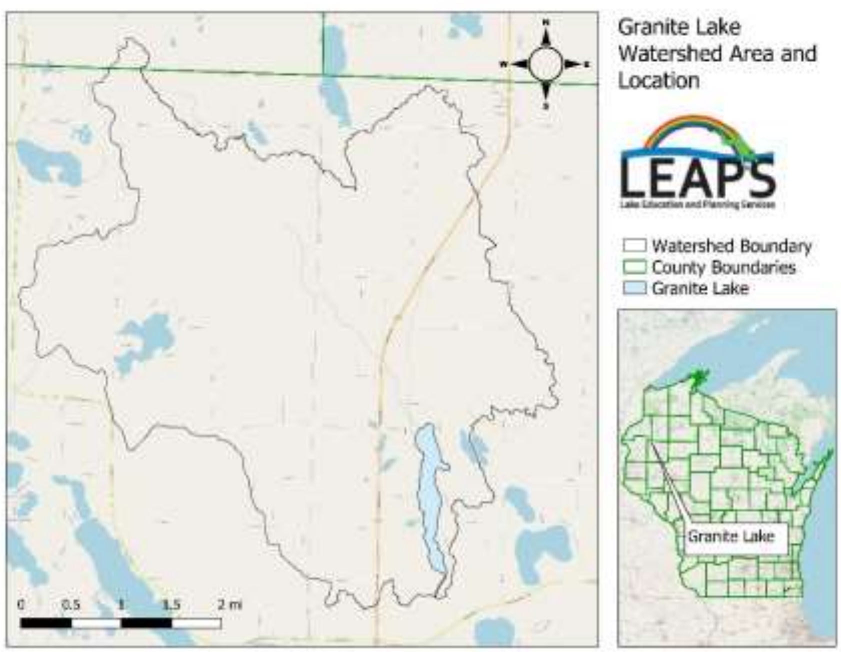
Lake Education and Planning Services, LLC
PO Box 26
Cameron, Wisconsin 54822

# GRANITE LAKE, BARRON COUNTY

## 2021-30 Comprehensive Lake Management Plan
## WBIC: 2100800

Prepared by: Dave Blumer, Lake Educator& Heather Wood, Lake Management Assistant

November 2020




Granite Lake Association
Cumberland, WI 54829

# Distribution List

| No. of Copies | Sent to |
|---|---|
| 2 | Jeanette Rydberg<br>Granite Lake Association<br>2600 8th Street<br>Cumberland, WI 54829 |
| 1 | Alex Smith<br>Wisconsin Department of Natural Resources<br>810 W. Maple Street<br>Spooner, WI 54801 |

# TABLE OF CONTENTS

# Figures

## Tables



## Appendices

# COMPREHENSIVE WATERSHED MANAGEMENT PLAN-GRANITE LAKE

PREPARED FOR THE GRANITE LAKE ASSOCIATION

## INTRODUCTION

Based on concerns related to a perceived worsening of water quality in Granite Lake, Barron County, the Granite Lake Association (GLA) applied for and received a Wisconsin Department of Natural Resources (WDNR) Lake Management Planning (LPL) grant in 2018 to review existing and collect new data to be used for preparing a Comprehensive Lake Management Plan (CLMP) focused on maintaining or improving water quality in the lake.

### PROJECT HISTORY

The GLA has been actively monitoring the water quality in Granite Lake since 1994 through the CLMN (CLMN). From 1994 to 2001 only Secchi disk data to determine water clarity was completed. In 2002, GLA volunteers started the "expanded" level of the CLMN program and added total phosphorus (TP), chlorophyll-a (Chl-A), and temperature/dissolved oxygen (DO) profiles to their data. In 2013, a small-scale lake planning grant was used to purchase a DO meter for the GLA. This data collection continues in 2020.

Through 2007 water clarity and water quality (based on TP and Chl-A monitoring) presented a visible trend toward improvement, but spiked back toward poorer water quality again in 2008. In response, the GLA met with the WDNR and successfully applied for a 1-yr small-scale lake management planning grant to complete an aquatic plant survey, to collect and analyze a sediment paleocore to determine pre and post development era changes in the lake, to collect inlet and outlet data, and to begin an assessment of the watershed. From 2009 to 2017 GLA constituents became more concerned about noticeable changes in the amount of algae suspended in the water (including some bluegreen algae), and unsightly surface mats of filamentous algae particularly in the north end of the lake.

In 2017, the GLA successfully applied for a lake management planning grant to complete the process of developing a Comprehensive Lake Management Plan for Granite Lake. To date, no other grants have been utilized for planning or implementation on Granite Lake.

### IMPAIRED WATERS

Every two years sections 303(d) and 305(b) of the Clean Water Act require states to publish water quality condition for all waters in the state. The Impaired Waters List, Restoration Waters List, and Healthy Waters List combined show the status of water quality in all evaluated waters.

Granite Lake was placed on the "impaired waters list" for excess algal growth in 2014. The 2016 and 2018 assessments showed continued excess algal growth. It continues to be on the list in 2020. Chl-A sample data exceeded the WisCALM listing thresholds for the Recreation use in 2014, 2016, and 2018. However, TP did not exceed Recreational thresholds. TP and Chl-A data were clearly below Fish and Aquatic Life listing thresholds.

## 2008 PALEO-LIMNETIC SEDIMENT CORE

Aquatic organisms are good indicators of a lake's water quality because they are in direct contact with the water and are strongly affected by the chemical composition of their surroundings. Most indicator groups grow rapidly and are short lived so the community composition responds rapidly to changing environmental conditions. One of the most useful organisms for paleo-limnology analysis is diatoms. These are a type of algae which possess siliceous cell walls, which enables them to be highly resistant to degradation and are usually abundant, diverse, and well-preserved in sediments. They are especially useful, as they are ecologically diverse. Diatom species have unique features which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to objects such as aquatic plants or the lake bottom.

By determining changes in the diatom community it is possible to determine water quality changes that have occurred in the lake. The diatom community provides information about changes in nutrient concentrations, water clarity, and pH conditions as well as alterations in the aquatic plant (macrophyte) community.

On July 29, 2008 a sediment core were taken from near the deep area of Granite Lake in about 27 feet of water using a gravity corer. Samples from the top of the core (0-1 cm) and a section (45-47 cm) deeper in the core were kept for analysis. It is assumed that the upper sample represents present conditions while the deeper sample is indicative of water quality conditions at least 100 years ago.

Diatom assemblages historically have been used as indicators of nutrient changes in a qualitative way. In recent years, ecologically relevant statistical methods have been developed to infer environmental conditions from diatom assemblages. These methods are based on multivariate ordination and weighted averaging regression and calibration. Ecological preferences of diatom species are determined by relating modern limnology variables to surface sediment diatom assemblages. The species-environment relationships are then used to infer environmental conditions from fossil diatom assemblages found in the sediment core.

Such models were applied to the diatom community in the core from Granite Lake. In summary, the models indicated that Granite Lake has experienced a moderate increase in nutrients which has resulted in a decline in water clarity as algal growth has increased. In addition to the increased nutrients, there appear to be more submerged aquatic plants at the present time. There has also been an increase in the pH of the lake. The increase in pH is likely the result of increased productivity as a result of the higher phosphorus levels. When algae photosynthesize they remove carbon dioxide from the water. Since $CO_2$ is an acid, increased algal growth results in an increase in the pH. These changes are common in lakes like Granite Lake that have shoreline development as well as some agriculture in their watershed.

## MANAGEMENT FUNDING

To date, WDNR grant money has only been used for management planning purposes. No implementation of actions to improve water quality and/or habitat in the lake has been completed. Upon approval of this plan, the GLA will likely request lake protection funds to implement recommended management actions over the course of the next 5-10 years.

## MANAGEMENT UNITS

Lake management planning and implementation for the purpose of maintaining or improving conditions in Granite Lake are spearheaded by the Granite Lake Association. Granite Lake is located in the Town of Lakeland in Barron County. The Barron County Soil and Water Department has completed projects in the watershed to reduce agricultural runoff, particularly from a farm immediately upstream of the lake.

## MAIN MANAGEMENT GOAL

The main goal for Granite Lake is to remove it from the Wisconsin Impaired waters list for exceeding Chl-A levels for recreational use. The WDNR uses the Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) to assess waterbodies that may or may not end up on the State's Impaired Waters list every two years. WisCALM uses available data to determine impairments based on two categories: aquatic life (natural) and recreational (human/full body emersion activities). A lake can exceed state standards in either or both of these categories and are generally based on the concentration of phosphorus in the water body and the concentration of Chl-A (a measurement of the amount of algae) in the water.

The Wisconsin standard for recreational phosphorus impairment in deep, lowland, drainage lakes like Granite Lake is based on a mean concentration that is ≥30 µg/l. The Wisconsin standard for Chl-A in a deep lowland drainage lake is to keep the number of lake use days in a sampling season (July15-September 15) that have moderate algal levels (Chl-A concentration exceeds 20µg/l) to 5% or below. The 20µg/l is derived from a Minnesota study that showed that up to 20µg/l, people's use of the water for swimming and other recreational activities is changed. But once that level has been exceeded, the amount of algae it represents in the surface water discourages people from swimming. Figure 1 provides a visual as it relates to the concentration of Chl-A in the water and water clarity as measured by a Secchi disk.

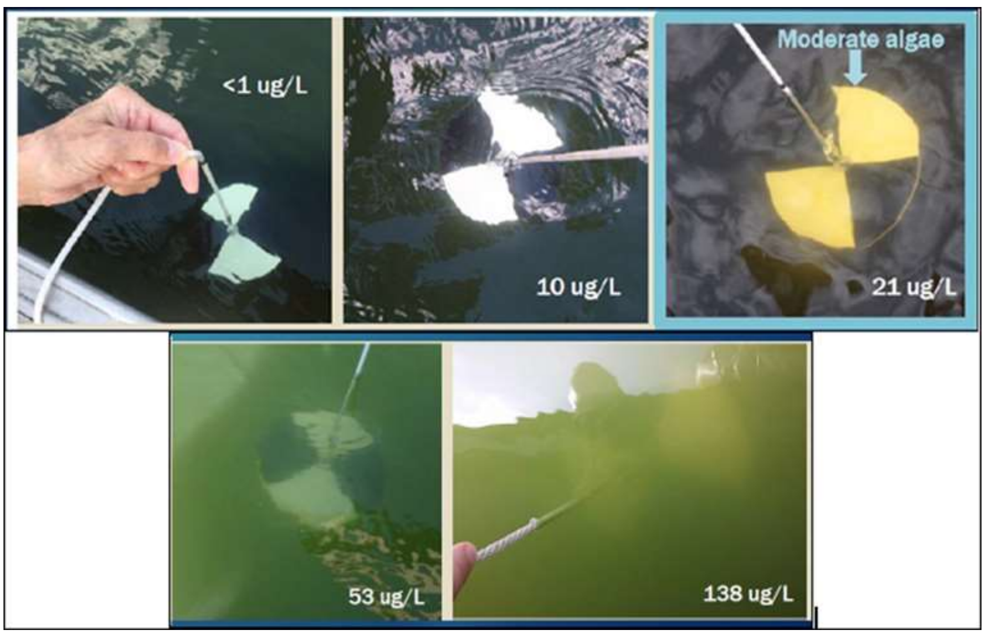



**Figure 1: Chl-A concentrations and the corresponding water clarity as measured by a Secchi disk**
*(WDNR, 2018)*

In the most recent assessment of Granite Lake for the Impaired Waters list (for 2020), WisCALM calculations based on summer Chl-A values from 2014-2018 indicated that the mean percent of lake use days where 20µg/l of Chl-A was exceeded, was 31.8% ranging from 13.7% to 55.7% clearly above the 5% standard. Under the same WisCALM calculations (for 2020) the mean summer phosphorus concentration was 27µg/l, below the 30 µg/l standard for recreation. The State standard values for aquatic life (≥30 µg/l for phosphorus and ≥27µg/l for Chl-A) have not been exceeded so a secondary goal would be to not have this happen. But if Granite Lake is taken off the Impaired Waters list for recreational impairments, it will also not be on the impaired list for aquatic life.

## PUBLIC PARTICIPATION AND STAKEHOLDER INPUT

In 2018, the first year of the 3-yr lake planning project, a multi-page "public use and opinion survey" was sent in paper copy to nearly 100 property owners on Granite Lake. Nearly half (47 surveys) were completed and returned for tabulation and analysis. The survey focused on 7 areas of interest for management planning. In 2019, an additional survey was sent to property owners to determine time at the lake annually and number of people occupying or using a residence on the lake during that time.

- Residency
- Shoreland Stewardship Practices
- Lake Use and Lake Issues
- Aquatic Plant Growth
- Aquatic Invasive Species
- Aquatic Plant Management
- Lake Association Satisfaction
- Time at the lake/time of use (related to Private Onsite Wastewater Treatment Systems (POWTS/septic systems)

### RESIDENCY

The majority (>90%) of survey respondents own property on Granite Lake. More than 60% of respondents have been on the lake for more than 10-yrs. More than a third of respondents have been on the lake for 20 plus yrs. People whose lake address is their permanent residence made up 45% of respondents. Weekend and seasonal residents made up most of the rest of the types of property. Survey respondents were pretty evenly split between the north, central, and south basins of the lake.

### SHORELAND STEWARDSHIP PRACTICES

When asked about shoreland practices that could either help to maintain or improve water quality and/or improve natural habitat around the lake, a little more than a third of respondents had some familiarity with them. Respondents were asked about rain gardens, shoreline buffers, runoff diversions, native plantings, and larger shoreland and prairie restorations. While this level of familiarity is welcomed, unless it leads to the implementation of such projects it doesn't help. Survey respondents were asked what would motivate them to install practices that could improve water quality and habitat. Motivators including increasing the natural beauty of the lake and shoreline; improving water quality; creating better fish and wildlife habitat; and setting a good example for neighbors all ranked above 30%. Improving water quality was the number one motivator. Less lawn care time, tax rebates, and technical and/or financial assistance to implement were not strong motivators.

### LAKE USE AND LAKE ISSUES

Granite Lake is listed as impaired water in Wisconsin because of lake conditions that do not meet recreational – full body immersion activities that are expected of the lake. More than 80% of the survey respondents use the lake for swimming or wading, and more than 50% for skiing/tubing. The issue of greatest concern to respondents is "too much algae growth" which tends to make the water green. The parameter used to determine recreational impairment is the amount of chlorophyll, the green pigment in algae, that there is in the water.

Fishing, whether from the shore or in a boat, is done by more than 85% of the survey respondents. Despite that level of fishing, less than a third of respondents listed "poor quality fishing" as a concern. In the last 6-yrs, lake conditions that meet expectations for fish and wildlife have not been a problem.

Other prominent lake uses include pontoon cruising, small craft use (kayaks-canoes etc.), wildlife viewing, and rest/relaxation. Pontoon boating, swimming, and fishing are the top three lake uses from this survey. Nearly 79% of survey respondents say water quality in the lake has gotten better or stayed the same since they have been on the lake. This observation on the part of the respondents is similar regardless of how long the respondent has been on the lake. Table 1 reflects the percent of respondents in each time period on the lake who felt water quality in the lake had gotten better or stayed the same.

**Table 1: Perceived changes in water quality based on time on the lake**

| Time on Lake | Better (%) | Stayed the same (%) | Combined (%) |
|---|---|---|---|
| >20 years | 40 | 27 | 67 |
| 11-20 years | 21 | 57 | 78 |
| 6-10 years | 43 | 57 | 100 |
| 1-5 years | 57 | 43 | 100 |

Water clarity, the color of the water, and the amount of aquatic plant growth including algae blooms are most often thought of when asked what respondents consider to be parameters of good or bad water quality.

## AQUATIC PLANT GROWTH

When asked about changes in aquatic plant and algae growth in the lake, the largest percentage of respondents, 55% felt things had "stayed the same" as when they first got to the lake (Table 2). The next largest percent (25%) was that there was more aquatic plants and algae growth then when they first got to the lake. A small percent of those on the lake for more than 10 years felt that the amount of aquatic plant growth had actually declined. When asked about the amount of aquatic plant growth in the lake, 60% of respondents felt the amount was "just right".

**Table 2: Perceived changes in aquatic plant growth based on "time on the lake"**

| Time on Lake | Increased (%) | Stayed the same (%) | Decreased (%) |
|---|---|---|---|
| >20 years | 19 | 44 | 19 |
| 11-20 years | 21 | 50 | 14 |
| 6-10 years | 29 | 57 | 0 |
| 1-5 years | 29 | 71 | 0 |

## AQUATIC INVASIVE SPECIES

There were only two questions in this part of the survey. What aquatic invasive species were respondents familiar with? And, would the respondent be interested in attending a training/workshop to learn more about them? The most familiar AIS were zebra mussels, Eurasian watermilfoil, purple loosestrife, and curly-leaf pondweed. More than 50% of the respondents knew about or at least had heard about these species. Nearly 60% said they would be interested in a training/workshop to learn more about AIS – 25% were not interested.

## AQUATIC PLANT MANAGEMENT

To date, no aquatic plant management except physical removal by some property owners around their docks and shoreline has been done. When this Plan was prepared, Granite Lake had a very small population of curly-leaf pondweed and an occasional sighting of purple loosestrife along its shores. No management has been done to control or remove these species from the lake. There are some dense areas of native aquatic vegetation that could be candidates for aquatic plant management if the lake property owners supported it. Less than 50% of the survey respondents felt that aquatic plant management might be necessary. About 24% felt aquatic plant management was not needed. A third of respondents were unsure.

If aquatic plant management were implemented, the survey wanted to determine what management action might be most supported by the lake constituency. An average of 41.5% of respondents supported either maintaining or increasing the level of raking and hand-pulling that was currently occurring. An average of 13.5% supported some use of aquatic herbicide. 20% supported some level of mechanical harvesting or diver removal. An average of 47% of survey respondents needed more information to answer the question, indicating that if aquatic plant management is implemented, more involvement on the part of the lake constituency will be needed.

## LAKE ASSOCIATION SATISFACTION

Most of the survey respondents (89%) were already members of the GLA. Of those, only 75% had ever attended a meeting of the GLA. More than half of the survey respondents were "very satisfied" with the operations of the GLA. Another 10% were "somewhat satisfied". Approximately 10% didn't have an opinion, and 1% was "somewhat dissatisfied". Nearly 20% on average were not familiar with many aspects of the GLA so were not able to choose one of the other responses.

The final page of the survey was somehow eliminated when reproducing the document for distribution. The questions on the last page of the survey had to do with the activities that the constituency of Granite Lake could get involved with, and an attempt to determine how much time residents would be willing to give doing these activities. This information was not gathered with this survey.

## COMMENTS FROM SURVEY RESPONDENTS

Throughout the survey, there were opportunities for respondents to add comments related to the subject matter in each Section. In Section 2, Shoreland Stewardship Practices, there were several comments about just leaving the shoreline in a natural state. Protecting the shore from erosion caused by recreational boating was also a motivator. In Section 3, Lake Use and Lake Issues, there were many comments about problem wildlife including beavers, carp, and lots of geese issues. Personal watercraft (jetskis) and wakeboarding causing eroding shorelines also came up. Comments from Sections 4-6 were limited. Comments in Section 7 generally explained why Granite Lake property owners may not be a member of the GLA or may not be able to attend meetings.

## TIME ON THE LAKE SURVEY

One line of questioning was unintentionally left out of the initial multi-page survey that was distributed to the constituency. The questions had to do with how much time people spend at the lake, and while there, how many people are using the property.

Based on the surveys returned, properties on Granite Lake are used 200 days a year by an average of 3 people. Most properties have a holding tank, followed by a conventional or mound system. All respondents felt their septic systems were functioning properly and were serviced according to what is required in Barron County.

## GRANITE LAKE ASSOCIATION MEETINGS TO DISCUSS THIS PROJECT

In each year of this project, the GLA has held two to three meetings to update their constituency about this project and its results.

# WATERSHED CHARACTERISTICS

## HUC-12 WATERSHEDS

The United States is divided and subdivided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are arranged or nested within each other, from the largest geographic area (regions) to the smallest geographic area (cataloging units). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system. The first level of classification divides the Nation into 21 major geographic areas, or regions. These geographic areas contain either the drainage area of a major river, such as the Missouri region, or the combined drainage areas of a series of rivers, such as the Texas-Gulf region, which includes a number of rivers draining into the Gulf of Mexico. Eighteen of the regions occupy the land area of the conterminous United States.

Granite Lake and its watershed are located within the Yellow River Watershed at the HUC-10 level. The Yellow River flows from its headwaters north and east of Granite Lake to the Red Cedar River south of Barron, WI (Figure 2). The HUC-10 watershed is further divided into three sub-watersheds (HUC-12): the Upper, Middle, and Lower Yellow River watersheds. More specifically, Granite Lake and its watershed are located in the Upper Yellow River sub-watershed (Table 3, Figure 3). As Table 3 indicates the Upper Yellow River sub-watershed is considered high priority in four different categories: reducing nonpoint source pollutants, reducing soil erosion, protecting outstanding and exceptional waters, and being aware of possible groundwater contamination.

The Upper Yellow sub-watershed includes several small headwater streams in addition to the Yellow River: Trout Creek, Granite Creek, and unnamed streams in the Sylvan and Silver Lake drainage systems. The Yellow River is classified as Class II trout water downstream of Hwy B. The western portion of this watershed was diverted into the Beaver Dam Lake/Hay River system in the 1930s. The watershed has agricultural areas north and south of the terminal moraine which bisects it. North of the moraine there are 4 dairy farms, 3 of which have adequate manure storage to prevent winter spreading. Two of the sites have had conservation projects done in the past to eliminate significant discharges. In observing the 2018 ortho-photos, some corrections to the management of these areas should be addressed. South of the moraine, there are 2 dairy farms that have done projects to correct areas of significant discharge. Neither of them have long-term manure storage. The majority of this area has a corn-soybean rotation along with some snap bean production. There are also some areas delineated as potential cropland buffer areas.

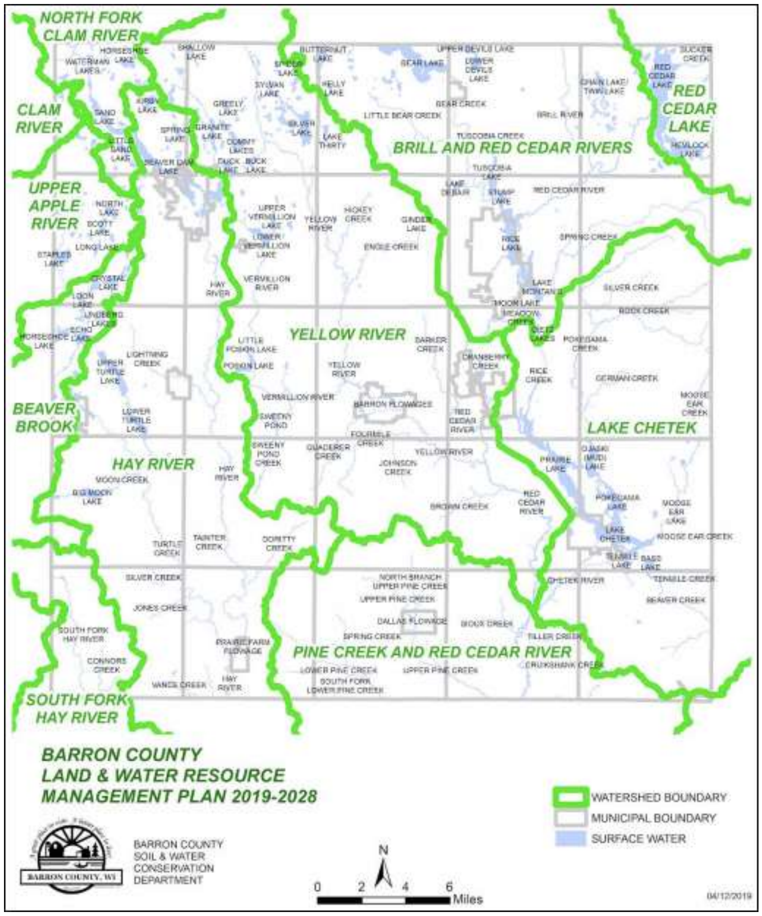



**Figure 2: Surface waters and watersheds in Barron County** *(Barron County SWCD, 2020)*

**Table 3: Condition of all HUC-12 sub-watersheds in the Yellow River Watershed** *(Barron County SWCD, 2020)*

| Watershed | Reduce Nonpoint source pollutants | Reduce Soil Erosion | Protect Outstanding & Exceptional Waters | Susceptible to groundwater contamination |
|---|---|---|---|---|
| Upper Yellow River | High | High | High | High |
| Vermillion River | Low | Medium | N/A | High |
| Lower Yellow River | High | High | N/A | High |
| Fourmile & Quarderer's Creeks | Medium | High | N/A | Medium |
| Brill, Fenton, Rice, Upper Red Cedar | Medium | Medium | High | High |
| Bear and Tuscobia Creeks | Medium | High | Medium | Medium |
| Desair Lake | High | High | N/A | Low |
| Spring Creek | Low | Medium | N/A | High |
| Chetek Chain of Lakes | Medium | High | Medium | High |
| Brown's Creek and Lower Red Cedar | Medium | High | High | High |
| Pine Creeks | High | High | Medium | High |
| South Fork Hay River | High | High | N/A | Low |
| Upper Hay River | High | High | N/A | Medium |
| Upper Turtle Creek | Medium | Medium | N/A | High |
| Lower Turtle, Silver & Vance Creeks | High | High | High | Medium |
| Lower Hay River | High | High | High | Medium |
| Staples & Sand Lakes | Medium | Medium | N/A | Medium |

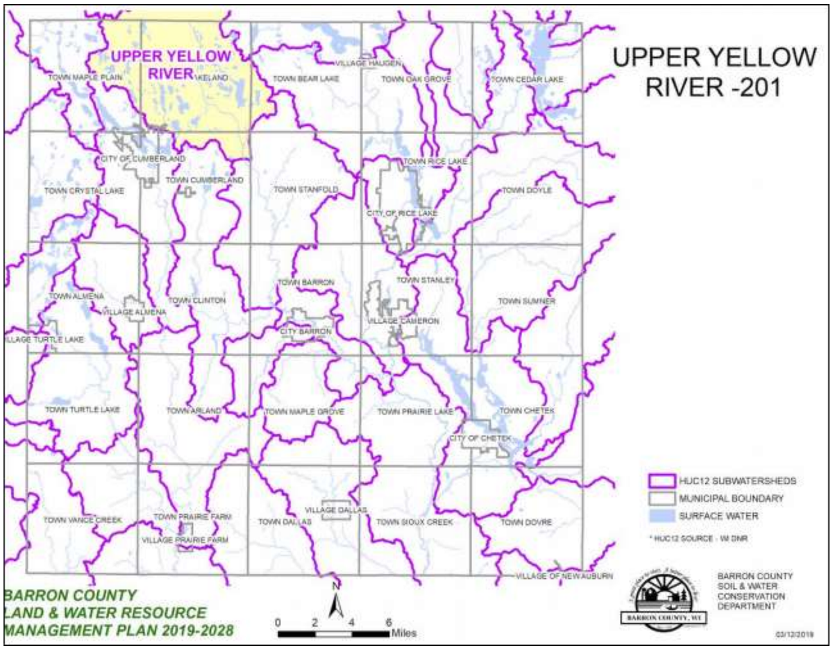


**Figure 3: HUC-12 sub-watersheds and the Upper Yellow River HUC** *(Barron County SWCD, 2020)*

## WHD-PLUS CATCHMENTS

WHD-Plus Catchments are 16 digit HUC sub-watersheds that are high-resolution watersheds derived from the 1:24k hydro geodatabase and the 10-meter National Elevation Dataset. Watersheds were delineated for over 160,000 streams and lakes in WI and boundary/contributing waters including those that are included in the Granite Lake watershed (Figure 4). For future management purposes, each catchment is broken down by land use including urban, agriculture, grassland, forest, open water, wetland, barrens, and shrubland allowing more targeted land use changes.


**Figure 4: WHD-Plus Catchments (pale yellow lines) in the Granite Lake watershed (red line) WDNR**

## SOILS IN THE GRANITE LAKE WATERSHED

Soils are classified into four main hydrologic soil groups (A, B, C, and D) to indicate their potential for producing runoff based off of the rate of infiltration. Group A soils have a high infiltration rate which makes the potential amount of runoff very low. These soils are, generally very sandy and allow water to pass through unimpeded. Conversely, group D soils have a very low infiltration rate making their runoff potential fairly high. Group D soils are generally very dense with high amounts of organic material. This causes water to move slowly through group D soils often resulting in standing water on flat surfaces and flowing water over sloped surfaces. Group D soils are generally found within wetland areas, but they can be problematic in areas that lack the hydrophitic vegetation found within those areas.

There are also three sub groups (A/D, B/D, and C/D) that indicate the infiltration rate of the soils with respect to the water table. If the water table is high and blocking infiltration, these soils are considered to have a high runoff potential and placed into group D, but when the water table is lower, these soils are similar to the first grouping (A, B, or C). Nearly 45% of the soils within the Granite Lake watershed fall into group B with moderate infiltration rates. Another 10% is in group A with high infiltration rates if the water table is not high. But with a high water table, infiltration rates are reduced (Table 4, Figure 5).

**Table 4: Soils within the Granite Lake Watershed**

| Soil Group | Percentage of Watershed | Infiltration Rate |
|---|---|---|
| A | 0.00% | High |
| B | 44.86% | Moderate |
| C | 26.84% | Slow |
| D | 0.00% | Very Slow |
| A/D | 9.29% | High when drained, very slow when undrained |
| B/D | 0.46% | Moderate when drained, very slow when undrained |
| C/D | 11.90% | Slow when drained, very slow when undrained |
| Water | 6.66% | N/A |

Nearly 40% of the area above water is considered to be poorly drained soils that fall into either group C or C/D. These soils often are comprised of high amounts of organic material and/or clay which make precipitation more likely to run off into a lake or stream than it would be to infiltrate the ground. While most of the agricultural land is within the area covered by moderately well-drained soils, some does exist in areas with the slowest draining soils with or without a high water table. Implementing agricultural BMP in these areas including cover crops, no-till planting, stream buffers, and grassed waterways may help reduce surface water runoff.

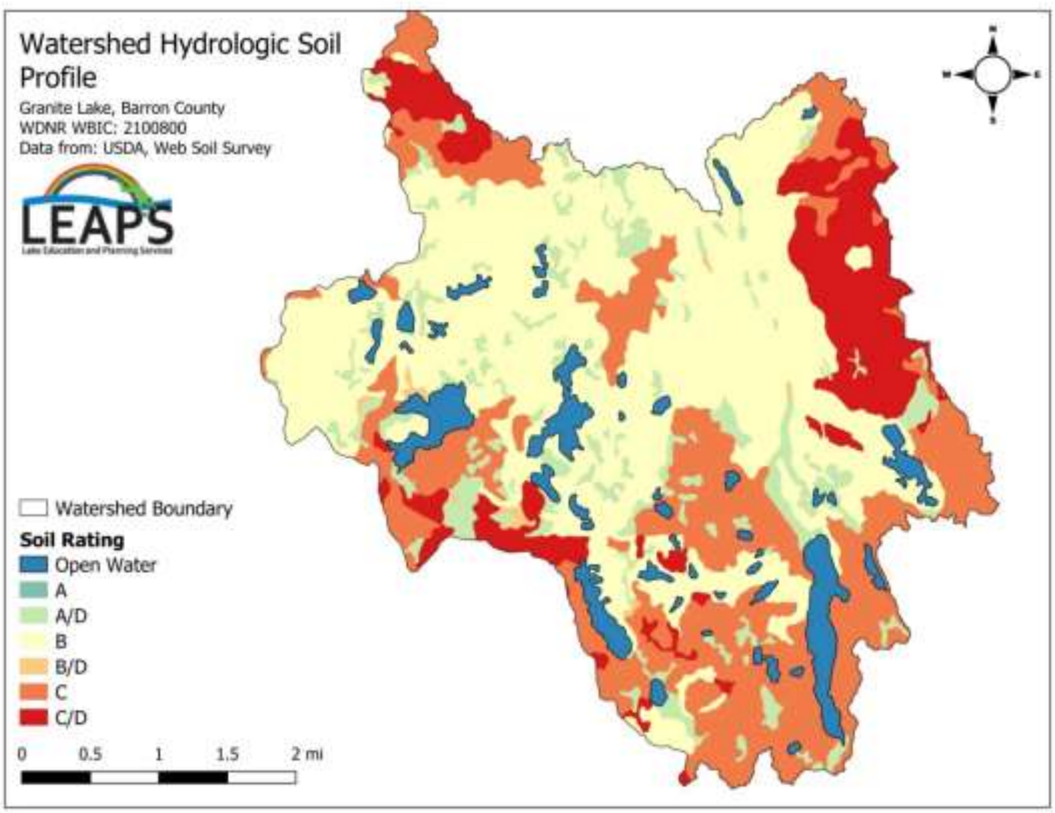



**Figure 5: Soils Drainage Classes within the Granite Lake Watershed**

## LAND USE IN THE GRANITE LAKE WATERSHED

More than half (58.75%) of the land within the Granite Lake Watershed is covered by forest land. The next most prevalent land uses are wetlands within the watershed (17.2%) and grasslands (11.9%). Developed acreage and acreage associated with agricultural practices – two of the land uses that general have the most impact on a water quality cover only 1.6% and 6.6% of the land use respectively (Table 5, Figure 6).

**Table 5: Land Cover Type Breakdown**

| Watershed Land Use | | |
|---|---|---|
| | Acres | Percent of Area |
| Developed | 164.00 | 1.6% |
| Agriculture | 683.00 | 6.6% |
| Grassland | 1,230.00 | 11.9% |
| Forest | 6,079.00 | 58.7% |
| Open Water | 413.00 | 4.0% |
| Wetland | 1,779.00 | 17.2% |

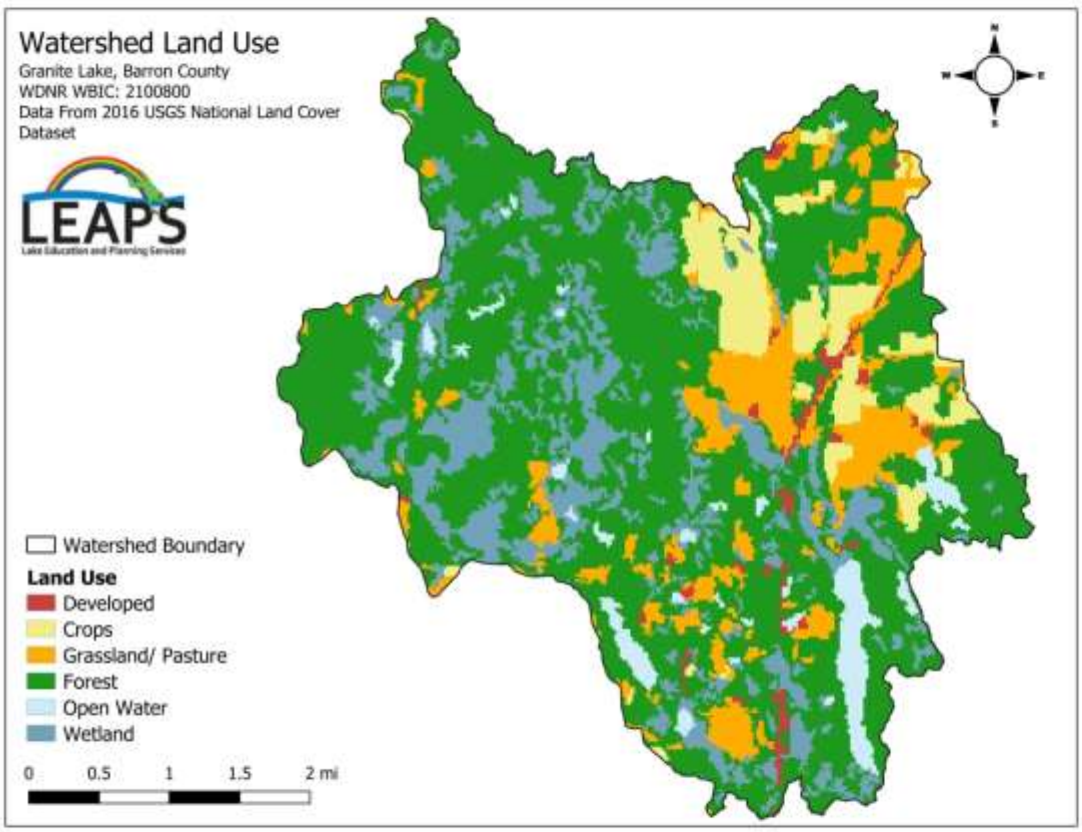



**Figure 6: Land Cover in the Granite Lake Watershed**

FORESTS

Trees and forests play an incredible role in reducing storm water in several ways and removing or filtering pollutants that would otherwise wind up in our waterways. A statement made by the Chesapeake Bay Executive Council in 2006 does a good job of summing up the benefits. "Forests are the most beneficial land use for protecting water quality, due their ability to capture, filter, and retain water… Forests are also essential to the provision of clean drinking water…and provide valuable ecological services and economic benefits including carbon sequestration, flood control, wildlife habitat, and forest products" (https://www.allianceforthebay.org/). In an article by the Penn State Extension three ways that forests protect water quality are listed: canopy interception and infiltration, consumption of stormwater, and removal of nutrient and pollutants (https://extension.psu.edu/the-role-of-trees-and-forests-in-healthy-watersheds).

### *Canopy Interception and Infiltration*

Forests filter and regulate the flow of water, in large part due to their leafy canopy that intercepts rainfall, slowing its fall to the ground and the forest floor, which acts like an enormous sponge, typically absorbing up to 18 inches of precipitation (depending on soil composition) before gradually releasing it to natural channels and recharging ground water (Figure 7). In a North Carolina Watershed study the mean soil infiltration rate went from 12.4 in/hr to 4.4 in/hr when a site was converted from forest (duff layer on soils) to suburban turf. Other studies have found similar results when comparing hourly infiltration rates and soil bulk density of forested areas with crops and grazed pasture.

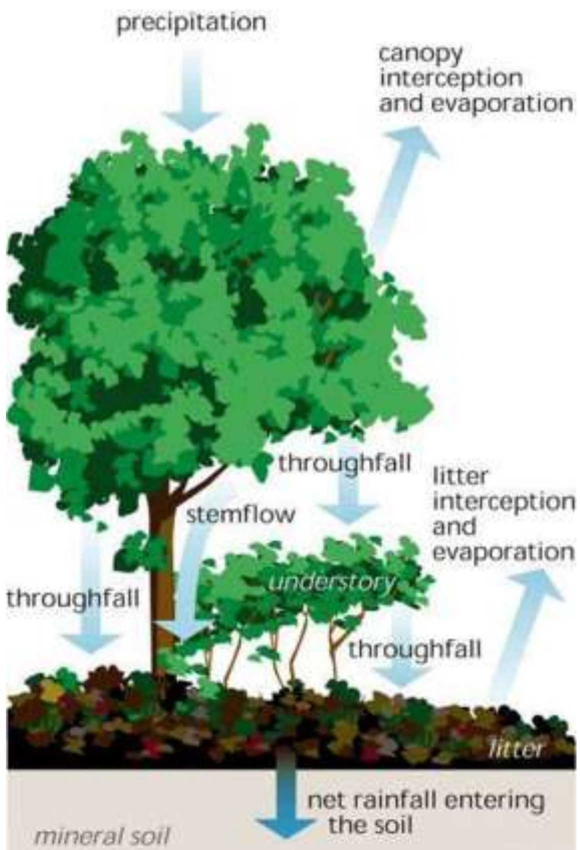



**Figure 7: Trees and rainfall interception and infiltration**

The average interception of rainfall by a forest canopy ranges from 10-40% depending on species, time of year, and precipitation rates per storm event. A study in the 1980's of Dayton, Ohio's existing tree canopy found that storm water runoff was reduced by 7% and could be increased to 12% through planting more trees. In a more recent UFORE Hydro study conducted by the USDA Forest Service a 54% tree canopy cover was able to reduce storm water runoff by 11%.

### *Consumption of Stormwater*

Trees and forests absorb and use tremendous amounts of water for growth, thereby consuming storm water. A single mature oak tree can consume (transpire) over 40,000 gallons of water in a year. In Pennsylvania forests, an average of 24 inches of the annual 40 inches of rainfall is taken up by trees through evapotranspiration (movement of water from the ground through the tree and leaves, evaporating back into the environment). That evapotranspiration also serves to cool and modify surrounding summer temperatures. If the forest is removed or harvested, evaporation drops to 14 inches and stream flow increases to receive 26 inches of the annual 40 inches of precipitation. So, just the removal of forests can have an impact on streams in the watershed.

### *Removal of Nutrients and Pollutants*

Plants, especially woody plants, are very good at removing nutrients (nitrates and phosphates) and contaminates (such as metals, pesticides, solvents, oils and hydrocarbons) from soil and water. These pollutants are either used for growth (nutrients) or are stored in wood. In one study, a single sugar maple growing roadside removed 60mg of cadmium, 140mg of chromium, 820mg of nickel, and 5200mg of lead in a single growing season. Studies in Maryland showed reductions of up to 88% of nitrate and 76% of phosphorus after agricultural runoff passed through a forest buffer.

The runoff from one acre of impervious surface generates the same amount of annual runoff as: 36 acres of forest; 20 acres of grassland; a 14 acre subdivision (2 acre lots); or a 10 acre subdivision (0.5 acre lots). One inch of rainfall on an acre of parking lot produces 27,000 gallons of stormwater. Large increases in stormwater volume reaching streams can cause major streambank erosion problems, downstream flooding, increased nutrient/sediment loads, and degraded aquatic habitat.

### *The Role of Streamside or Riparian Forest Buffers*

Planting and maintaining woody vegetation along streams provide a wealth of benefits. Research at the Stroud Water Center and elsewhere have shown that stream health is dependent on the presence of woody vegetation along its banks. Riparian forest buffers filter sediment from streams during storm events; remove nitrogen and phosphorous leaching from adjacent land uses such as agriculture; provide stability to the bank (wood root systems); shade and modify stream temperatures, critical for habitat and pollution reduction; provide aquatic and wildlife habitat for many species; reduce stream velocity; and reduce downstream flooding. Buffer widths vary from 50 feet, providing some bank stability to 250 feet, providing flood mitigation and wildlife habitat.

### *Forestry Practices*

Through an extensive review of land management impacts on water quality in North America, research complied by the EPA determined that there is the potential for forestry operations to adversely affect water quality if best management practices (BMPs) are poorly implemented. Sediment concentrations can increase due to accelerated erosion; water temperatures can increase due to removal of over story riparian shade; slash and other organic debris can accumulate in water bodies depleting dissolved oxygen; and organic and inorganic chemical concentrations can increase due to harvesting and fertilizer/pesticide applications. These potential increases in contaminants are usually proportional to the severity of site disturbance. Impacts of nonpoint-source pollution from forestry activities depend on site characteristics, climatic conditions, and the forest practices employed (Fulton & West, 2002).

If BMPs are properly designed and implemented, the adverse effects of forestry activities on hydrologic response, sediment delivery, stream temperature, dissolved oxygen, and concentrations of nutrients and pesticides can be minimized. The following specific management measures should be considered by all forest managers as they develop comprehensive forest management plans.

- Planning of the timber harvest to ensure water-quality protection will minimize nonpoint-source pollution and increase operational efficiency.

- Streamside management areas of sufficient width and extent are crucial because they can greatly reduce pollutant delivery.
- Identification and avoidance of high hazard areas can greatly reduce the risk of landslides and mass erosion.
- Careful planning of roads and skid trails will reduce the amount of land disturbed by them, thereby reducing erosion and sedimentation.
- Proper design of drainage systems and stream crossings can prevent system destruction by storms, thereby preventing severe erosion, sedimentation, and channel scouring.
- Road system planning is a critical part of pre-harvest planning. Good road location and design can greatly reduce the sources and transport of sediment. Road systems should generally be designed to minimize the number of road miles per acre, the size and number of landings, the number of skid trail miles, and the number of watercourse crossings, especially in sensitive watersheds.
- Timing operations to take advantage of favorable seasons or conditions and avoiding wet seasons prone to severe erosion or spawning periods for fish reduce impacts to water quality and aquatic organisms.
- Drainage problems can be minimized when locating roads by avoiding clay beds, seeps, springs, concave slopes, ravines, draws, and stream bottoms.

***Granite Lake Watershed Forests***

Nearly 60% of the watershed that drains to Granite Lake is forested, including a large block of Barron County forest (Figure 8). This likely means there is some level of timber harvest and other forestry practices occurring on both public and private land. Protecting and enhancing these forests is an important part of protecting Granite Lake.

It is not currently known how much of county forest land within the Granite Lake watershed is either currently being harvested or is currently out for bid. Expressing concern to the County Soil and Water Conservation Department and the County Forestry may be all it takes to ensure proper forestry BMPs that will protect the watershed are being implemented.

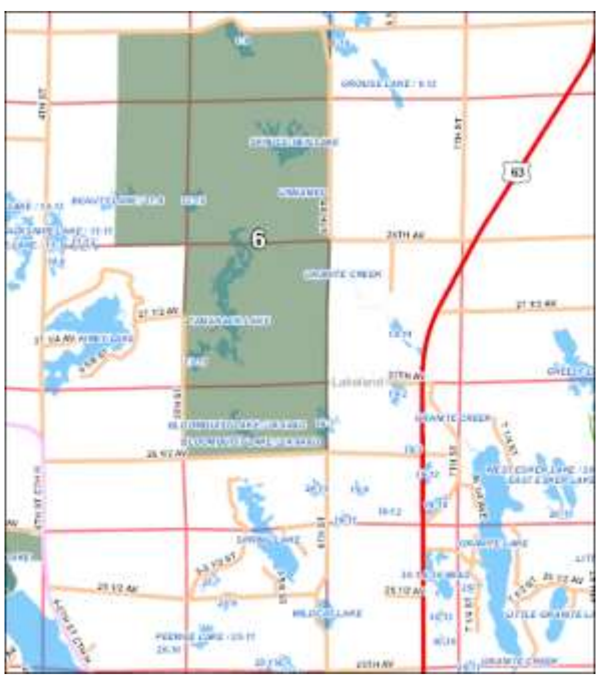



**Figure 8: Barron County forest land (green coloring) in the Granite Lake watershed (Barron Co. GIS).**

## WETLANDS

A wetland is an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions. Wetlands have many functions which benefit the ecosystem surrounding Granite Lake. Wetlands with a higher floral diversity of native species support a greater variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl.

Wetlands also provide flood protection within the landscape. Due to the dense vegetation and location within the landscape, wetlands are important for retaining stormwater from rain and melting snow moving towards surface waters and retaining floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes.

Wetlands along the shoreline of a lake also provide lake protection by acting as buffers between land and water. They protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This shoreline protection is important in waterways where boat traffic, water current, and wave action cause substantial damage to the shore. Wetlands also provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

There is a good amount of wetland area within the Granite Lake watershed including a large wetland area adjacent to the inlet on the north end of the lake (Figure 9). This area provides some buffering of pollutants coming from the agricultural practices upstream. There is another complex of wetlands and small ponds that enter Granite Lake on the west side. The impact of the water flow through this area on Granite Lake is not known. These areas help trap nutrients and sediments from making their way into the lake.

Figure 9 also shows wetland areas that could potentially be restored within the Granite Lake watershed. Barron County supports wetland restoration activities and could be a partner in restoring these areas.

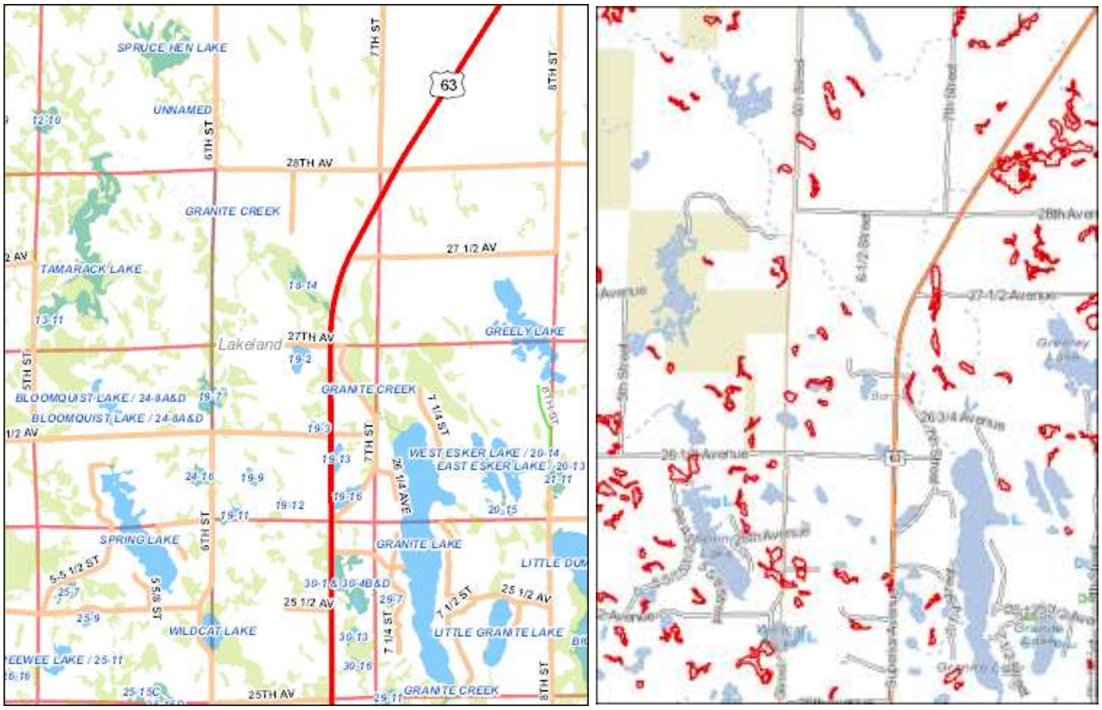



**Figure 9: Wetlands within the Granite Lake watershed (left) (Barron Co. GIS), and potentially restorable wetlands (right) (WDNR Surface Water Viewer)**

AGRICULTURE

Agricultural land covers approximately 6.6% of the watershed or about 680 acres. The bulk of this land use occurs in the northeast portion of the watershed where there are at least five farmsteads (Figure 10). The barnyards of these five farmsteads cover about 72 acres; the rest of the agricultural land is in row crops, hay, and pasture. Agricultural BMPs including conservation tillage or no-till field preparation; buffers along wetlands adjacent to farm field, grassed waterways, and barnyard improvements can reduce the amount of agricultural runoff in the watershed.

The Barron County Soil and Water Conservation Department has already identified several projects on farms in the watershed including buffers between streams/wetlands and barnyards, and barnyard improvement installations (Figure 10). In addition, there are several manure storage pits that could be evaluated (Figure 10). One is considered active, one is considered idle, and a third is considered abandoned by Barron County.

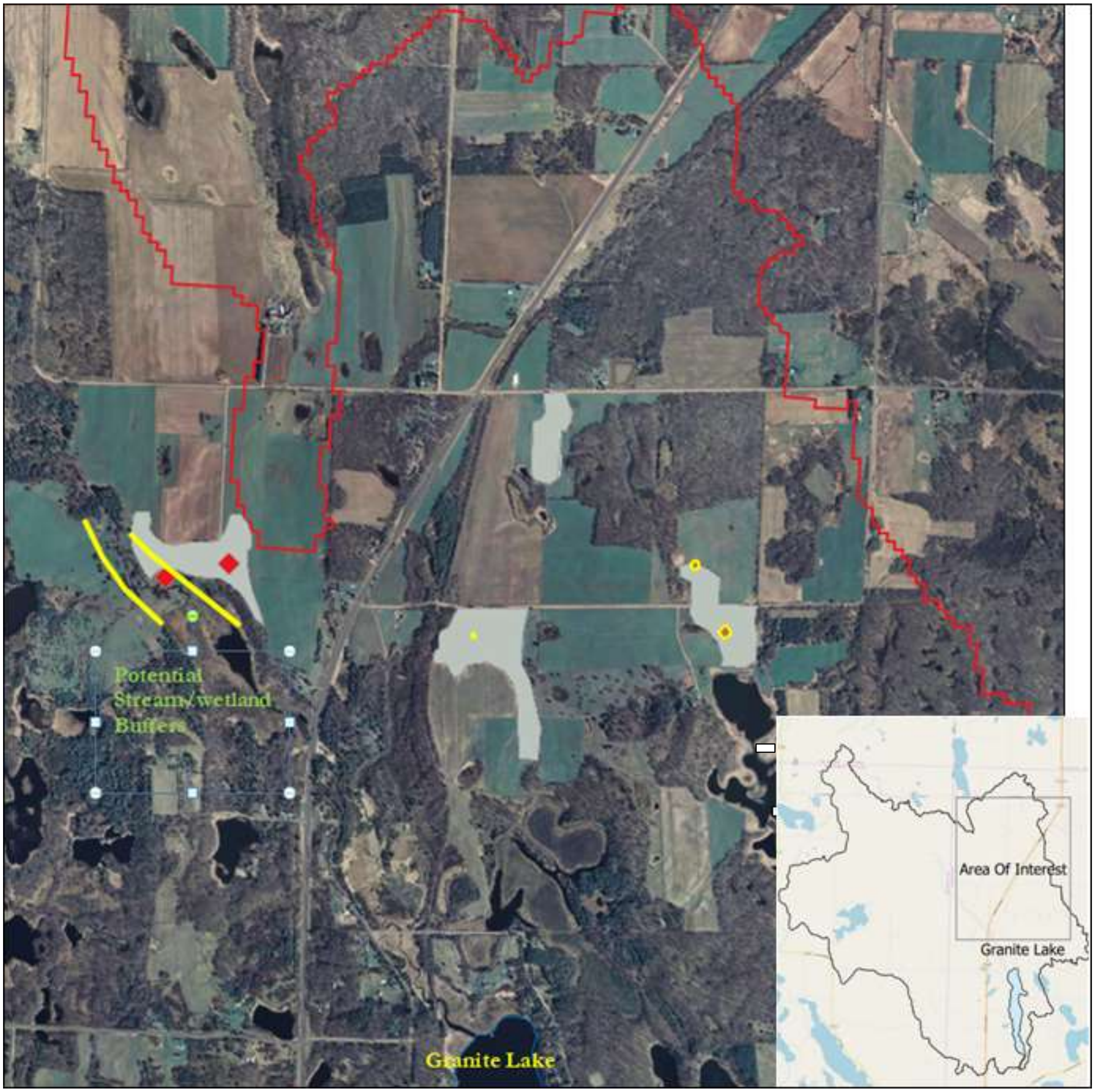



**Figure 10: Agriculture in the NE portion of the Granite Lake Watershed (red line), local farmsteads (grey areas), manure storage pits (brown-yellow outline), and conservation practices (red diamonds) identified by Barron County**

## SHORELANDS/NEARSHORE AREA

How the shoreline of a lake is managed can have big impacts on the water quality and health of that lake. Natural shorelines prevent polluted runoff from entering lakes, help control flooding and erosion, provide fish and wildlife habitat, may make it harder for AIS to establish themselves, muffle noise from watercraft, and preserve privacy and natural scenic beauty. Many of the values lake front property owners appreciate and enjoy about their properties - natural scenic beauty, tranquility, privacy, relaxation - are enhanced and preserved with good shoreland management. And healthy lakes with good water quality translate into healthy lake front property values.

Shorelands may look peaceful, but they are actually the hotbed of activity on a lake. At least 90% of all living things found in lakes - from fish, to frogs, turtles, insects, birds, and other wildlife - are found along the shallow margins and shores. Many species rely on shorelands for all or part of their life cycles as a source for food, a place to sleep, cover from predators, and to raise their young. Shorelands and shallows are the spawning grounds for fish, nesting sites for birds, and where turtles lay their eggs. There can be as much as 500% more species diversity at the water's edge compared to adjoining uplands.

Lakes are buffered by shorelands that extend into and away from the lake. These shoreland buffers include shallow waters with submerged plants (like coontail and pondweeds), the water's edge where fallen trees and emergent plants like rushes might be found, and upward onto the land where different layers of plants (low ground cover, shrubs, trees) may lead to the lake. A lake's littoral zone is a term used to describe the shallow water area where aquatic plants can grow because sunlight can penetrate to the lake bottom. Shallow lakes might be composed entirely of a littoral zone. In deeper lakes, plants are limited where they can grow by how deeply light can penetrate the water.

Shorelands are critical to a lake's health. Activities such as replacing natural vegetation with lawns, clearing brush and trees, importing sand to make artificial beaches, and installing structures such as piers, can cause water quality decline and change what species can survive in the lake.

## PROTECTING WATER QUALITY

Shoreland buffers slow down rain and snow melt (runoff). Runoff can add nutrients, sediments, and other pollutants into lakes, causing water quality declines. Slowing down runoff provides more time for water to soak (infiltrate) into the ground. Water that soaks into the ground is less likely to damage lake quality and recharges the groundwater that supplies water to lakes. Slowing down runoff water also reduces flooding, and stabilizes stream flows and lake levels.

Shoreland wetlands act like natural sponges trapping nutrients where nutrient-rich wetland sediments and soils support insects, frogs, and other small animals eaten by fish and wildlife.

Shoreland forests act as filters, retainers, and suppliers of nutrients and organic material to lakes. The tree canopy, young trees, shrubs, and forest understory all intercept precipitation, slowing runoff, and contributing to water infiltration by keeping the soil's organic surface layer well-aerated and moist. Forests also slow down water flowing overland, often capturing its sediment load before it can enter a lake or stream. In watersheds with a significant proportion of forest cover, the erosive force of spring snow melts is reduced as snow in forests melts later than snow on open land, and melt water flowing into streams is more evenly distributed. Shoreland trees grow, mature, and eventually fall into lakes where they protect shorelines from erosion, and are an important source of nutrients, minerals and wildlife habitat.

## PROTECTING AGAINST INVASION OF INVASIVE SPECIES

In addition to removing essential habitat for fish and wildlife, clearing native plants from shorelines and shallow waters can open up opportunities for invasive species to take over. Like tilling a home garden to prepare it for seeding, clearing shoreland plants exposes bare earth and removes the existing competition (the cleared shoreland plants) from the area. Nature fills a vacuum. While the same native shoreland plants may recover and reclaim their old space, many invasive species possess "weedy" traits that enable them to quickly take advantage of new territory and out-compete natives.

The act of weeding creates continual disturbance, which in turn benefits plants that behave like weeds. The modern day practice of mowing lawns is an example of keeping an ecosystem in a constant state of disturbance to the benefit of invasive species like turf grass, dandelions, and clover, all native to Europe. Keeping shoreline intact is a good way to minimize disturbance and minimize opportunities for invasive species to gain a foothold.

THREATS TO SHORELANDS

When a landowner develops a waterfront lot, many changes may take place including the addition of driveways, houses, boat houses, decks, garages, sheds, piers, rafts and other structures, wells, septic systems, lawns, sandy beaches and more. Many of these changes result in the compaction of soil and the removal of trees and native plants, as well as the addition of impervious (hard) surfaces, all of which alter the path that precipitation takes to the water.

Each of these alterations decreases the ability of the shoreland area to serve its natural functions: removal of trees and native plants eliminates the food and shelter on which wildlife depends, natural beauty is replaced with manmade materials, water cannot soak into the ground thereby increasing stormwater runoff that carries fertilizers, pesticides and other pollutants to the lakes and streams. If 50% of a lot is converted to impervious surfaces, half of this lot is no longer capable of filtering rainwater or providing the food and shelter on which wildlife depends. Figure 11 is a real-life example how a new development project can change the landscape in just two years.

**Figure 11: New lakeside development (2016-left), same site (2018-right)**

Changing one waterfront lot in this fashion may not result in a measurable change in the quality of the lake or stream. But cumulative effects when several or many lots are developed in a similar way can be enormous. A lake's response to stress depends on what condition the system is in to begin with, but bit by bit, the cumulative effects of tens of thousands of waterfront property owners "cleaning up" their shorelines, are destroying the shorelands that protect their lakes. Increasing shoreline development and development throughout the lake's watershed can have undesired cumulative effects.

SHORELAND PRESERVATION AND RESTORATION

If a native buffer of shoreland plants exists on a given property, it can be preserved and care taken to minimize impacts when future lake property projects are contemplated. If a shoreline has been altered, it can be restored. Shoreline restoration involves recreating buffer zones of natural plants and trees. Not only do quality wild shorelines create higher property values, but they bring many other values too. Some of these are aesthetic in nature, while others are essential to a healthy ecosystem. Healthy shorelines mean healthy fish populations, varied plant life, and the existence of the insects, invertebrates and amphibians which feed fish, birds, and other creatures. Figure 12 shows the difference between a natural and unnatural shoreline adjacent to a lake home. More information about healthy shorelines can be found at the following website: http://wisconsinlakes.org/index.php/shorelands-a-shallows (last accessed 1-12-2017).

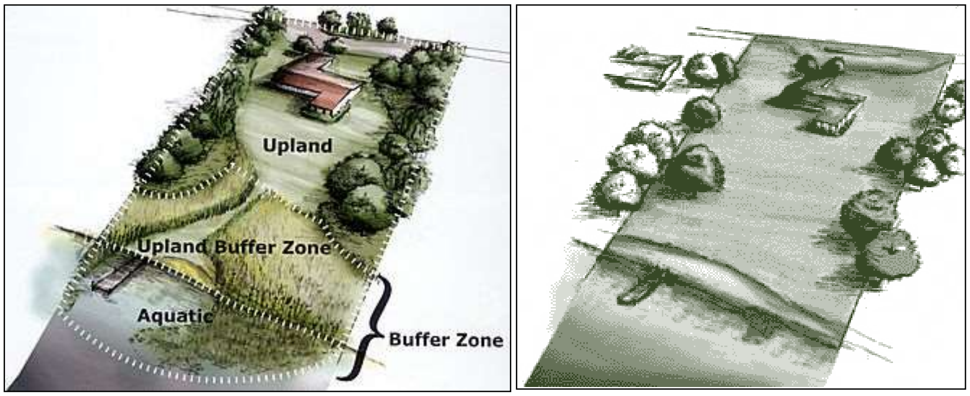



**Figure 12: Healthy, AIS resistant shoreland (left) vs. shoreland in poor condition (right)**

Much of the shoreline of Granite Lake is natural however where development is greater, improvements to the shoreline would help maintain water quality in the lake. Turf grass, mowed lawns to the edge of the lake, exposed earth, and rip rap increase the amount of runoff from roof tops, driveways, lawns and pathways to the lake. The WDNR encourages the installation of relatively simple BMPs including rain gardens, native plantings, and runoff diversion projects through its Healthy Lakes and Rivers Initiative. The GLA could sponsor some of these projects for individual property owners who are interested in improving their shorelines.

## 2017 SHORELAND HABITAT ASSESSMENT

As a part of the 2018-19 lake management planning project, a shoreland habitat assessment was completed on Granite Lake. The protocol used in this survey was developed by the WDNR as a way to evaluate shoreline habitat. This survey is intended to provide management recommendations to individual property owners based on the evaluation of their property. This protocol involves photographing each parcel from the lake which is then matched to land use information about the riparian zone. For this survey, the riparian zone is defined as the strip of land, along the shore, from the high water level back 35 feet. The information collected includes ground cover which includes lawn, impervious surfaces, and native plants. Additional land use information includes the number of human structures in the riparian zone and various other runoff concerns. This protocol also assesses the amount of woody debris present in the lake however this is done for the entire lake instead of for each individual parcel. Woody debris provides habitat for fish, birds, and numerous other types of wildlife as well in addition to providing some protecting from bank erosion. This protocol defines woody debris as wood in no deeper than 2 feet of water that is at least 4 inches in diameter, at the widest point, and at least 5 feet long.

During the assessment each property was given a priority ranking in terms of the projects that could be done and the benefits to the lake they could provide. The priority rankings that accompany each parcel evaluation were developed by LEAPS in order to determine the needs of the each lake that the survey is conducted on with concern to the projects that could realistically be completely on each parcel. The parameters used to determine the priority were considered to be those that would have the biggest impact on rainwater runoff and habitat quality. This includes percentage of canopy cover, as well as the percentage of undisturbed vegetation and a summed percentage of ground covered by manicured lawn, impervious surfaces, and easily eroded surfaces such as exposed soil or shredded vegetation such as pine needles, loose leaves, small branches, etc. also known as duff. Additional consideration was given to the number of buildings present in the riparian zone and the presence or absence of lawns that sloped directly to the lake. For each factor that was considered, there are value ranges assigned to each parameter which determine the color to be assigned, the value ranges can be seen below in Table 6. Values that fall within the red range are worth 2 points, values in the yellow range are worth 1 point, and values in the white range are not given any points. The points are then summed and the properties prioritized based on the point range for the entire lake.

**Table 6: Parameters used in the 2018 Granite Lake Shoreland Habitat Assessment**

| Parameter | Red range (2 points) | Yellow Range (1 Point) | White (No points) |
|---|---|---|---|
| Percent canopy cover | 0-33% | 34-66% | >66% |
| Percent shrub and herbaceous (undisturbed) | 0-33% | 34-66% | >66% |
| Percent lawn, impervious, and other surfaces | >66% | 34-66% | 0-33% |
| Number of buildings and other human structures | >1 | 1 | 0 |
| Presence/ Absence of lawn or soil sloping to lake | N/A | 1 (Present) | 0 (Absent) |
| Presence/Absence of bare soil | 1 (Present) | N/A | 0 (Absent) |
| Presence/Absence of sand deposits | N/A | 1 (Present) | 0 (Absent) |

## LAKE-WIDE SUMMARY OF RESULTS

To establish priority rankings for this lake, it was important to consider the entire lake. The maximum possible score was 16 points, but the highest scoring parcel only scored 9 points. From here, four levels of concern were established: red, orange, yellow, and white. These colors correspond to the priority of concern red properties are of high concern, orange are moderate, yellow is low, and white parcels are of almost no concern. Table 7 and Figure 13 summarize the survey results for the entire lake.

**Table 7: Score ranges and priority rankings for the 92 parcels surrounding Granite Lake**

| Color | Overall Score | Priority | Number of Parcels |
|---|---|---|---|
| Red | 7-9 Points | High | 11 |
| Orange | 4-6 Points | Moderate | 15 |
| Yellow | 2-3 Points | Low | 24 |
| White | 0-1 Points | No Concern | 42 |

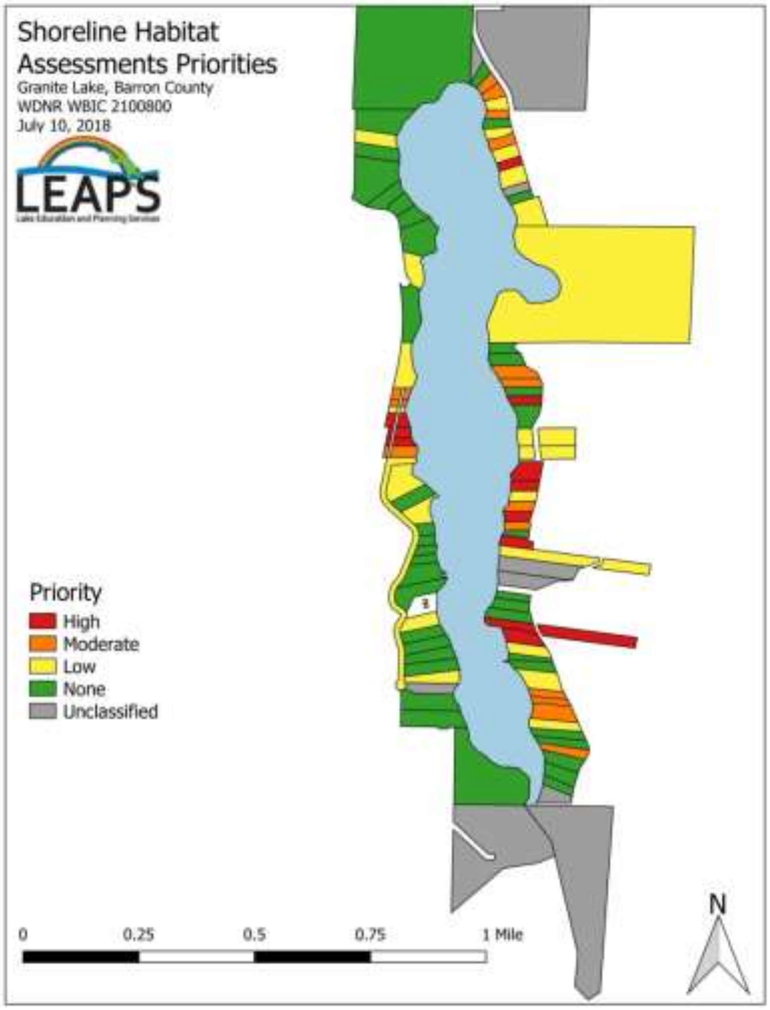



**Figure 13: Lakewide Shoreline Habitat Parcel Evaluations for Granite Lake**

PRIORITY RANKINGS BY PARCEL

Generally speaking, there are very few recommendations for properties scoring under 3 points, so these have been marked with no priority ranking. Many of the low priority parcels would benefit from native plantings along the shore to act as a buffer zone. The high and moderate priorities would do well with rain gardens, rock infiltrations near structures, as well as native plantings. These are all general patterns, but it is important to note that there is a good amount of variation between each parcel. To account for this, there are specific management recommendations for each parcel. The recommendations for each parcel are meant to give property owners an idea of some of inexpensive small scale projects that would best suit the needs of their property. The projects suggested come primarily from the WDNR's Healthy Lakes and Rivers Initiative which means most of them are eligible for grant funding through the WDNR.

COARSE WOODY HABITAT

Coarse woody habitat (CWH) in lakes is classified as trees, limbs, branches, roots, and wood fragments at least 4 inches in diameter that enter a lake by natural (beaver activity, toppling from ice, wind, or wave scouring) or human means (logging, intentional habitat improvement, flooding following dam construction). CWH in the littoral or near-shore zone serves many functions within a lake ecosystem including erosion control, as a carbon source, and as a surface for algal growth which is an important food base for aquatic macro invertebrates.

Presence of CWH has also been shown to prevent suspension of sediments, thereby improving water clarity (Sass, 2009). CWH serves as important refuge, foraging, and spawning habitat for fish, aquatic invertebrates, turtles, birds, and other animals. The amount of littoral CWH occurring naturally in lakes is related to characteristics of riparian forests and likelihood of toppling. However, humans have also had a large impact on amounts of littoral CWH present in lakes through time. During the 1800's the amount of CWH in northern lakes was increased beyond natural levels as a result of logging practices (Sass, 2009). But time changes in the logging industry and forest composition along with increasing shoreline development have led to reductions in CWH present in many northern Wisconsin lakes.

CWH is often removed by shoreline residents to improve aesthetics or select recreational opportunities (swimming and boating). Jennings et al. (2003) found a negative relationship between lakeshore development and the amount of CWH in northern Wisconsin lakes. Similarly, Christensen et al. (1996) found a negative correlation between density of cabins and CWH present in Wisconsin and Michigan lakes. While it is difficult to make precise determinations of natural densities of CWH in lakes it is believed that the value is likely on the scale of hundreds of logs per mile. The positive impact of CWH on fish communities have been well documented by researchers, making the loss of these habitats a critical concern (Wolter, 2012).

The Shoreland Habitat Assessment referred to earlier also assessed the amount of CWH present in the lake. However this is done for the entire lake instead of for each individual parcel. For shoreland habitat assessment purposes, CWH is defined as wood (trees, stumps, logs, and brush) in no deeper than 2 feet of water that is at least 4 inches in diameter, at the widest point, and at least 5 feet long. CWH in the water provides habitat for fish, birds, and numerous other types of wildlife in addition to protecting from banks from erosion. Figure 14 shows all the locations in Granite Lake where CWH was identified. Granite Lake had 35 points with CWH or approximately 8 points per mile of shoreline, far from the estimates of 100's of locations per mile of shoreland in natural, undisturbed lakes.

While many points with CWH were identified during the survey, much of this consisted of a log or branch in the water (simple CWH) versus a whole tree with many branches and larger stumps or logs all intertwined (complex CWH). The greater the complexity of the CWH the more habitat it can provide for fish and other inhabitants of the lake. Larger trees can last for several hundred years in the water providing habitat for many creatures (Sass, 2009). WDNR Fisheries Managers have expressed their support for the construction of "Fishsticks" projects along the shores of the lakes. Fishsticks are fish structure created from whole trees cut and stacked on top of each other (Figure 15). Fishsticks are typically installed in the winter, anchored to the shore, and often weighted down to help woody material sink to the bottom during spring ice melt.

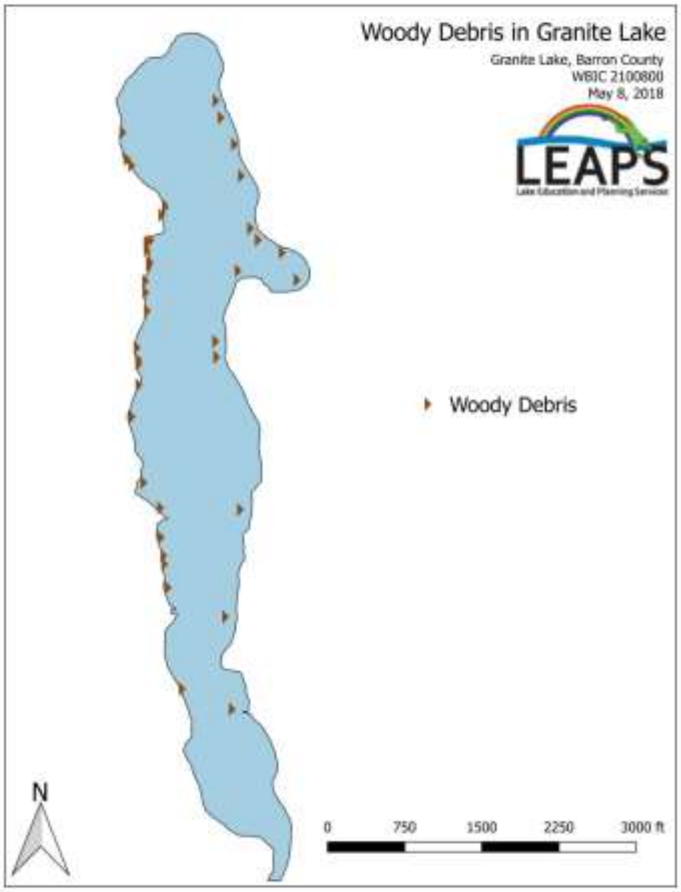



**Figure 14: Woody habitat around Granite Lake**

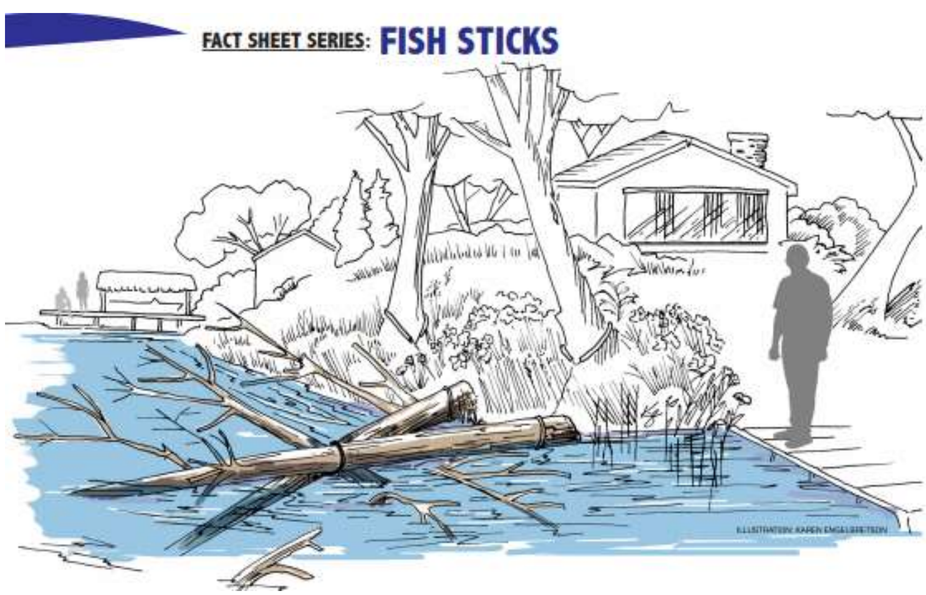



**Figure 15: Healthy Lakes Fact Sheet Series: Fishsticks. WDNR/Wisconsin Lakes Partnership**

## NEARSHORE DEVELOPMENT

Although residential areas only make up a small percentage of the total land use in the watershed (1.6%), the residential areas are concentrated around the lake. Development replaces the natural landscape with buildings, roads, driveways and lawns which prevent rainwater and snowmelt from slowly infiltrating into the ground. The increased runoff carries with it sediment, pollutants, and nutrients which can lead to poor water quality and can fuel algae growth. Nutrients and pollutants are also supplied by the fertilizers, pesticides and septic systems associated with development.

Land use in the near-shore area (within 300 feet of the lake) was assessed using recent high resolution (6-inch) ortho-photos and GIS. Land use was classified as lawn, impervious surface (rooftops, driveways, sidewalks), wetland, or natural (forest, herbaceous, open water) (Table 8, Figure 16). The land use data was input into the Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider, 2002) to estimate the nutrient loading to the lake from the near-shore area. Loading from septic systems in the near-shore area was estimated from the septic system usage data, which was collected for both permanent and seasonal dwellings as part of the sociological survey, and from the number of near-shore dwellings, which were identified during the analysis.

Granite Lake has undergone extensive development since the mid-1960s when there were approximately 15 cabins around the lake. There are now more than 70 dwellings on the lake, 45% of which are permanent residences. Despite the development, the shoreline is in relatively good condition with 69% of it still in a natural state.

When the shoreland habitat assessment was completed, a few properties were identified that had potential for multiple shoreland improvement projects. These properties could be approached by members of the lake association and encouraged to take advantage of funding through the Healthy Lakes and Rivers Initiative. Other properties could also be approached.

**Table 8: Nearshore land use in a 300-ft band around Granite Lake**

| Land Use | Acreage | % of Total |
|---|---|---|
| Lawn | 22 | 14.4 |
| Impervious | 11.2 | 7.3 |
| Natural | 105.7 | 69.4 |
| Wetland | 13.5 | 8.9 |
| | 152.4 | 100 |

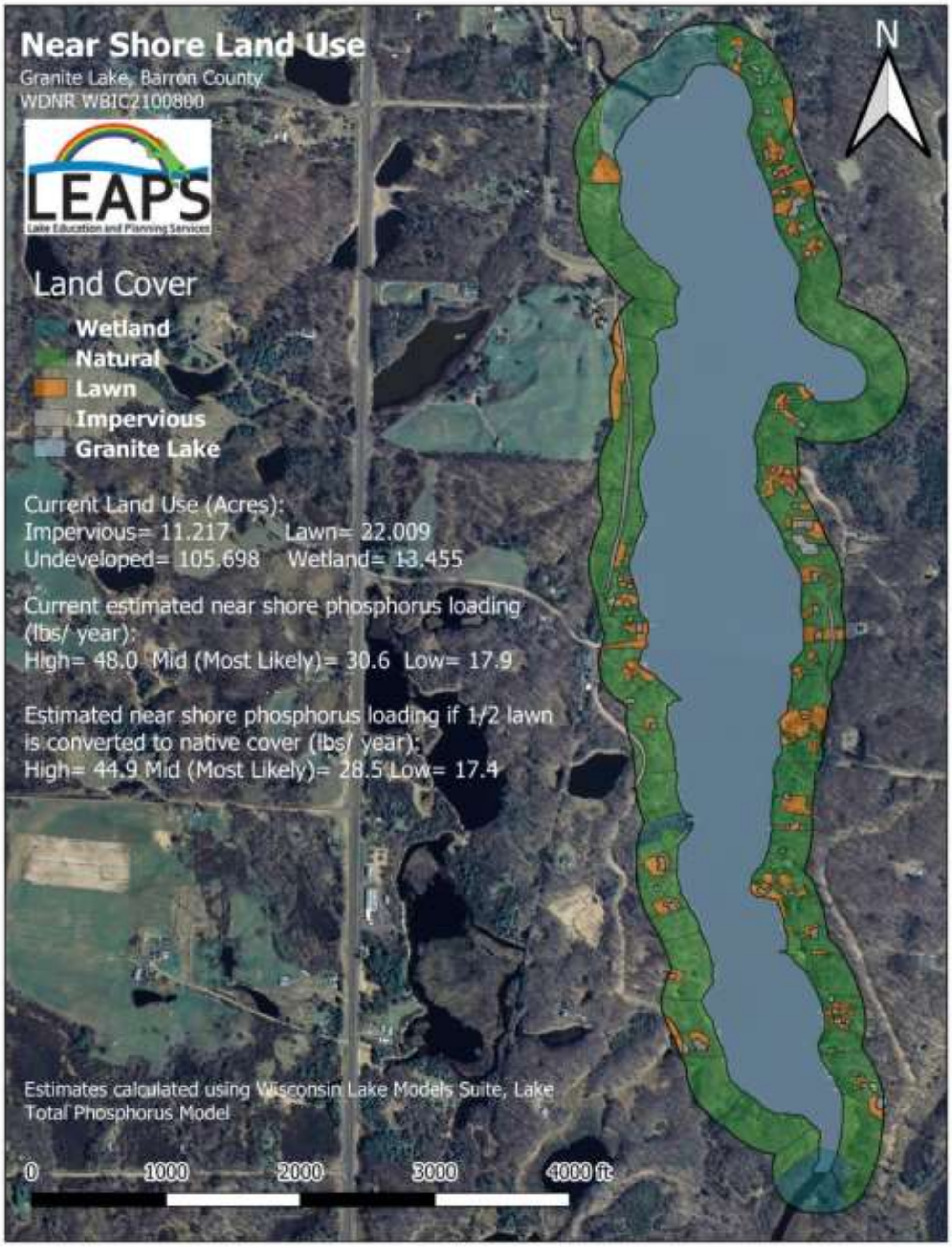



**Figure 16: Nearshore land use within a 300-ft band of "developed" shoreland around Granite Lake**

One of the worst areas of the developed shoreland is at the Town of Lakeland owned public boat launch on the west side of the lake. The landing is a steep (8-9% slope) gravel roadway straight down to the lake (Figure 17). A great deal of erosion is visible on the landing (Figure 18). Currently there are no diversions to direct the water away from flowing straight down the landing into the lake despite there being ample lowland areas on either side of the gravel drive to do so. At a minimum, installing several diversions to channel water into adjacent lowlands would reduce direct runoff into the lake and likely keep the landing in better shape.

A larger planning project to improve accessibility, reduce runoff, and prevent erosion could be completed by an engineer and installed with support from a WDNR lake protection grant.

**Figure 17: Lakeland Township boat landing on the west side of Granite Lake – 2-ft (red) and 10-ft (yellow) contours. Red line is 300-ft long.**

**Figure 18: Erosion from the public boat landing facing the lake (left) and facing away from the lake (right)**

## WAVES AND WATERCRAFT

While not exactly a watershed characteristic, the use of large watercraft on Granite Lake for recreational purposes including waterskiing, tubing, wake boarding, and wake surfing does occur and has an impact. Waves created by these large boats and just waves in general stir up bottom sediments and erode shorelines which in turn suspends sediments in the water causing temporary or even long-term changes in water clarity and available nutrients that feed plant and algal growth.

WAKE BOATS

Low-speed boating is a relatively new phenomenon on Wisconsin lakes. It involves watercraft specifically designed to be driven at slow speeds and to create large wakes for skiing, boarding, and surfing. Specialized "wake boats" are designed to increase wave height in the wake in a number of different ways. These specialized boats are often built with a hull shaped to achieve maximum wake, may have a hydrofoil device that lowers the stern of the boat when under power, and may have built in ballast tanks to increase weight in the back of the boat causing more water to be displaced and larger waves created. Not every boat has all of these features, but there are some that do.

The problem with increased wake height is related to the adverse effects that go along with large waves. The larger the wave, the deeper it can churn sediment in shallow water. The larger the wave, the more energy it delivers when it crashes against the shore exacerbating erosion along both natural and disturbed shorelines. The boats themselves are designed such that the propeller driving the boat is lower in the water, and often larger than on a normal boat, creating turbulence that can reach the bottom in as much as 10-ft of water again disturbing the lake bed and churning up sediments.

Whether it is propeller-induced or the result of boat-induced waves, sediment and nutrients can become re-suspended in the water column of the lake. Depending on how fine the sediment is, it could take up to 24-hrs. for sediment stirred up to settle back to the bottom of the lake. Sediment in suspension means nutrients like nitrogen and phosphorus can re-enter the lake ecosystem able to interact with the biotic community in the water column. The sediment itself can reduce water clarity, limited sunlight penetration which is vital for aquatic plant growth. Often times phosphorus re-suspended and now available in the water column can fuel rapid algae growth (blooms) which can contribute to further water clarity and quality issues.

The deeper the propeller, or if a boat is operating in shallow water, it can uproot or fragment aquatic vegetation, leading to the destruction of desirable aquatic plants or the spread of non-native invasive species like Eurasian watermilfoil (EWM) if present. Ballast tanks on some of these boats that help create the large wakes, are generally filled with lake water and the process of filling and emptying them into a lake or at the boat landing of another lake can spread other aquatic invasive species like zebra mussel larvae that may live in the water (Keller, 2017).

MOTORIZED BOATING IN GENERAL

It is not just the "relatively new" phenomenon that is wake boats that can cause problems in lakes, motor boat use in general cause the same impacts. Large or small, fishing or other recreation, if driven in the wrong place.in the wrong way, or at the wrong time, drivers can cause lake issues with their watercraft. In a review of existing studies related to boats and how they affect lakes, (Apslund, 2000) concludes that boats in general have been shown to affect water clarity and can be a source of nutrients and algal growth in aquatic ecosystems, and that shallow lakes, and shallows parts of lakes and rivers, and channels connecting lakes are the most susceptible to impacts. In another part of the review, he concludes that waves or wakes produced by boats can influence shoreland erosion. River systems, channels connecting lakes, and small lakes are the most impacted. The type of shoreline also impacts how much these waves erode, with loosely consolidated, steep, un-vegetated banks being the most susceptible.

Apslund, 2000 further identifies some other impacts of boating, but these in general are less studied, and not as conclusive. Boats impact aquatic plants by direct cutting, scouring of sediments in shallow areas preventing aquatic plant growth, uprooting of plants, and increased wave activity. The effects of boating on the fishery is less studied and basically centers around disturbing fish from spawning nests, or in changing fish habitat (water clarity, sediment, aquatic plant beds, etc.). Effects on wildlife are also little studied, but include temporary disturbance (waterfowl, birds of prey) and in some cases more permanent disturbance (loons and loon nesting).

In another part of the Apslund, 2000 study, personal watercraft (PWC) or jetskis are discussed. The conclusions drawn suggest that the issues caused by PWC are similar to those caused by boats in general. Noise and emissions, and how PWC are used by their riders are of generally more concern than the impacts on the ecosystem.

IMPACTS ON GRANITE LAKE

Granite Lake has characteristics that make the use of large wake boats (and other boats) somewhat problematic. Specifically, the long, narrow shape of the lake makes it pretty much assured that any large wake/wave created by a boat, even in the center of the lake, will reach the shore. Both the north and south ends of the lake are relatively shallow compared to the center basin, so any boat turning around in these areas will cause greater disturbance of the bottom sediments.

Negative impacts caused by boating in general (not just wake boats) can be minimized through education. Continuous boater reminders of the “no wake” areas of the lake - within 100-ft of the shore for boats and within 200-ft for PWC should be made. Encouraging lake users to minimize motor startups close to shore can also help. Regulating boat use is a much more complicated and controversial management issue and is not recommended in this management plan. However, voluntary limits placed on this type of boating activity should be encouraged.

## NATURAL HERITAGE INVENTORY

The Natural Heritage Inventory is a dynamic database of species and natural communities that are of concern around the State of Wisconsin. The Wisconsin natural heritage working list contains species known or suspected to be rare in the state along with natural communities native to Wisconsin. This list was last updated on July 1, 2020. It includes species legally designated as "endangered" or "threatened" as well as species in the advisory "special concern" category. Species that fall under the “threatened” or “endangered” category are afforded special protections within the State while those that are considered “special concern” category carry no legal protections, but are being monitored because of the potential need for legal protection. In Barron County, which contains the entire Granite Lake Watershed, there are two endangered and eight threatened animal species. In addition to these species that have legal protections there are also 18 animal species of special concern (Table 9).

**Table 9: Endangered, Threatened, and Special Concern Animal Species within Barron County**

| Scientific Name | Common Name | WI | Group |
|---|---|---|---|
| Hemidactylium scutatum | Four-toed Salamander | SC/H | Rare Amphibians |
| Lithobates septentrionalis | Mink Frog | SC/H | Rare Amphibians |
| Striatura ferrea | Black Striate | SC/N | Rare Aquatic and Terrestrial Snails |
| Accipiter gentilis | Northern Goshawk | SC/M | Rare Birds |
| Ammospiza leconteii | LeConte's Sparrow | SC/M | Rare Birds |
| Botaurus lentiginosus | American Bittern | SC/M | Rare Birds |
| Buteo lineatus | Red-shouldered Hawk | THR | Rare Birds |
| Centronyx henslowii | Henslow's Sparrow | THR | Rare Birds |
| Chlidonias niger | Black Tern | END | Rare Birds |
| Coturnicops noveboracensis | Yellow Rail | THR | Rare Birds |
| Lanius ludovicianus | Loggerhead Shrike | END | Rare Birds |
| Phalaropus tricolor | Wilson's Phalarope | SC/M | Rare Birds |
| Sturnella magna | Eastern Meadowlark | SC/M | Rare Birds |
| Sturnella neglecta | Western Meadowlark | SC/M | Rare Birds |
| Vermivora chrysoptera | Golden-winged Warbler | SC/M | Rare Birds |
| Xanthocephalus xanthocephalus | Yellow-headed Blackbird | SC/M | Rare Birds |
| Epiaeschna heros | Swamp Darner | SC/N | Rare Dragonflies and Damselflies |
| Ophiogomphus smithi | Sioux (Sand) Snaketail | SC/N | Rare Dragonflies and Damselflies |
| Etheostoma microperca | Least Darter | SC/N | Rare Fishes |
| Lythrurus umbratilis | Redfin Shiner | THR | Rare Fishes |
| Notropis anogenus | Pugnose Shiner | THR | Rare Fishes |
| Notropis nubilus | Ozark Minnow | THR | Rare Fishes |
| Sorex palustris | Water Shrew | SC/N | Rare Mammals |
| Alasmidonta marginata | Elktoe | SC/P | Rare Mussels and Clams |
| Emydoidea blandingii | Blanding's Turtle | SC/P | Rare Reptiles |
| Glyptemys insculpta | Wood Turtle | THR | Rare Reptiles |
| Plestiodon septentrionalis | Prairie Skink | SC/H | Rare Reptiles |

Animal species that are listed as threatened or endangered are afforded significantly more protection than plant species with the same designations. Despite this there are still restrictions on what can and cannot be done to these plants. Within Barron County there is one endangered and three threatened species as well as 11 species of special concern (Table 10). Vasey's pondweed, a species of special concern, was found in Granite Lake in the most recent aquatic plant survey.

**Table 10: Endangered, Threatened, and Special Concern Plant Species within Barron County**

| Scientific Name | Common Name | WI | Group |
|---|---|---|---|
| Artemisia dracunculus | Dragon Wormwood | SC | Rare Plants |
| Asclepias ovalifolia | Dwarf Milkweed | THR | Rare Plants |
| Botrychium minganense | Mingan's Moonwort | SC | Rare Plants |
| Callitriche hermaphroditica | Autumnal Water-starwort | SC | Rare Plants |
| Carex prasina | Drooping Sedge | SC | Rare Plants |
| Elatine triandra | Longstem Water-wort | SC | Rare Plants |
| Eleocharis robbinsii | Robbins' Spike-rush | SC | Rare Plants |
| Leucophysalis grandiflora | Large-flowered Ground-cherry | SC | Rare Plants |
| Potamogeton bicupulatus | Snail-seed Pondweed | SC | Rare Plants |
| Potamogeton confervoides | Algae-leaved Pondweed | THR | Rare Plants |
| Potamogeton diversifolius | Water-thread Pondweed | SC | Rare Plants |
| Potamogeton vaseyi | Vasey's Pondweed | SC | Rare Plants |
| Ribes oxyacanthoides ssp. oxyacanthoides | Canadian Gooseberry | THR | Rare Plants |
| Schoenoplectus torreyi | Torrey's Bulrush | SC | Rare Plants |
| Viburnum edule | Squashberry | END | Rare Plants |

## LAKE INVENTORY

In order to effectively make management recommendations it is necessary to fully evaluate the conditions within the area of concern. While this plan generally focuses on issues at the scale of the entire watershed, it is still important to take stock of the baseline conditions of the lake, in order to be able to estimate how management could positively or negatively impact the lake(s) affected.

### PHYSICAL CHARACTERISTICS

Granite Lake is a 155 acre drainage lake in northwestern Barron County. The average depth is 18 feet with a deepest point of 34 feet. Water inputs for Granite Lake come from a main tributary on the north end of the lake, a secondary tributary on the west shore, groundwater, and precipitation. At the southern end of the lake, the water drains through a large wetland complex on its way to and through Duck Lake and Buck Lake eventually joining the Yellow River. Table 11 reflects the physical characteristics of Granite Lake.

**Table 11: Physical characteristics of Granite Lake**

| | | |
|---|---|---|
| **Lake Area** | 155 | acres |
| **Watershed Area** | 10,348 | acres |
| **Watershed to Lake Ratio** | 67 to 1 | |
| **Maximum Depth** | 34 | feet |
| **Mean Depth** | 18 | feet |
| **Volume** | 2723 | acre-feet |
| **Maximum Fetch** | 1.49 | miles |
| **Miles of Shoreline** | 4.15 | miles |
| **Lake Type** | Drainage | |

Depth readings taken in 2018 showed Granite Lake is a classic narrow glacial "straight lake" running north/south. Both the east and west sides of the main basin have sharp drop-offs into 20-ft+ of water, while the north and south ends slope more gradually into deeper water. The lake's only side bay on the eastern shoreline also drops off rapidly from shore and empties into the deepest point in the lake (Figure 19).The lake's bottom substrate is predominantly rock and sand along the central basin with organic muck in the north and south bays as well as the creek inlet/outlet (Figure 19). Thick nutrient-rich organic muck was most common in the immediate inlet and outlet areas of the north and south bays, while thinner and sandier muck dominated the rest of the bays. Along the immediate shoreline, especially in the central basin, most substrates were pure sand, gravel, or cobble.

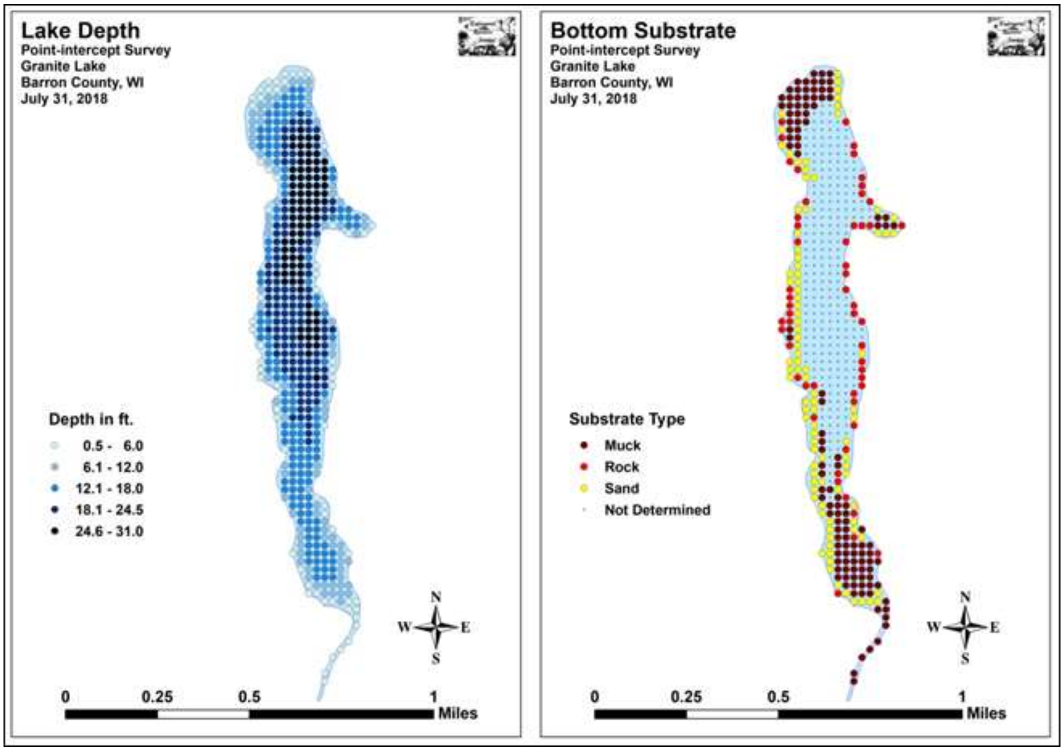



**Figure 19: Lake depth and bottom substrate (ERS, 2018)**

## WATER QUALITY

Citizen Lake Monitoring Network (CLMN) volunteers have collected water quality data from the Deep Hole monitoring site in Granite Lake (Station ID 033177) since 1994 (Figure 20). Data was collected from the South Basin from 2008 to 2013, then again from 2017-2019. Volunteers measured quantitative parameters such as temperature, dissolved oxygen, and Secchi depth; and collected water samples which were sent to the Wisconsin State Lab of Hygiene for analysis of TP and chlorophyll *a*. Qualitative observations such as lake level, color, and perception of water quality were also recorded.

From 1994-2017 volunteers recorded water quality data from the Deep Hole on more than 155 dates. From that data, the perception of the lake was considered beautiful or with only minor aesthetic problems 43.2% of the time. Enjoyment was somewhat impaired based on how green the water was (algae) another 37.4% of the time. The final 19.4% of the time, the lake was considered bad enough that swimming and other whole-body emersion activities was substantially impaired. About 50% of the time the lake water was clear, the remaining time it was considered murky. The water color was mostly described as green or brown.

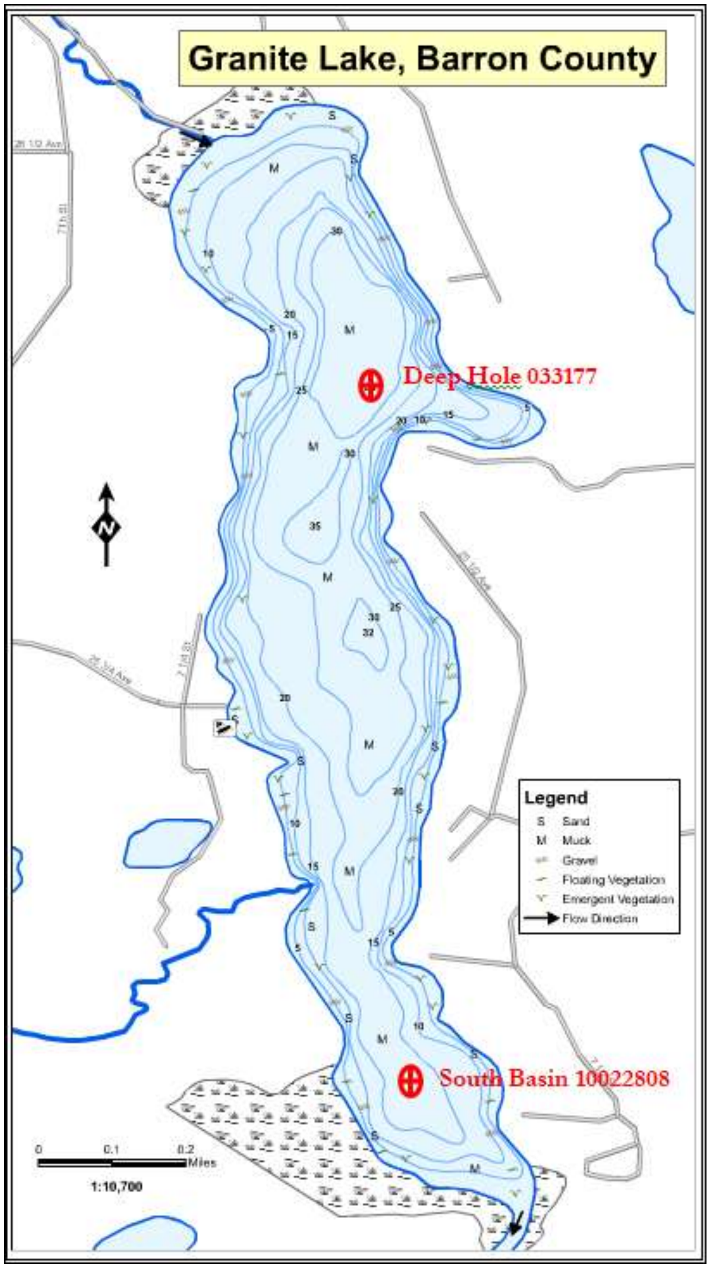



**Figure 20: Granite Lake, Barron County CLMN water quality testing sites**

These water quality parameters provide information on lake trophic status, the nutrient limiting production in the lake, potential sources of nutrients, and in-lake nutrient release. The information gathered further develops datasets that can be used for analysis trends and establishment of baseline conditions.

DIMICTIC VERSE POLYMICTIC LAKES

Dimictic lakes are lakes that mix from top to bottom during two mixing periods each year. During winter they are covered by ice. During summer they are thermally stratified, with temperature-derived density differences separating the warm surface waters (the epilimnion), from the colder bottom waters (the hypolimnion). The area in between the surface and the bottom layers is called the metalimnion, but more commonly called the thermocline. Mixing typically occurs only during the spring and autumn, when the water in the lake is at the same temperature from the top to the bottom. During these times the lake readily mixes from top to bottom (Figures 21 & 22).

A polymictic lake is a lake that is ice-covered part of the year, ice-free above 40ºF and stratified during the warm season for periods of several days to weeks, but with irregular interruption by mixing. Mixing occurs when the thermocline is disturbed or broken by wind and wave action or possibly after heavy usage by watercraft. Mixing caused by waves is partially supported by the "fetch" of a given lake. The maximum fetch is the maximum length of open water over which wind can blow. A larger fetch allows larger and more powerful waves to be created from wind and therefore induce mixing to a greater depth in the lake. Areas of the lake with a longer fetch are also more susceptible to shoreline erosion via wind-induced wave action. Granite Lake has a maximum fetch of nearly 1.5 miles from north to south. So both winds out of the northwest and winds out of the south can create fairly sizable waves.

The Osgood Index is used to describe how likely a lake is to mix due to wind forces. Lakes with Osgood Index values less than 4 tend to be polymictic. Granite Lake has an Osgood Index of 6.9 suggesting that it is mostly dimictic. For at least the last three years (2018-2020) data indicates that the lake is strongly stratified during the summer months supporting the Osgood Index. However, fairly consistent Temperature and DO profiles collected by volunteers through CLMN, indicate that at least in certain years, Granite Lake does have polymictic tendencies.

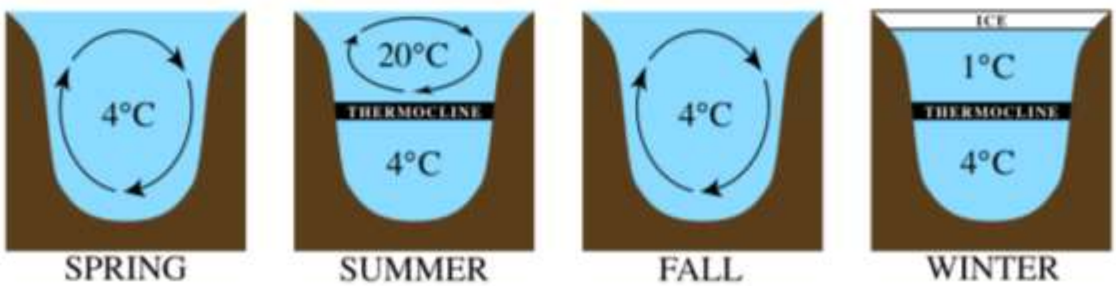



**Figure 21: Typical mixing pattern in a dimictic lake (wikipedia.org)**

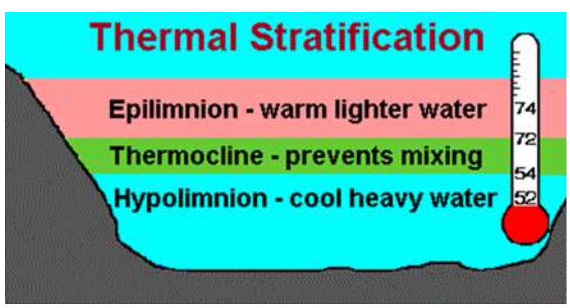



**Figure 22: Summer thermal stratification in a dimictic lake**

TEMPERATURE AND DISSOLVED OXYGEN

At least in the last three years, dissolved oxygen and temperature profiles taken once a month through August have shown Granite Lake to be a dimictic lake that strongly stratifies during the summer months (Figure 23) and then experiences spring and fall turnover. Profiles were not taken often enough to determine if there were short periods of time when stratification was disturbed either due to a large storm event or excessive boat traffic. But going by the existing profiles that have been collected, stratification occurs in early to mid-June and remains that way likely through early September. During the summer months the thermocline establishes somewhere between 9 and 18 feet, with waters below the thermocline being devoid of oxygen. These anoxic conditions indicate that there is a lot of phosphorus released from the bottom sediments during the summer but it is prevented from mixing with surface water by a well-established thermocline. The average concentration of phosphorus in the bottom waters of Granite Lake was 486-µg/l, while at the surface the average concentration was only around 30-µg/l.

| 06/20/2018 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 76 | 8.1 |
| 3 | 75 | 8.16 |
| 6 | 74 | 8.07 |
| 9 | 72 | 7.55 |
| 12 | 67 | 4.94 |
| 15 | 55 | .34 |
| 18 | 51 | .16 |
| 21 | 48 | .12 |
| 24 | 46 | .1 |
| 27 | 45 | .09 |

| 07/25/2018 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 76.2 | |
| 3 | 76.3 | 7.98 |
| 6 | 75.8 | 7.99 |
| 9 | 76.2 | 7.95 |
| 12 | 75.7 | 7.64 |
| 15 | 70.4 | .78 |
| 18 | 59.7 | .17 |
| 21 | 52.9 | .1 |
| 24 | 49.6 | .09 |
| 27 | 47.6 | .08 |
| 30 | 46.4 | .08 |

| 08/22/2018 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 73.9 | 8.13 |
| 3 | 73.8 | 8.13 |
| 6 | 73.7 | 8.08 |
| 9 | 73 | 8.25 |
| 12 | 71 | 8.08 |
| 15 | 69.5 | .26 |
| 18 | 60.8 | .11 |
| 21 | 53.6 | .08 |
| 24 | 50.2 | .08 |
| 27 | 48.5 | .08 |
| 30 | 47 | .08 |

| 06/19/2019 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 68.4 | |
| 3 | 68.2 | 8.67 |
| 6 | 68.1 | 8.68 |
| 9 | 66.4 | 8.85 |
| 12 | 67.3 | 8.76 |
| 15 | 54.3 | 3.54 |
| 18 | 51.5 | 2.79 |
| 21 | 49.9 | .61 |
| 24 | 48.7 | .1 |
| 27 | 48.5 | .09 |

| 07/16/2019 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 81 | 7.52 |
| 3 | 80.5 | 7.56 |
| 6 | 80.2 | 7.54 |
| 9 | 78.2 | 5.5 |
| 12 | 64.4 | .19 |
| 15 | 58.9 | .1 |
| 18 | 55.2 | .08 |
| 21 | 51.5 | .1 |
| 24 | 50.3 | .09 |
| 27 | 49.6 | .06 |
| 30 | 49 | .05 |

| 08/19/2019 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 71.9 | |
| 3 | 74 | 8.15 |
| 6 | 74.1 | 7.99 |
| 9 | 74 | 7.91 |
| 12 | 73.1 | 3.88 |
| 15 | 65.7 | 3.08 |
| 18 | 58.1 | .19 |
| 21 | 53.9 | .13 |
| 24 | 52.7 | .12 |
| 27 | 50.8 | .1 |
| 30 | 49.8 | .09 |

| 06/29/2020 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 3 | 77 | 8.94 |
| 6 | 76.8 | 8.92 |
| 9 | 76.8 | 8.85 |
| 12 | 76.5 | 8.25 |
| 15 | 64.4 | .29 |
| 18 | 59 | .12 |
| 21 | 53.6 | .1 |
| 24 | 53.1 | .1 |
| 27 | 51.3 | .09 |
| 30 | 50.4 | .09 |

| 07/27/2020 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 76.6 | 8.08 |
| 3 | 76.5 | 7.83 |
| 6 | 76.3 | 7.77 |
| 9 | 75.7 | 6.51 |
| 12 | 74.6 | 5.89 |
| 15 | 72.8 | 2.88 |
| 18 | 67.6 | .29 |
| 21 | 60.2 | .09 |
| 24 | 55 | .08 |
| 27 | 52.6 | .08 |
| 30 | 51.4 | .07 |

| 08/25/2020 | | |
|---|---|---|
| Depth FEET | Temp. DEGREES F | D.O. MG/L |
| 0 | 77.3 | 7.89 |
| 3 | 77.3 | 7.93 |
| 6 | 77.3 | 7.76 |
| 9 | 75.4 | 5.49 |
| 12 | 73.2 | 2.04 |
| 15 | 70.7 | .12 |
| 18 | 68.7 | .1 |
| 21 | 60.5 | .07 |
| 24 | 55.4 | .06 |
| 27 | 53.5 | .06 |
| 30 | 51.7 | .06 |

**Figure 23: 2018-2020 dissolved oxygen and temperature profiles from the Deep Hole in Granite Lake**

The data in Figure 23 represents the last three years; however temperature and DO profiles have been measured pretty regularly since 2002. From 2002 to 2007, monthly profiles clearly show the lake is stratified beginning in June, and remains so until sometime in late September. This pattern is again clearly shown from 2013 through 2019. However, between 2008 and 2012, the dimictic pattern is less definable suggesting that the lake was acting in a more polymictic way during that time frame. As discussed, alternate states of a mixed and stratified water column will often increase the amount of phosphorus available for algae growth during the summer.

WATER CLARITY

Water clarity was measured by volunteers using a Secchi disk. Data are available from 1994 through 2019. The Secchi disk measurement is the average of the depth that when lowered the disk just disappears from sight and the depth that when raised the disk is just visible. Secchi depths vary throughout the year, with shallower readings in summer when algae become dense and limit light penetration and generally deeper readings in spring and late fall. Because light penetration is usually associated with algae growth, a lake is considered eutrophic, or highly productive, when Secchi depths are less than 6.5 feet.

The Secchi measurements taken in Granite Lake at the Deep Hole are shown in Figure 24. There has been slight improving trend in water clarity over the past 25 years. Between 2005 and 2010 water clarity averaged a little more than 5.0-ft during the summer. After dropping a bit from 2011 to 2013 it picked up again starting in 2015.

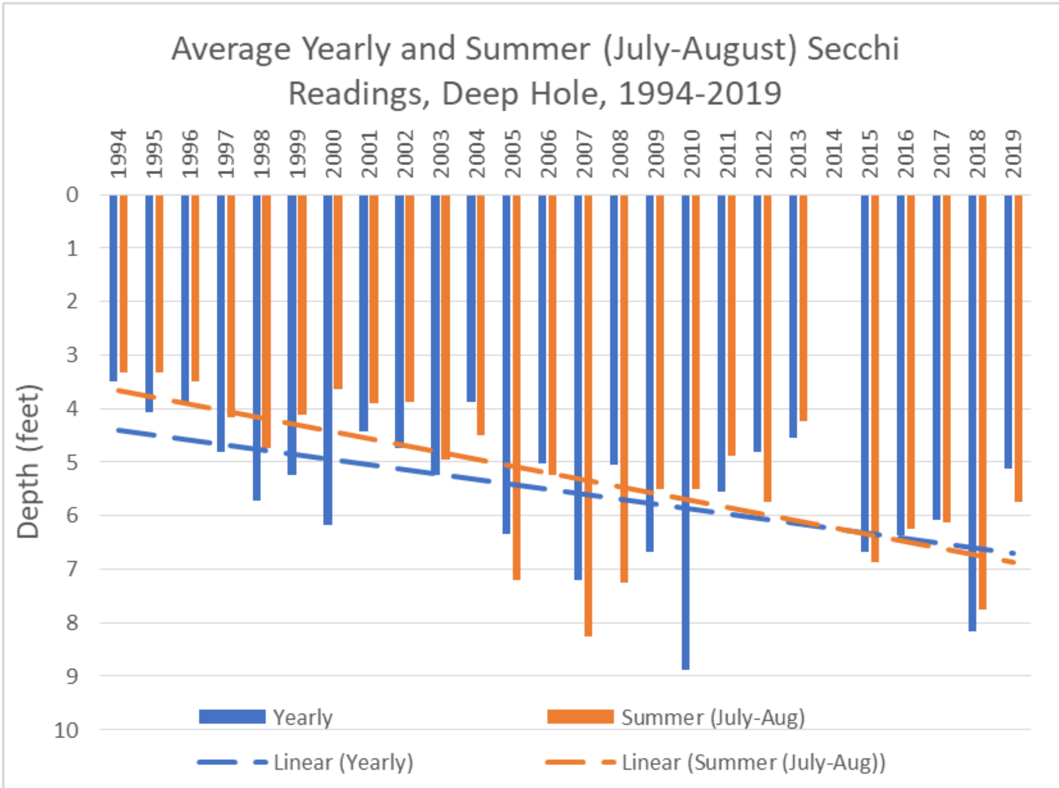


**Figure 24: Secchi disk readings of water clarity in Granite Lake from 1994-2019**

TP

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. When phosphorus is limiting production, small additions of the nutrient to a lake can cause dramatic increases in plant and algae growth.

Near-surface TP concentrations measured throughout the open water season have ranged from 16 to as much as 72-µg/l (Figure 25). The mean summer (July and August) concentrations ranged from a low of 20.8-ug/l in 2018 to a high of 34.7-µg/l in 2008 which is pretty close to the mean reported for northwest Wisconsin lakes (28.0 µg/L) by Lillie and Mason (1983). Monthly concentrations are high in the spring and again in the fall likely due to spring and fall turnover (Figure 26). The acceptable phosphorus concentration based on Wisconsin phosphorus standards for a stratified, drainage lake greater than 5 acres is 30-ug/l (WDNR, 2020). In Figure 25, the purple dashed line represents what is considered the state standard for TP in Granite Lake. In only five of the last 17 years has the summer mean exceeded the state standard.

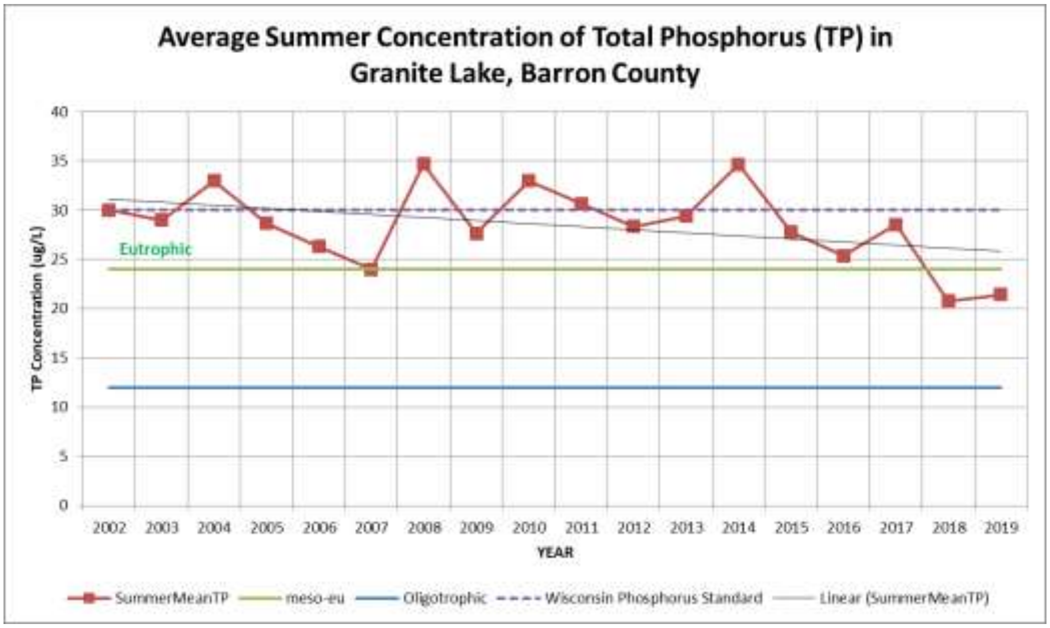



**Figure 25: Average summer surface concentration of TP in Granite Lake based on CLMN data**

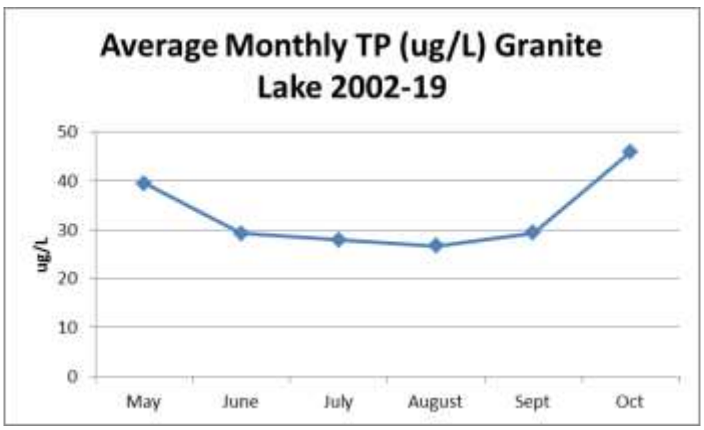



**Figure 26: Average monthly TP concentration (2002-2019 CLMN)**

BOTTOM PHOSPHORUS AND IRON

During the years of 2002-2004, CLMN volunteers also collected water samples from near the bottom of the lake for TP analysis. A Van Dorn water sampler was lowered to a depth of 1-2 feet off the bottom of the lake and a water sample collected. In 2005, the collection of bottom water samples was discontinued by the CLMN program. During this project, bottom samples were again collected in 2018 and analyzed for TP and iron.

When phosphorus enters a lake, from whatever source, some of it settles out of the water column to the bottom of the lake. Over time, large amount of phosphorus can build up in the bottom of the lake. In the presence of oxygen, that phosphorus will bind with iron in the bottom sediments and become trapped in the bottom waters (hypolimnion). When a deeper lake like Granite Lake stratifies during the summer season, with warm, oxygen-rich water at the surface, colder water with limited oxygen at the bottom, and a thermocline that establishes between the two layers, the oxygen in the waters at the bottom of the lake is used up by decomposition of bottom detritus. Because the thermocline prevents mixing of the two layers of water, it also prevents any new oxygen from recharging the waters below the thermocline. Eventually the oxygen is completely used up beginning at the sediment-water interface at the bottom and working its way up in the water column to the thermocline.

Once the oxygen has been depleted, a reaction occurs which breaks the bond between iron and phosphorus which then releases phosphorus back into the water column. If this extra "pulse" of phosphorus somehow gets mixed or entrained in the surface waters (like during a polymictic mixing event) it becomes available to support the accelerated growth of excessive algae – an algae bloom. This process called internal loading of phosphorus and can negatively impact a lake long after external inputs of phosphors are cut off.

One of the keys is iron. If there is enough iron present in the bottom waters much of the phosphorus in the bottom waters can be recaptured or bound by iron and held in the sediments when oxygen levels are recharged during turnover. Research suggests that iron to phosphorus ratios of 8:1 or greater are needed to enable phosphorus retention in oxidized sediment at the bottom of the lake (Hansen, Reitzel, Jensen, & Anderson, 2003). The average summer phosphorus in the bottom of the lake during those four years data was collected was 486-ug/l. Although iron measurements were only taken in 2018, the iron to phosphorus ratio at the bottom of the lake was 24:1 in June, 6:1 in July and 34:1 in August. Bottom phosphorus was measured in October only once in 2004, but was very low at only 145-ug/L.

CHLOROPHYLL A

Chl-A is a measurement of algae in the water and has been measured in Granite Lake since 2002. The concentration varies throughout the year, generally peaking in late summer (Figure 27). The overall mean summer (June through August) Chl-A concentration from 2002 through 2019 was 16.1-µg/l (Figure 28). Aside from a couple of higher concentrations in 2013 and 2014, the trend for the last 10-yrs has been decreasing.

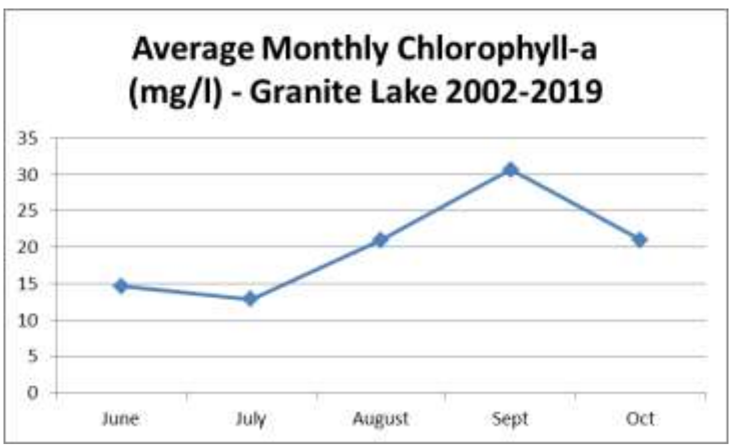



**Figure 27: Average monthly Chl-A concentration (2002-2019 CLMN)**

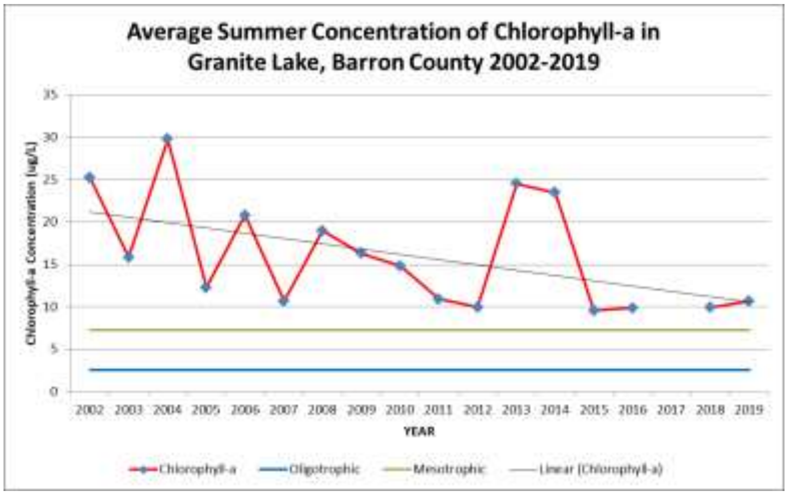



**Figure 28: Average summer concentration of Chl-A 2002-2019**

PRECIPITATION

Two volunteers collected and reported rainfall data starting in 2018 via the Community Collaborative Rain, Hail, and Snow program. Volunteers collect rainfall daily and record it online via [www.cocorahs.com](www.cocorahs.com). There are two sites on Granite Lake – one on the north end (WI-BR-26) and one on the south end (WI-BR-30). Rainfall data was recorded on the north beginning in June 2018 and continues through the current date. Rainfall data was recorded on the south end beginning in April 2019 and continues through the current date. Total rainfall recorded at the two sites through Sept 12, 2020 is shown in Table 12. Only the 2019 data shows a complete record of annual precipitation with both sites recording over 40" of rainfall.

CoCoRaHS records rainfall by water years beginning in October and going through September of the following year. A total of 363 days in the 2018-19 water year were covered at the north site with 38.32 inches of rain and snowfall reported (Figures 29 & 30). A total of 171 days were covered at the south site over the same period of time with a total of 31.55 inches of rainfall (Figures 31 & 32).

**Table 12: 2018-2020 Total rainfall recorded by volunteers on the north and south ends of Granite Lake (CoCoRaHS)**

| CoCoRaHS Reports | Northside WI-BR-26 | | | Southside WI-BR-30 | | |
|---|---|---|---|---|---|---|
| Year | Start Date | End Date | Total Rainfall (inches) | Start Date | End Date | Total Rainfall (inches) |
| 2018 | 6/1/2018 | 12/31/2018 | 26.3 | NA | NA | NA |
| 2019 | 1/1/2019 | 12/31/2019 | 44.02 | 4/1/2019 | 12/31/2019 | 41.84 |
| 2020 | 1/1/2020 | 9/12/2020 | 23.63 | 1/1/2020 | 9/12/2020 | 23.28 |

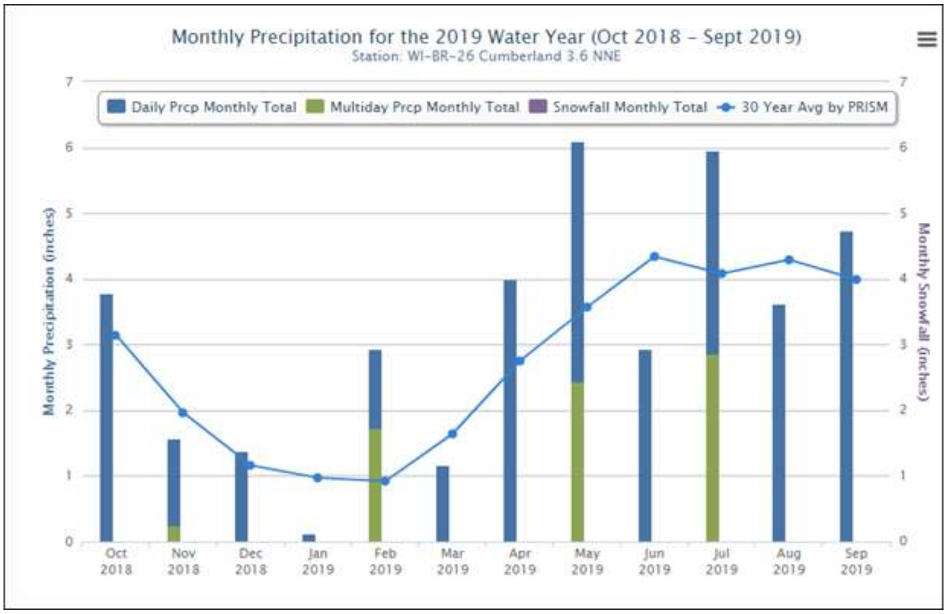



**Figure 29: Monthly precipitation for the 2018-19 water year - Site WI-BR-26 - Northside**

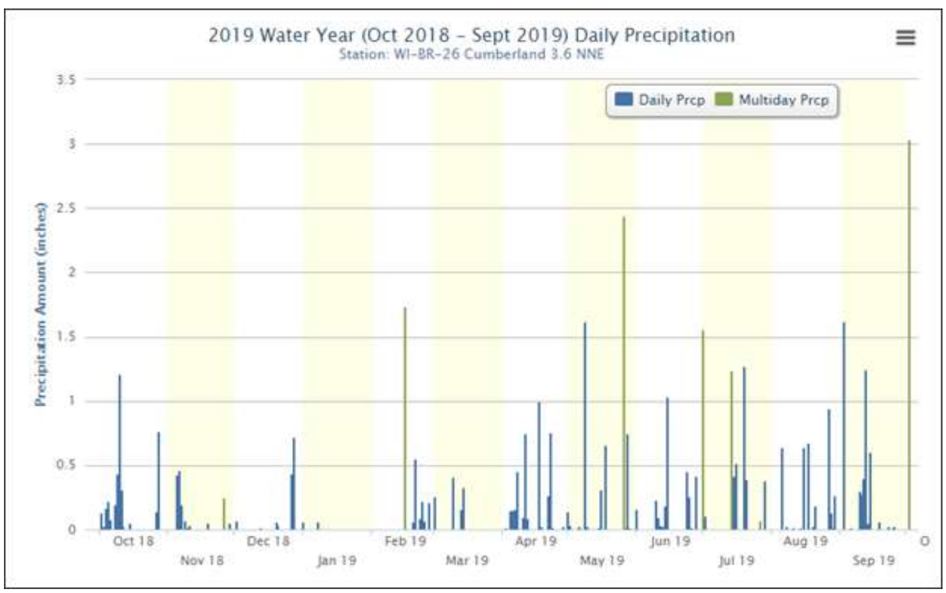



**Figure 30: Daily precipitation for the 2018-19 water year - Site WI-BR-26 – Northside**

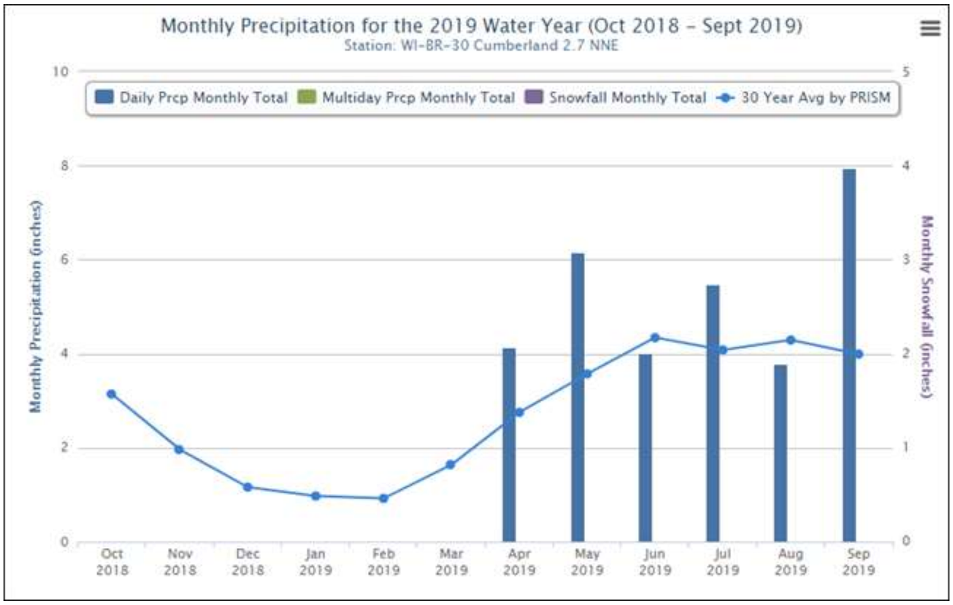



**Figure 31: Monthly precipitation for the 2018-19 water year - Site WI-BR-30 - Southside**

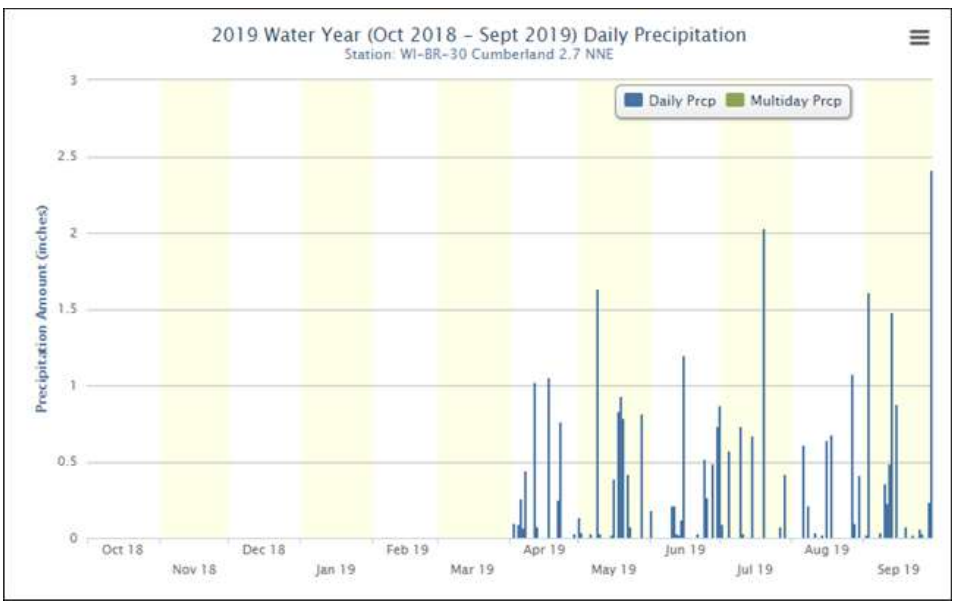



**Figure 32: Daily precipitation for the 2018-19 water year - Site WI-BR-30 – Southside**

## WATER BUDGET

Inflow and outflow data collected in 2018 was used to determine a water budget for the lake in 2018 (Figure 33). Monitoring results in 2018 indicated that nearly 2 x as much water was leaving the lake via the outlet, than was entering through the main inlet on the north end of the lake and via surface runoff from rainfall during the same time frame. There are two other sources of water input that could account for this difference: 1) water running off of the area of the watershed not drained by the main inlet which was unmonitored in this study, and 2) from groundwater entering the lake.

The base flow of the monitored tributary (only perennial inlet) was used to establish a runoff value for the non-monitored watershed. This created a substantial shortage of water input in the water mass balance model.

Groundwater inflow was added to accommodate this discrepancy. There is limited groundwater data for Barron County, but the maps that are available indicate groundwater is likely flowing into Granite Lake and outflowing via the outlet tributary from Granite Lake (and not outflowing as groundwater and therefore a discharge).

Based on these results, the residence time, or the amount of time it takes a water molecule entering the lake to leave the lake, is estimated to be about 186 days. The longer water entering the lake stays in the lake, the more nutrients, sediment, and other pollutants there will be that drop out of that water and stay in the lake. Stream sampling in 2008 and again in 2018 both show that more TP is entering the lake than is leaving it over the same time period.

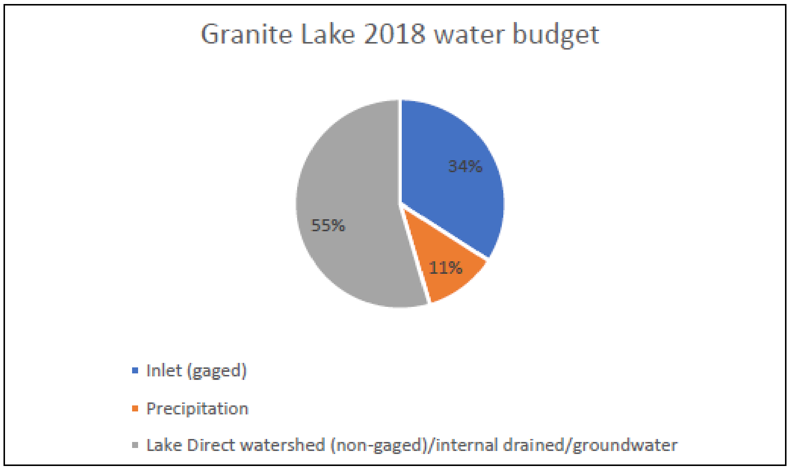



**Figure 33: 2018 Granite Lake water budget (EIS, 2019)**

## NUTRIENT BUDGET

This nutrient budget model utilized Bathtub reservoir model created by the US Army Corp of Engineers. It is a steady-state, mass balance empirical model. The focus for nutrient budget was phosphorus, which likely limits algae production in Granite Lake. This model is based on very limited data, so calibration is difficult and some assumptions were made to make the nutrients and water balance over the averaging period (0.58 years) of the growing season.

The modeling of Granite Lake utilized the nutrient data from the inlet and outlet monitoring in 2018, as well as the in-lake nutrient concentrations. The monitored inlet water budget and nutrients were used to calibrate the un-monitored watershed. Base flow and runoff flow in the unmonitored watershed was estimated from inlet monitored flow as well. Results suggested that the concentration of the phosphorus in the inlet was much higher than the concentration of the inflow of water from the non-monitored watershed. The land use is different in the monitored watershed which could account for some of the difference, as well as nutrients in groundwater/internally drained water, or release of nutrients from wetland flushing.

### EXTERNAL LOADING OF PHOSPHORUS

The monitored portion of the watershed is approximately 64% of the entire watershed draining to Granite Lake. The unmonitored watershed covers approximately 36% of the watershed. Agriculture land in the monitored watershed is about 29% of its total acreage. Forest land is about 58%. In the unmonitored watershed agriculture land is about 15% while forest land is about 61% so it makes sense that it would contribute less to the overall water and nutrient budgets.

No phosphorus data is available for groundwater entering Granite Lake, so the phosphorus concentration used in the model was determined by the mass balance. Also, as already suggested, there is likely groundwater that is a significant portion of the flow for the inlet. The phosphorus concentration in the groundwater potentially entering this inlet is not known and therefore the contribution of phosphorus via groundwater is unknown. However, this phosphorus is accounted for in the monitoring data from the inlet.

The land use information is from NLCD, 2006. This land use is not very specific and is obviously several years old. Also, the land use was not precise for the near-lake watershed as the land use graphic indicates most development in the riparian zone as forested. To improve upon this, aerial photographs from 2015 were used to digitize the residential land use immediate to the lake and integrated into the model. The septic phosphorus loading was determined using capita year data (600 capita years) generated by a LEAPS in survey sent to all property owners. A load of 0.3kg per capita year and 90% soil retention were also used in the calculation.

Since the trophic state of northern lakes pertains mainly to the growing season (May to Sept), the data collected was only during this season and the modeling was conducted for an averaging period of 0.58 years (7 months), since this was the time period that the inlet and outlet were monitored.

The phosphorus calculation used Canfield/Bachman natural lakes to create a steady-state, mass balanced nutrient budget. The water budget was mass balanced using inlet monitoring data and outlet monitoring data. Evaporation rates were estimated using published monthly evaporation rates from NLCD. Precipitation data was utilized from the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) website, from a station near Cumberland, WI. All data was entered into the empirical model Bathtub, and calibrated to predict nutrient budget for 2018 (Table 13).

The model was then implemented for the 2019 lake and precipitation data to determine TP load in 2019 for comparison purposes and to reflect the function of the model (Table 14). The modeling used matches the in-lake data from both years and should be an accurate measure of the TP load in to Granite Lake.

**Table 13: Model calibration results – 2018 (EIS, 2019)**

| Parameter | Observed from lake data | Predicted from model | Difference |
|---|---|---|---|
| Total P (ug/L) | 23.5 | 24 | 0.5 |
| Chlorophyll-a | 8.2 | 8.0 | 0.2 |
| Secchi depth | 2.46 | 2.5 | 0.04 |

**Table 14: Model calibration results – 2019 (EIS, 2019)**

| Parameter | Observed from lake data | Predicted from model |
|---|---|---|
| Total P (ug/L) | 29.7 | 30 |
| Chlorophyll-a | 13.2 | 12 |
| Secchi depth | 1.55 | 1.6 |

## INTERNAL LOADING

Internal phosphorus loading is a term used to describe phosphorus movement and recycling between sediment in a lake and the water column (James, 2016). Phosphorus usually limits the growth of algae in freshwater systems and its enhanced availability via anthropogenic watershed runoff (i.e., external phosphorus loading) and internal phosphorus loading processes often leads to eutrophication and deterioration of ecosystem health such as frequent cyanobacterial blooms, dissolved oxygen depletion, poor water clarity, impaired fisheries, and declines in submersed aquatic plant communities that offer critical habitat for invertebrates and other biota. Since sediment phosphorus is ultimately derived from the watershed, land use practices that over-fertilize the soil and promote surface water runoff can result in considerable deposition over decades and centuries of phosphorus-rich sediment in lake basins. Lakes are essentially traps for sediment and thus reflect the activities in its watershed. Internal phosphorus loading is, in essence, in-lake recycling of phosphorus that was derived from the watershed (James, 2016).

There are many mechanisms of internal phosphorus loading that can result in the movement of soluble phosphorus (i.e., the form of phosphorus that is readily assimilated by algae for growth) from sediment to the overlying water. It can diffuse from the sediment pore water (i.e., interstitial water that surrounds sediment particles) directly into the water column. Rooted aquatic plants translocate phosphorus from the sediment into plant tissue during their growth phase, then release soluble phosphorus back into the surrounding water when they die. Aquatic invertebrates and other creatures inhabiting the sediment can cause internal phosphorus loading to the water by burrowing activities that mix sediment soluble phosphorus into the water. Benthic-feeding fish like carp cause sediment disturbance and internal phosphorus loading on a larger scale. Finally, groundwater movement through phosphorus-rich sediments and wave-induced resuspension of sediment can result in the transfer of soluble phosphorus from sediment to the water column for uptake by algae. Phosphorus recycled to algae by any of these processes can become deposited back to the sediment in the form of algal remains or in fecal pellets from zooplankton or fish after being consumed (James, 2016).

### INTERNAL LOADING IN GRANITE LAKE

Granite Lake does appear to have internal loading going on based upon the large spike in lake phosphorus concentration in October (Figure 26). Recent but limited temperature and DO profiling indicates that Granite Lake stratifies early and remains strongly stratified through the summer and into the fall (Figure 23). There is likely a significant accumulation of phosphorus in the hypolimnion June-August, which could be a significant load if/when the lake mixes. If a lake is strongly stratified, the potential for passage of that phosphorus into the epilimnion (upper layer) where algae can grow may be limited. If stratification isn't strong, or the metalimnion (middle or transition layer) is closer to the surface, the phosphorus in the hypolimnion can mix into the upper layer and result in algae production. Limited temperature and DO profiling back in the mid-2000s shows that stratification wasn't as strong, and the lake was subject to mixing events even during the summer season. During this same time frame, water quality was worse with multiple bluegreen algae blooms documented.

As mentioned, in-lake phosphorus spikes were documented in October suggesting internal loading. However, with limited temperature and DO profiling data collected during the growing season on Granite Lake, it is not possible to determine if enough mixing took place prior to October to cause a flux of phosphorus into the epilimnion. However, the phosphorus spikes observed in 2018 and 2019 during October would have required some level of additional phosphorus input which had to come from somewhere – internal loading makes sense.

Not all of this increase in phosphorus may be due to internal loading alone. Precipitation events could also contribute, but it is unlikely that a runoff flux would be enough to account for the higher concentrations. Whatever the source, mixing events late in or at the end of the growing season are generally less concerning than events that happen during the growing season. Furthermore, the negative impact of end of season mixing events may be reduced by rebinding of iron and phosphorus with oxygen present in the hypolimnion.

Sampling showed a mean phosphorus concentration in water flowing out of the lake higher than the mean phosphorus concentration within the lake itself. This also indicates that some internal loading of phosphorus is occurring. However, the load of phosphorus entering the lake from external sources is still much higher than the load that is leaving showing that Granite Lake is retaining, by one estimate, around 35% of phosphorus that enters the lake each season.

## SOURCES OF PHOSPHORUS TO GRANITE LAKE

Although this modeling of Granite Lake is based on limited data, it is a starting point to anticipate changes in water quality caused by changes in land use and reductions in phosphorus loading. Figure 34 reflects the sources of phosphorus to Granite Lake and the estimated percentage of the total load they each represent. What is being carried in from the watershed and that which is being retained and recycled within the lake are the two biggest sources.

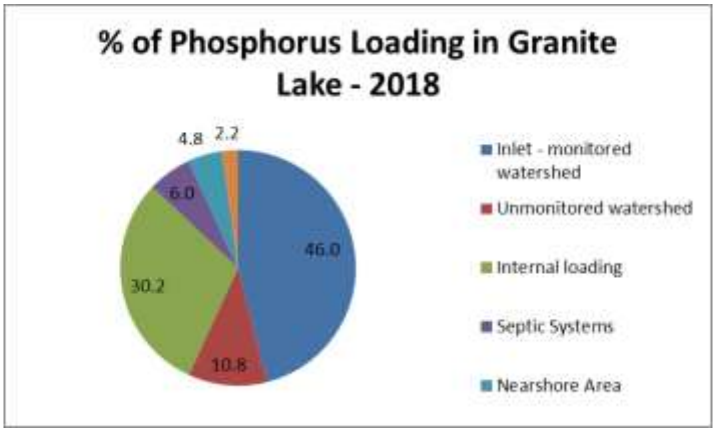



**Figure 34: Phosphorus budgeting for Granite Lake – based on 2018 data**

## FUTURE WATERSHED MONITORING

Often times modeling water and nutrient budgets in lakes with limited data can create more questions than answers. In the case of Granite Lake, this initial model suggests a need for further data to better understand the budgets for this lake. The following are suggestions for data collection if there is more interest in the sources of water and nutrients for Granite Lake.

### WATERSHED EVALUATION

The land use of Granite Lake should be updated with the use of Lidar data. Lidar used in conjunction with elevation data in GIS mapping would allow a better understanding of areas where water is flowing directly into Granite Lake and where it is not (infiltrated or into another surface water body). The intensity of runoff could also be evaluated in response to storm events. Furthermore, if the watershed is divided into sub-watersheds, the highest contributing land areas can be determined to focus on BMPs. Lastly, monitoring the inlet tributary further upstream (in addition to the mouth already monitored), could reflect the concentration of nutrients as the water enters the last catchment of Granite Lake. Outflow as well as lake depth (stage) changes would allow better determination of the inflow of water from watershed runoff, separated from groundwater/internally drained inflow of water.

### GROUNDWATER EVALUATION

Groundwater begins as precipitation. Some precipitation (rain or snow) runs off into lakes, streams, rivers and wetlands. Some evaporates back into the atmosphere. Plants take some up. Groundwater is that water that makes it past the plants down into the subsurface soil and rock (Wisconsin Groundwater Coordinating Council, 2002).

In Wisconsin, an average of 30-32 inches of precipitation falls each year. Six to ten inches of that precipitation seep into the ground to become groundwater recharge. The amount of recharge varies depending upon the topography, soil, vegetation and land use. Groundwater moves through openings between soil or rock particles or along fractures. A layer of rock or soil that is capable of storing, transmitting and yielding water to wells is called an aquifer. The water surface below which water fills all the openings in soil and rock is called the water table. Above the water table is the unsaturated zone and below it is the saturated zone.

Groundwater normally migrates from upland areas to lowland areas, eventually discharging in low places where the water table intersects the land surface in lakes, streams and wetlands. Most precipitation that recharges groundwater moves only a few miles from the point of recharge to the point of discharge. Wisconsin's groundwater doesn't come from Canada or Lake Superior, or flow in some mysterious underground stream.

Phosphorus loading is responsible for significant lake degradation with sometimes severe societal and economic impacts. Historically, the source of phosphorus is generally attributed to surface water runoff from agricultural fields, impervious surfaces, lawns, etc. However, ongoing investigations suggest that phosphorus sources and mobility through the hydrologic system is much more complex. Significant non-point sources of phosphorus may include both surface water runoff and naturally-occurring phosphorus in the bedrock that groundwater is flowing through. These investigations have demonstrated that phosphorus concentrations in groundwater can be exceedingly high (often exceeding the WI surface water regulatory limits of 30 ppb), and that phosphorus is highly mobile in the subsurface, and that these high groundwater P concentrations may contribute to lake eutrophication.

It appears groundwater is contributing a large amount of water into Granite Lake. This estimate is based on very little data, and should be scrutinized with more data. Furthermore, the nutrient concentration of the groundwater entering Granite Lake is unknown and a value was used to balance the model. If this concentration were known, then the loading of phosphorus attributed to groundwater could be determined. Although typically low, some areas in Wisconsin can have high phosphorus in groundwater. Internally drained portions of the watershed can contribute greatly to groundwater phosphorus. Groundwater samples can be collected from springs and/or shallow water wells that likely don't get affected by septic.

INTERNAL LOAD

The internal load in Granite Lake is predicted to occur but is based upon limited data. The internal load in Granite Lake could be significant in any given year. More frequent temperature and DO profiles would help evaluate the strength of stratification as well as any potential mixing events prior to fall overturn that can make phosphorus concentrations increase in the epilimnion, resulting in more algae and less water clarity. Alternatively a logging thermistor string with DO logger could be installed at the hypolimnion level to get daily data. If it is determined that the internal load could be significant and mitigation is reasonable, then sediment cores could be collected and studied to get a precise release rate from the sediments.

DATA COLLECTION TIME PERIOD

Modeling water budget and nutrient budget in lakes should be based on several years of data rather than a single year. The likelihood of one year being different than an "average" year is high. Therefore, error or misrepresentation of the lake dynamics can be very high. At least two years of data should be collected; preferably 3-4 years would provide more accuracy in the model estimates. In the case of Granite Lake, 2018 had significantly different in-lake data than in 2019. More flow data in 2019 would have provided valuable information in the changes that were documented.

## PHOSPHORUS LOADING REDUCTIONS

Using the Bathtub model calibrated for Granite Lake data, it is possible to see improvements in water quality based on reductions in TP loading. Table 15 suggests that even just a 10% reduction in TP entering the lake will improve water quality and clarity conditions, or perhaps more importantly, prevent water quality conditions from getting worse. BMP that could be implemented to reduce watershed loading of phosphorus will be discussed in another section of this plan.

**Table 15: How changes in phosphorus loading to Granite Lake may improve water quality (Schieffer, 2019)**

| Phosphorus overall reduction (from model) | Change in chlorophyll conc. | Change in Secchi depth |
|---|---|---|
| 10% | -2 ug/L | +0.2 meters |
| 20% | -3 ug/L | +0.3 meters |
| 40% | -6 ug/L | +0.6 meters |

## AQUATIC PLANTS

Like trees in a forest, a lake's native plants are the basis of the aquatic ecosystem. They capture the sun's energy and turn it into usable food, "clean" the water of excess nutrients, and provide habitat for other organisms like aquatic invertebrates and the lake's fish populations. Because of this, preserving them is critical to maintaining the lake's overall health. Unfortunately, when phosphorus and nitrogen levels exceed what the lake's macrophytes can utilize, it tends to promote algae blooms which impact these sensitive species as well as general lake aesthetics.

### AQUATIC PLANT SURVEY WORK

In 2009, the Granite Lake Association and the WDNR authorized a series of whole-lake plant surveys to determine whether or not Granite Lake was a candidate for aquatic plant management. During those surveys, the exotic invasive species Curly-leaf pondweed (CLP) was identified in scattered locations throughout the lake's spring littoral zone. Despite this, it was decided that the low growth levels of CLP in the lake did not justify active management.

About 8 years later, following several years of high filamentous algae levels on the lake, the GLA decided to revisit some form of active management. Per WDNR expectations, plant surveys are normally repeated every five to seven years to remain current. Because of this, the GLA was informed they needed to have the lake resurveyed so they could revisit management planning.

In anticipation of creating a plan in 2019, three lakewide aquatic plant surveys on Granite Lake were completed in 2018. On June 4$^{th}$, an early-season CLP point-intercept survey was conducted. This was followed by a CLP bed mapping survey on June 12$^{th}$, and a warm-water point-intercept survey of all aquatic plants on July 31$^{st}$. The study objectives were to document the current levels of CLP; determine if Eurasian water-milfoil (EWM) or any other new exotic plants had invaded the lake; and to compare data from the original 2009 surveys with the 2018 data to identify any significant changes in the lake's vegetation over this time.

The data reported on in this section of the Comp Plan is taken from the final aquatic plant survey report completed by ERS in 2019 (Berg M. , 2019).

#### ***Curly-leaf Pondweed Point-intercept Survey***

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, and total acreage, the original 505 point sampling grid for Granite Lake was generated in 2009. Using this same grid in 2018, a CLP density survey was completed where CLP was sampled at each littoral point in the lake.

During this survey, every point in the lake <13-ft was rake-sampled. In 2018, no CLP was found at any point; however a single plant along the western shoreline was discovered and rake-removed during the survey. These results were similar to what was found in 2009 when CLP was only found at one point in the entire lake. The low number of plants found do not allow for statistical comparison.

### ***Curly-leaf Pondweed Bed Mapping Survey***

Bed mapping involves a meandering visual search of the lake's entire littoral or plant-growing zone for CLP. In 2018, this survey was completed on June 12th. More than four miles of meandering survey work only found 16 CLP plants in the entire lake. All of these plants were rake-removed by the surveyor. The plants were located along the eastern shoreline of the south bay (Figure 35). Based on the density of these plants, no negative impacts to native vegetation and no concern for navigation impairment were noted by the surveyor.

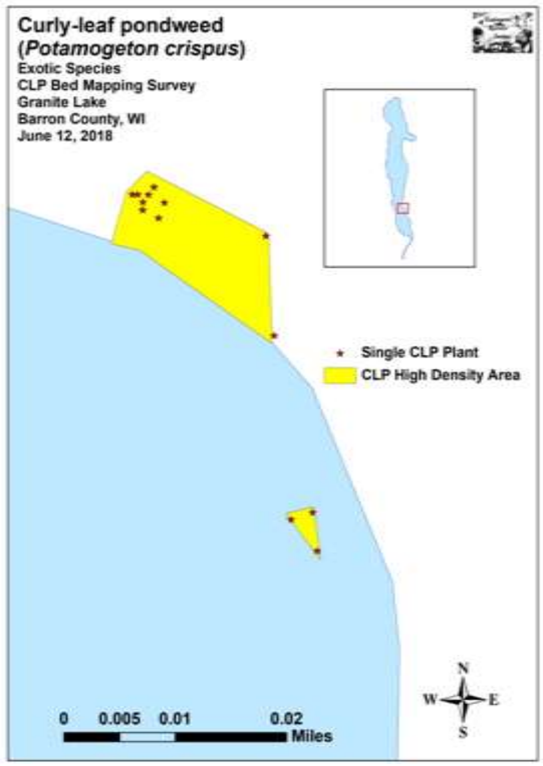



**Figure 35: 2018 CLP bed mapping results** *(Berg M. , 2019)*

### ***Warm-water Full Point-intercept Aquatic Plant Survey***

A warm-water point-intercept survey is completed in late July or early August and involved rake sampling all points within the designated littoral zone of the lake. Each of the 505 survey points in the lake determined in 2009 is located with a GPS, a depth reading is recorded, and a rake sample of all vegetation is taken. All plants on the rake, as well as any that were dislodged by the rake, are identified and assigned a rake fullness value of 1-3 as an estimation of abundance. Visual sightings of all plants within six feet of the sample point not found in the rake are also recorded. In addition to a rake rating for each species, a total rake fullness value is also noted. Substrate (bottom) type is assigned at each site where the bottom is visible or could be reliably determined using the rake.

Out of the 505 points surveyed, only 262 were shallow enough to take a rake sample. In July 2018, only 61 points had aquatic plants. The maximum depth of plant growth was 10-ft. The 61 points is identical to the number of points found with plants in 2009, although the maximum depth of aquatic plant growth was 13-ft. Even though the maximum depth of aquatic plant growth in 2018 was less than in 2009, it was skewed to deeper water than in 2009 (Figure 36).

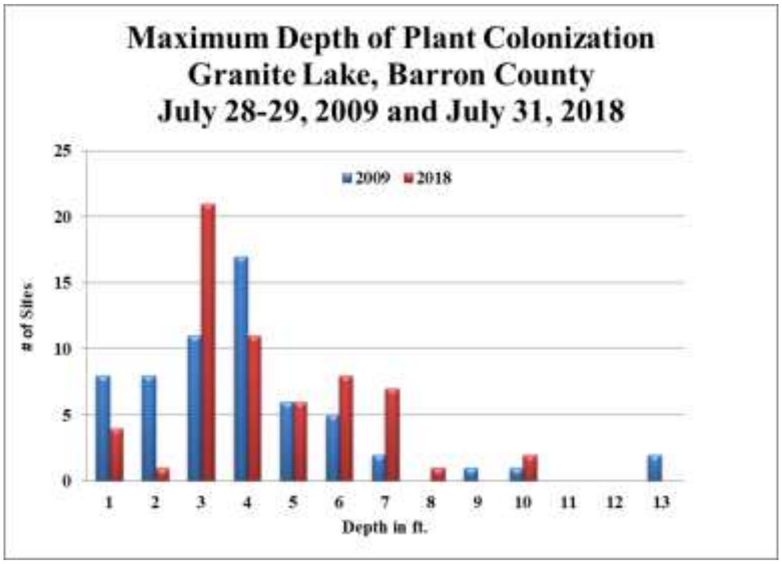



**Figure 36: 2009 and 2018 plant colonization depth chart (Berg, 2019)**

Table 16 reflects the changes in survey statistics from 2009 to 2018. Some results suggest the aquatic plant community is heathier in 2018 than in was in 2009 including the Simpson's Diversity Index, average number of plant species per sampling site, and species richness when including visuals. The most significant change was the maximum depth at which aquatic plant growth was documented. In 2009 it was 13-ft, in 2018 it was down 3-ft to 10-ft. This change in maximum depth of plant growth does not seem to be a function of water clarity since the average summer Secchi disk reading of water clarity in 2018 was >2-ft deeper than it was in 2009. Both years' averages were based on only one reading in July and one reading in August so should only be a viewed as an observation, not the definitive reason for the change.

**Table 16: Aquatic plant PI survey summary statistics July 28-29, 2009 and July 31, 2018 (Berg, 2019)**

| Summary Statistics: | 2009 | 2018 |
|---|---|---|
| Total number of points sampled | 505 | 505 |
| Total number of sites with vegetation | 61 | 61 |
| Total number of sites shallower than the maximum depth of plants | 179 | 114 |
| Frequency of occurrence at sites shallower than maximum depth of plants | 34.1 | 53.5 |
| Simpson Diversity Index | 0.88 | 0.89 |
| Maximum depth of plants (ft) | 13.0 | 10.0 |
| Mean depth of plants (ft) | 3.8 | 4.2 |
| Median depth of plants (ft) | 3.5 | 4.0 |
| Average number of all species per site (shallower than max depth) | 0.71 | 1.27 |
| Average number of all species per site (veg. sites only) | 2.08 | 2.38 |
| Average number of native species per site (shallower than max depth) | 0.69 | 1.27 |
| Average number of native species per site (sites with native veg. only) | 2.03 | 2.38 |
| Species richness | 24 | 22 |
| Species richness (including visuals) | 25 | 28 |
| Species richness (including visuals and boat survey) | 34 | 38 |
| Mean rake fullness (veg. sites only) | Est. 2.02 | 1.69 |

*Comparison of Native Macrophyte Species in 2009 and 2018*

Slender naiad and coontail were the two most common species in both the 2009 and 2018 survey (Figure 37). Slender naiad did not have any statistically significant changes in distribution or density from 2009 to 2018. Coontail did not experience a statistically significant change in distribution; however its density had significantly declined in 2018 from where it was in 2009.

**Figure 37: Slender naiad (left) and coontail (right) (Berg, 2019)**

In 2009 only six species had a relative frequency in the lake >4%. In 2018, 10 species had a relative frequency in the lake >4%. Relative frequency refers to a species' frequency in the lake relative all other species. It is expressed as a percentage, and the total of all species' relative frequency will add up to 100%. Organizing species from highest to lowest relative frequency value gives an idea of which species are most important within the aquatic plant community.

Two species showed statistically significant changes lake wide from 2009 to 2018 – small duckweed and Vasey's pondweed. Interestingly, small duckweed is considered a low grade aquatic plant that does well in degraded water quality conditions. Vasey's pondweed is considered a high grade aquatic plant more frequently found in lakes with minimal human-caused disturbances. Figure 38 shows the differences for all species between 2009 and 2018.

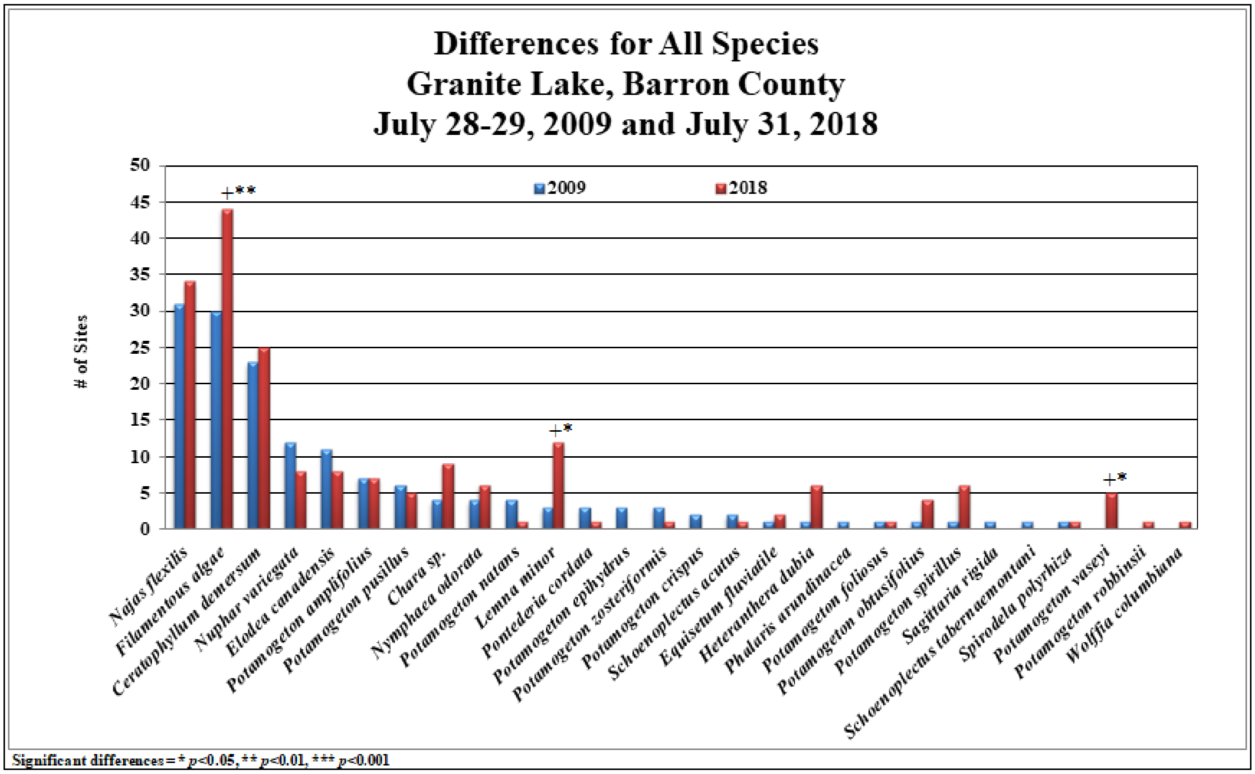



**Figure 38: Aquatic plant changes from 2009 to 2018 (Berg, 2019)**

Another measure of the overall health of the aquatic plant community is the Floristic Quality Index or FQI. The FQI measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Granite Lake is in the North Central Hardwood Forests Ecoregion.

In 2009, a total of 22 native index species were identified in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 6.1 and a Floristic Quality Index of 28.8. In 2018, again 22 native index plants were found in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 6.3 and a Floristic Quality Index of 29.4. Nichols (1999) reported an average mean C for the North Central Hardwood Forests Region of 5.6 putting Granite Lake well above average for this part of the state in both surveys. The FQI in both years was also significantly above the median FQI of 20.9 for the North Central Hardwood Forests (Nichols, 1999).

These numbers along with the other data suggests that the aquatic plant community in Granite Lake was healthier in 2018 than it was in 2009. The distribution of aquatic plants was fairly similar to 2009, but density was down, and diversity was up – all good indicators.

Despite this, there was one negative aspect to the 2018 plant survey when compared to the 2009 survey. Filamentous algae experienced a moderately significant increase in 2018 when compared to 2009. Filamentous algae, normally associated with excessive nutrients in the water column, were common to abundant throughout the lake during each survey (Figure 39). In 2009, it was found at 30 points with a mean rake fullness of 1.93. During the 2018 survey, it was found at 44 points but did experience a moderately significant decline in mean rake fullness to 1.36. The presence of filamentous algae which typically forms a mat of bubbly looking "gook" is one of the changes noticed most by lake users (Figure 40).

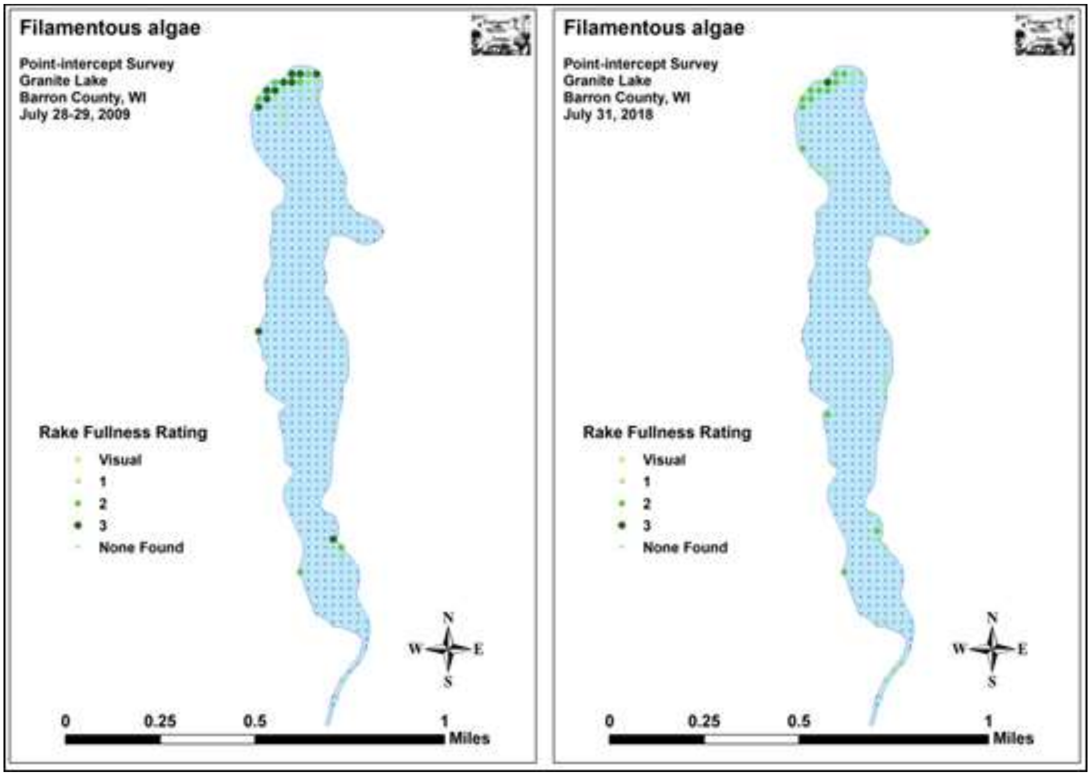



**Figure 39: 2009 and 2018 filamentous algae density and distribution (Berg, 2019)**

**Figure 40: Filamentous algae in Granite Lake**

### *Other Exotic Plant Species*

No evidence of EWM was found in Granite Lake during any of the 2009 or 2018 surveys. However, in addition to CLP, two other exotic species were documented growing around the lake: common forget-me-not and purple loosestrife.

Common forget-me-not was present at a single point just south of the public boat landing on the western shoreline. Although plants were only identified at this one point, there were perhaps a hundred plants on either side of a dock in an area that appeared to have a seep entering the lake (Figure 41).

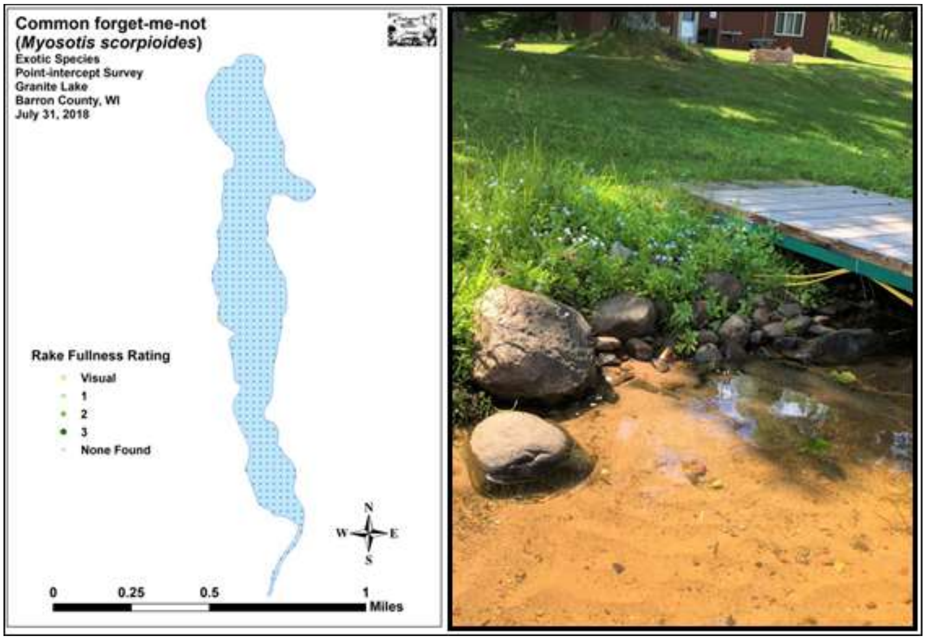



**Figure 41: Common Forget-me-not Distribution/Population on Western Shoreline (Berg, 2019)**

During the 2018 survey, a single cluster of purple loosestrife plants along the eastern shoreline of the southern bay was found and removed (Figure 42). This was similar to 2009 when scattered purple loosestrife plants were also found and removed in this general vicinity. Another single plant was found on the west shoreline in 2020. While not yet considered a problem, continued monitoring and removal of any purple loosestrife found should be continued.

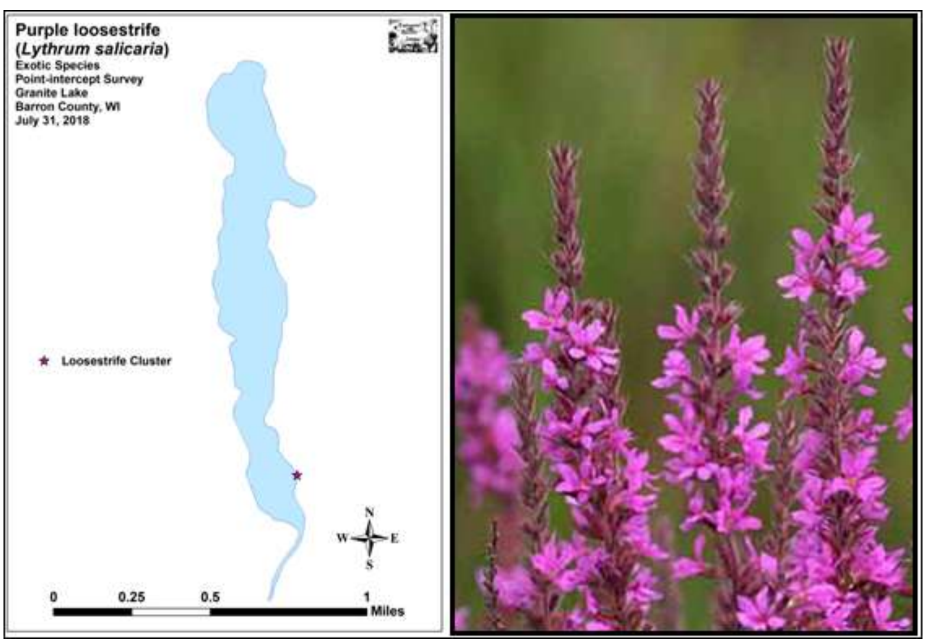



**Figure 42: Purple loosestrife distribution and inflorescence**

## FISHERIES

Granite Lake has a diverse, healthy fishery consisting of walleye, largemouth bass, northern pike, bluegill, black crappie, yellow perch, white sucker, and common carp. A 1975 fish survey of Granite Lake found a naturally reproducing walleye population, a stable northern pike population and a low density largemouth bass population. A 1983 survey indicated a decline in the walleye population and an increase in bass abundance. In an effort to bolster the walleye population, walleye stocking in Granite Lake was initiated in 1984. Walleye stocking from 1984-2004 consisted of small fingerling (< 3 in) stocking except for 1989 and 2000 when large fingerlings (> 5 in) were stocked.

A full fisheries study was completed during the 2004-05 fishing season that had the following fisheries management recommendations.

- Adult walleye densities should be maintained between at 3.5-4.5 fish/acre. Walleye stocking should continue at 35 fish per acre on an alternate year basis until the next survey and be re-evaluated to determine if additional stocking is warranted if natural reproduction remains strong.
- Largemouth bass densities should remain at 1-2 fish/acre. If largemouth bass densities increase above 2 fish per acre in the future, regulation changes should be considered to increase harvest opportunities in an effort to maintain a low density bass population and minimize any potential secondary impacts on the walleye population.
- The northern pike and panfish populations appear healthy. No changes are recommended. Future monitoring of northern pike and panfish should occur to document any trends that may be present in northern pike abundance and size structure.

It is not known whether a "next" fisheries survey was conducted between 2005 and 2019 that evaluated these recommendations.

### 2019-20 CREEL SURVEY

During the 2019 fishing season, the WDNR conducted a season-long angler creel survey, fyke netting survey, and a boom shocker survey to assess the adult walleye, northern pike, largemouth bass, black crappie, and other fish populations in Granite Lake and to assess fishing pressure on Granite Lake. Results from the 2019-20 creel survey do not go into the detail found in the 2004-05 report and are not meant to be a comparison of what was found then.

A creel survey is a sampling tool used to measure the fishing activities of the sport anglers and to estimate the amount of fish harvested on a body of water. Creel surveys are designed to have a creel clerk on a lake, work random shifts, and forty hours each week throughout the fishing season. Summer creel surveys begin with the fishing opener and run through the end of October, and then are started up again during the winter season from December to the close of the game fishing season on March 1. Each month these shifts cover a sample of all the daylight hours. Creel clerks travel their lakes using a boat, snowmobile or vehicle to count and to interview anglers.

A creel survey report provides four types of estimated information for the body of water:

- Overall fishing pressure
- Fishing effort directed at each species
- Catch and harvest rates
- Numbers of fish caught and harvested.

Figure 43 shows which fish species were most targeted by anglers on Granite Lake during the 2019-20 fishing season. Granite Lake is known as a walleye lake and creel survey results support this notion.

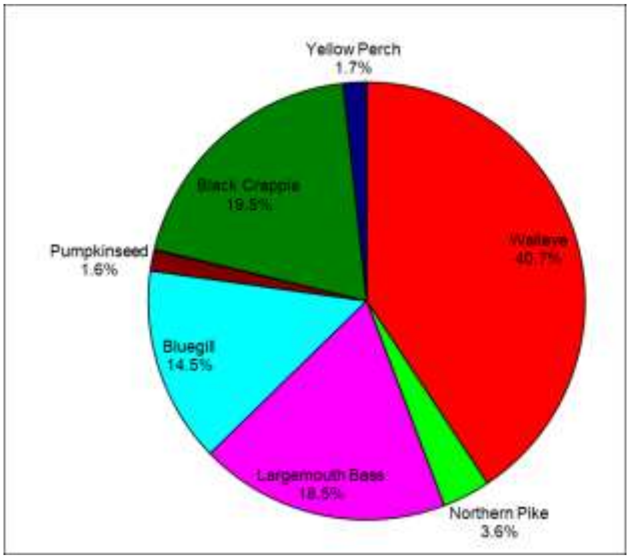



**Figure 43: Total annual angler directed effort by species in Granite Lake 2019-20** *(WDNR, 2019-20)*

Creel surveys collect species catch and harvest information, fishing effort by anglers for different fish species, how much time is spent fishing in general, how long it takes an angler to catch a fish (fishing hours), and length of harvested fish measurements. Table 17 shows the estimated angler fishing effort on Granite Lake for each month surveyed and by season (summer and winter).

**Table 17: Seasonal angler effort summary 2019-20** *(WDNR, 2019-20)*

| Month | Number of Angler Party Interviews | Total Angler Hours | Total Angler Hours/Acre | Barron County Average Hours/Acre | Ceded Territory Average Hours/Acre |
|---|---|---|---|---|---|
| May | 18 | 845 | 5.5 | 5.7 | 5.1 |
| June | 12 | 848 | 5.5 | 8.2 | 6.4 |
| July | 9 | 575 | 3.7 | 7.9 | 6.9 |
| August | 8 | 460 | 3.0 | 5.6 | 5.4 |
| September | 5 | 196 | 1.3 | 3.5 | 3.3 |
| October | 1 | 7 | 0.0 | 0.8 | 1.5 |
| December | 5 | 186 | 1.2 | 1.7 | 1.1 |
| January | 6 | 251 | 1.6 | 2.8 | 1.6 |
| February | 10 | 380 | 2.5 | 2.8 | 1.5 |
| March | 0 | 12 | 0.1 | 0.3 | 0.2 |
| *Summer Total | 53 | 2931 | 19.0 | 31.7 | 28.6 |
| *Winter Total | 21 | 827 | 5.4 | 7.5 | 4.4 |
| Grand Total | 74 | 3759 | 24.4 | 39.2 | 33.0 |

Figure 44 shows the average length and largest fish caught/kept (harvested) for the main fish species targeted by anglers on Granite Lake in the 2019-20 season. Table 18 shows creel survey totals for the 2019-20 fishing season.

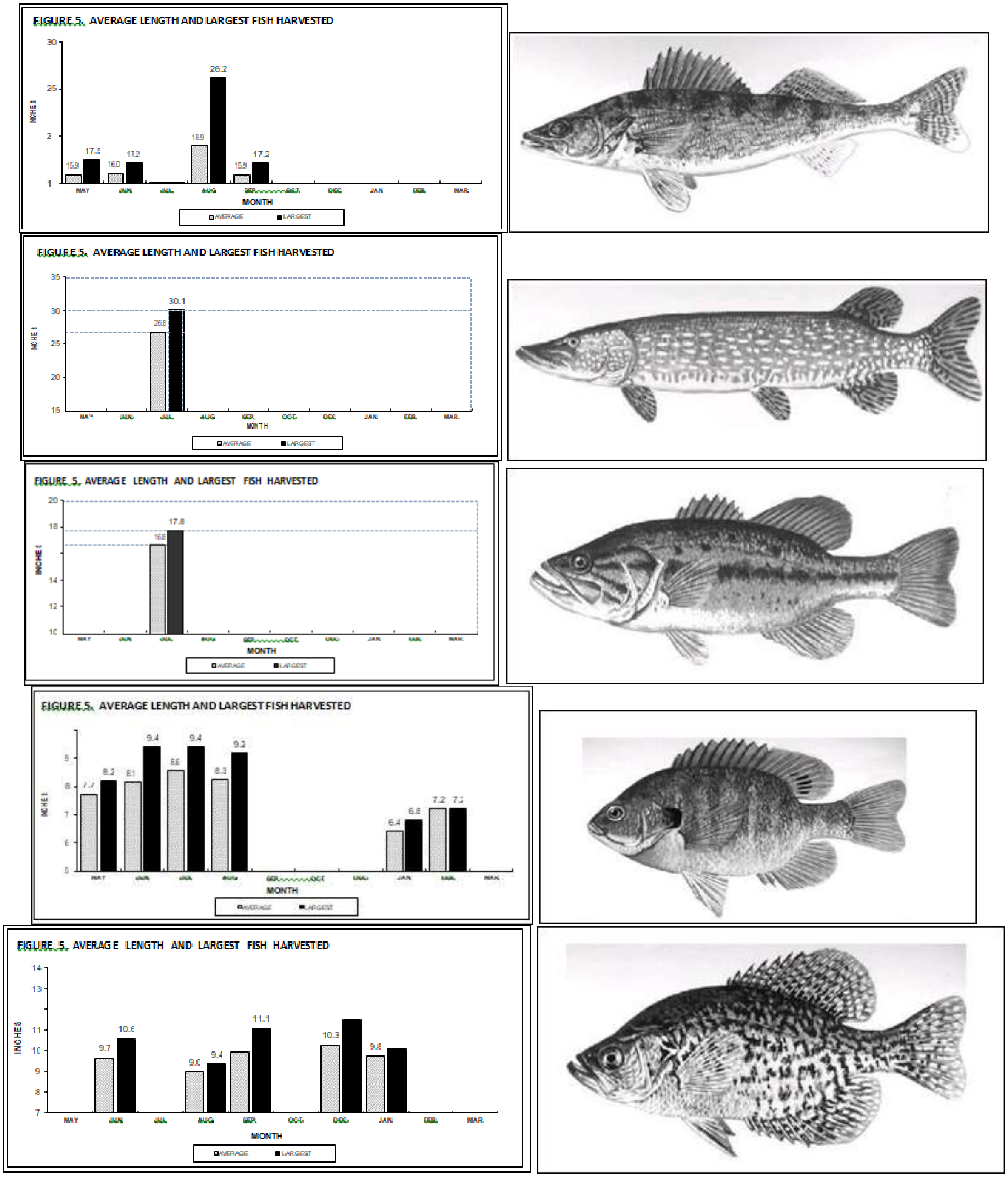



**Figure 44: Average length and largest fish harvested for several species during the 2019-20 season**
*(WDNR, 2019-20)*

**Table 18: 2019-20 Granite Lake creel survey history/synopsis** *(WDNR, 2019-20)*

| SPECIES | DIRECTED EFFORT (Hours) | PERCENT OF TOTAL | TOTAL CATCH | SPECIFIC CATCH RATE (Hrs/Fish) | TOTAL HARVEST | SPECIFIC HARVEST RATE (Hrs/Fish) | MEAN LENGTH OF HARVESTED FISH |
|---|---|---|---|---|---|---|---|
| Walleye | 1920 | 40.7% | 1462 | 1.4 | 248 | 7.7 | 16.3 |
| Northern Pike | 168 | 3.6% | 490 | 1.9 | 11 | 15.5 | 26.8 |
| Largemouth Bass | 873 | 18.5% | 1579 | 0.6 | 19 | 44.8 | 16.8 |
| Bluegill | 684 | 14.5% | 1172 | 0.6 | 429 | 1.6 | 8.0 |
| Pumpkinseed | 75 | 1.6% | 49 | 1.5 | 29 | 2.6 | 7.9 |
| Black Crappie | 919 | 19.5% | 1066 | 0.9 | 424 | 2.2 | 9.8 |
| Yellow Perch | 82 | 1.7% | 19 | NA | 8 | NA | 9.5 |

NA=Not Applicable

## 2019 FYKE NET AND SHOCKING SURVEYS

When a lake is included in a creel survey, fyke netting and boom shocking surveys are also conducted. Both were conducted in 2019 on Granite Lake. A final report has not been completed or reviewed, but some general data from the surveys is available and have been referenced here.

From April 22 to April 24 fyke nets (Figure 45) were placed in Granite Lake. It is assumed that four different nets were installed as the WDNR reports 12 "net nights" of fish capture. A net night is defined as each fyke net placed in the water for a total number of days. Four nets placed in Granite Lake for three nights would equal 12 net nights. At the time this report was written only walleye results for fyke netting had been obtained. Over three days, 449 walleyes ≥10 inches in length were captured for an average of 37.4 fish per night. Any fish ≥10 inches is consider an adult fish and counted. Any fish over ≥15 inches is considered a quality fish – primarily due to the fact that at the present time the size limit for a harvestable walleye on Granite Lake is 15 inches. Of the 449 fish captured, 25% of them were ≥15 inches in length. The largest walleye captured was 20.5 inches. The average size of all walleyes captured was 14.5 inches, just under the 15 inch limit for harvest.

**Figure 45: Fyke nets (left) and electro boom shocking (right)**

Several boom shocking surveys were completed: one on April 22, 2019; one on May 29, 2019; and one on September 25, 2019. The goal of each boom shocking survey differs with each date. WDNR boom shockers patrolled up to 3.4 miles of the 3.7 total miles of shoreline. Table 19 shows the results of those surveys for walleyes on all three dates, but for other fish only in the May 29 results. There may be additional results but they were not accessible when this report was written.

**Table 19: Electro Boom Shocking Results from 2019 in Granite Lake** *(WDNR, 2019-20)*

| **Boomshocking Results April22, 2019** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fish Species | Fish Captured | Miles Shocked | Fish/mile | Min size | Max size | Ave size | Quality Size | % captured of quality size |
| Walleye | 224 | 3.4 | 65.88 | 10.5 | 27 | 14.64 | 15 | 27 |

| **Boomshocking Results May 29, 2019** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fish Species | Fish Captured | Miles Shocked | Fish/mile | Min size | Max size | Ave size | Quality Size | % captured of quality size |
| Walleye | 60 | 3.5 | 17.14 | 5.5 | 21.5 | 13.76 | 15 | 35 |
| Northern Pike | 12 | 3.5 | 3.43 | 15 | 20.5 | 17.75 | 21 | 0 |
| Crappie | 22 | 2.5 | 8.8 | 7 | 10.5 | 9.5 | 8 | 95 |
| Blugill | 61 | 2.5 | 24.4 | 5 | 8.5 | 7.18 | 6 | 93 |
| Largemouth Bass | 25 | 3.5 | 7.14 | 12.5 | 19 | 14.99 | 12 | 100 |
| Perch | 4 | 2.5 | 1.6 | 6 | 6 | 6.25 | 8 | 0 |

| **Boomshocking Results September 25, 2019** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fish Species | Fish Captured | Miles Shocked | Fish/mile | Min size | Max size | Ave size | Quality Size | % captured of quality size |
| Walleye | 63 | 3.4 | 18.53 | 5 | 17 | 10.33 | 15 | 4.7 |

More than 85% of the public use survey respondents said they fished in Granite Lake either from a boat or from their docks/shore. As mentioned, despite this only a third reported poor fishing conditions. Other than a reputation of having lots of small walleyes, which the 2019 surveys seem to support, Granite Lake has a healthy and diverse fishery that is complemented by a large variety of mammals, birds, and reptiles that also use the lake and the surrounding shorelands. As such there are no specific recommendations related to the fishery in Granite Lake.

## AQUATIC INVASIVE SPECIES

Currently, the only aquatic invasive species present within the waters of Granite Lake is curly-leaf pondweed which was verified in 2009. However, it is important to maintain monitoring and prevention efforts to keep other AIS from being introduced into the lake. The following sections provide information about CLP and other non-native, invasive species threats to Granite Lake.

### CURLY-LEAF PONDWEED

Curly-leaf pondweed is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia (Figure 46). It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early August. CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine.

CLP spreads through burr-like winter buds (turions), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring. It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. CLP forms surface mats that interfere with aquatic recreation.

**Figure 46: CLP Plants and Turions**

### EURASIAN WATERMILFOIL

Eurasian water milfoil (EWM) (Figure 47) is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, EWM is difficult to distinguish from Northern water milfoil. EWM has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

EWM grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, and bait buckets; and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, EWM is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms in infested lakes.

**Figure 47: EWM fragment with adventitious roots and EWM in a bed**

EWM has not been found within Granite Lake, but should still be monitored for regularly.

## PURPLE LOOSESTRIFE

Purple loosestrife (Figure 48) is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers that vary from purple to magenta possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, more than 20 states, including Wisconsin have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America.

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.
Purple loosestrife can germinate successfully on substrates with a wide range of pH. Optimum substrates for growth are moist soils of neutral to slightly acidic pH, but it can exist in a wide range of soil types. Most seedling establishment occurs in late spring and early summer when temperatures are high.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland. The plant can also make morphological adjustments to accommodate changes in the immediate environment; for example, a decrease in light level will trigger a change in leaf morphology. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways.

Purple loosestrife has been found on the shores of Granite Lake.

**Figure 48: Purple Loosestrife**

## REED CANARY GRASS

Reed canary grass (Figure 49) is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades 3 1/2 to 10 inches long and 1/4 to 3/4 inch in width. Blades are flat and have a rough texture on both surfaces. The lead ligule is membranous and long. The compact panicles are erect or slightly spreading (depending on the plant's reproductive stage), and range from 3 to 16 inches long with branches 2 to 12 inches in length. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800's for forage and erosion control. It has become naturalized in much of the northern half of the U.S., and is still being planted on steep slopes and banks of ponds and created wetlands.
Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as bergs and spoil piles.

Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring and then spreads laterally. Growth peaks in mid-June and declines in mid-August. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in just a few years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, and deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites.

Reed canary grass is located in a few locations along the shoreland of Granite Lake.

**Figure 49: Reed Canary Grass**

**MYSTERY SNAILS**

The Chinese mystery snails and the banded mystery snails (Figure 50) are non-native snails that have been found in a number of Wisconsin lakes, and are likely in Granite Lake. There is not a lot yet known about these species, however, it appears that they have a negative effect on native snail populations. The mystery snail's large size and hard operculum (a trap door cover which protects the soft flesh inside), and their thick hard shell make them less edible by predators such as rusty crayfish.

The female mystery snail gives birth to live crawling young. This may be an important factor in their spread as it only takes one impregnated snail to start a new population. Mystery snails thrive in silt and mud areas although they can be found in lesser numbers in areas with sand or rock substrates. They are found in lakes, ponds, irrigation ditches, and slower portions of streams and rivers. They are tolerant of pollution and often thrive in stagnant water areas. Mystery snails can be found in water depths of 0.5 to 5 meters (1.5 to 15 feet). They tend to reach their maximum population densities around 1-2 meters (3-6 feet) of water depth. Mystery snails do not eat plants. Instead, they feed on detritus and in lesser amounts algae and phytoplankton. Thus, removal of plants in your shoreline area will not reduce the abundance of mystery snails.

Lakes with high densities of mystery snails often see large die-offs of the snails. These die-offs are related to the lake's warming coupled with low oxygen (related to algal blooms). Mystery snails cannot tolerate low oxygen levels. High temperatures by themselves seem insufficient to kill the snails as the snails could move into deeper water.

A common fear for many lake residents is mystery snails being carriers of the swimmer's itch parasite. In theory they are potential carriers, however, because they are an introduced species and did not evolve as part of the lake ecosystem, they are less likely to harbor the swimmer's itch parasites.

**Figure 50: Chinese Mystery Snails**

## RUSTY CRAYFISH

Rusty crayfish (Figure 51) live in lakes, ponds and streams, preferring areas with rocks, logs and other debris in water bodies with clay, silt, sand or rocky bottoms. They typically inhabit permanent pools and fast-moving streams of fresh, nutrient-rich water. Adults reach a maximum length of 4 inches. Males are larger than females upon maturity and both sexes have larger, heartier, claws than most native crayfish. Dark "rusty" spots are usually apparent on either side of the carapace, but are not always present in all populations. Claws are generally smooth, with grayish-green to reddish-brown coloration. Adults are opportunistic feeders, feeding upon aquatic plants, benthic invertebrates, detritus, juvenile fish and fish eggs.

The native range of the rusty crayfish includes Ohio, Tennessee, Kentucky, Indiana, Illinois and the entire Ohio River basin. However, this species may now be found in Michigan, Massachusetts, Missouri, Iowa, Minnesota, New York, New Jersey, Pennsylvania, Wisconsin, New Mexico and the entire New England state area (except Rhode Island). The Rusty crayfish has been a reported invader since at least the 1930's. Its further spread is of great concern since the prior areas of invasion have led to severe impacts on native flora and fauna. It is thought to have spread by means of released game fish bait and/or from aquarium release. Rusty crayfish are also raised for commercial and biological harvest.

Rusty crayfish reduce the amount and types of aquatic plants, invertebrate populations, and some fish populations--especially bluegill, smallmouth and largemouth bass, lake trout and walleye. They deprive native fish of their prey and cover and out-compete native crayfish. Rusty crayfish will also attack the feet of swimmers. On the positive side, rusty crayfish can be a food source for larger game fish and are commercially harvested for human consumption.

Rusty crayfish may be controlled by restoring predators like bass and sunfish populations. Preventing further introduction is important and may be accomplished by educating anglers, trappers, bait dealers and science teachers of their hazards. Use of chemical pesticides is an option, but does not target this species and will kill other aquatic organisms.

It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except the Mississippi River). It is also illegal to release crayfish into a water of the state without a permit.

Rusty crayfish have not been found in Granite Lake.

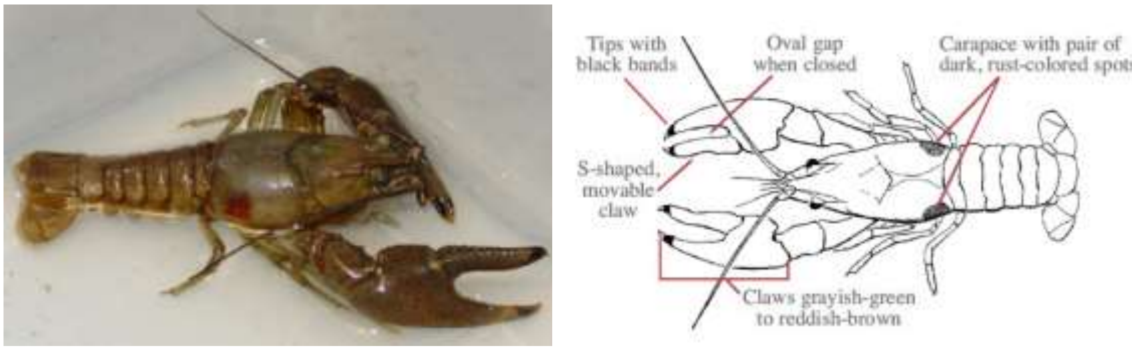



**Figure 51: Rusty Crayfish and identifying characteristics**

## ZEBRA MUSSELS

Zebra mussels (Figure 52) are an invasive species that have inhabited Wisconsin waters and are displacing native species, disrupting ecosystems, and affecting citizens' livelihoods and quality of life. They hamper boating, swimming, fishing, hunting, hiking, and other recreation, and take an economic toll on commercial, agricultural, forestry, and aquacultural resources. The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

Zebra mussels feed by drawing water into their bodies and filtering out most of the suspended microscopic plants, animals and debris for food. This process can lead to increased water clarity and a depleted food supply for other aquatic organisms, including fish. The higher light penetration fosters growth of rooted aquatic plants which, although creating more habitats for small fish, may inhibit the larger, predatory fish from finding their food. This thicker plant growth can also interfere with boaters, anglers and swimmers. Zebra mussel infestations may also promote the growth of blue-green algae, since they avoid consuming this type of algae but not others.

Zebra mussels attach to the shells of native mussels in great masses, effectively smothering them. A survey by the Army Corps of Engineers in the East Channel of the Mississippi River at Prairie du Chien revealed a substantial reduction in the diversity and density of native mussels due to Zebra Mussel infestations. The East Channel provides habitat for one of the best mussel beds in the Upper Mississippi River. Future efforts are being considered to relocate such native mussel beds to waters that are less likely to be impacted by zebra mussels.

Once zebra mussels are established in a water body, very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Some of the preventative and physical control measures include physical removal, industrial vacuums, and back flushing.

Chemical applications include solutions of chlorine, bromine, potassium permanganate and even oxygen deprivation. An ozonation process is under investigation (patented by Bollyky Associates Inc.) which involves the pumping of high concentrations of dissolved ozone into the intake of raw water pipes. This method only works in controlling veligers, and supposedly has little negative impacts on the ecosystem. Further research on effective industrial control measures that minimize negative impacts on ecosystem health is needed.

**Figure 52: Zebra Mussels**

While zebra mussels have not been identified in Granite Lake, they were found in western Washburn County in 2016. This was the first time that zebra mussels had been found in Northwestern Wisconsin. This discovery heightens the importance of monitoring and prevention activities for all northwestern Wisconsin lakes. This discovery heightened the importance of monitoring and prevention activities for all northwestern Wisconsin lakes. In 2019, a team of researchers out of the UW- Madison Center of Limnology re-launched the AIS Smart Prevention tool. This tool takes several lake factors, including calcium concentration, into consideration to model lakes that are susceptible to zebra mussel populations. This tool breaks lakes down into suitable, borderline suitable, unsuitable, and no data. Granite Lake considered unsuitable (Center for Limnology, 2019). This means that if introduced to the Granite Lake, zebra mussels would likely be able to survive and sustain a population.

## AIS PREVENTION STRATEGY

Granite Lake currently only has one established in-lake AIS, but there are many more that could be introduced to the lake. The GLA has and will continue to implement a watercraft inspection and AIS Signage program at the public access point on the lake. Information will be shared with lake residents and users in an effort to expand the watercraft inspection message. In addition to the watercraft inspection program, an in-lake and shoreland AIS monitoring program will be implemented. Both of these programs will follow UW-Extension Lakes and WDNR protocol through the Clean Boats, Clean Waters program and the CLMN Aquatic Invasive Species Monitoring program.

Additionally, having an educated and informed lake constituency is the best way to keep non-native aquatic invasive species at bay in Granite Lake. To foster this, the GLA should host and/or sponsor lake community events including AIS identification and management workshops; distribute education and information materials to lake property owners and lake users through the newsletter, webpage, and general mailings.

# INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is an ecosystem-based management strategy that focuses on long-term prevention and/or control of species of concern or their damage. IPM considers all the available control practices such as: prevention, biological control, biomanipulation, nutrient management, habitat manipulation, substantial modification of cultural practices, pesticide application, water level manipulation, mechanical removal and population monitoring. Integrated pest management projects should be informed by current, comprehensive information on pest life cycles and the interactions among pests and the environment.

Groups should focus their efforts to keep the species of concern from becoming a problem by looking into the environmental factors that affect the species and its ability to thrive. Once groups understand the species of concern, they can create conditions that are either unfavorable or less beneficial for it.
Monitoring means checking the waterbody to identify what species are present, how many there are and what their impacts are on each other and on water use. Correctly identifying the species of concern and other species in the waterbody is key to knowing whether it is likely to become a problem and determining the best management strategy.

After monitoring and considering the information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. If control is needed, the data collected on the species and the waterbody will also help groups select the most effective management methods and the best time to use them.

The most effective, long-term way to manage species of concern is by using a combination of methods that work better together than separately. Approaches for managing pests are often grouped in the following categories:

- **Assessment** – is the use of learning tools and protocols to determine a waterbodies' biological, chemical, physical and social properties and potential impacts. Examples include: point-intercept (PI) surveys, water chemistry tests and boater usage surveys. This is the most important management strategy on every single waterbody.
- **Biological Control** – is the use of natural predators, parasites, pathogens and competitors to control target species and their impacts. An example would be beetles for purple loosestrife control.
- **Cultural controls** – are practices that reduce target species establishment, reproduction, dispersal, and survival. For example, a Clean Boats, Clean Waters program at boat launches can reduce the likelihood of the spread of species of concern.
- **Mechanical and physical controls** – can kill a target species directly, block them out, or make the environment unsuitable for it. Mechanical harvesting, hand pulling, and diver assisted suction harvesting are all examples.
- **Chemical control** – is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Groups should use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality.

IPM isn't a single solution to problems caused by a species of concern. It's a process that combines common-sense methods and practices to provide long-term, economic pest control (Figure 53). Over time, a good IPM program should adapt whenever new information is provided on the target species or monitoring shows changes in control effectiveness, habitat composition and/or water quality.

While each situation is different, eight major components should be established in a group's IPM program:

1. Identify and Understand the species of concern

2. Prevent the spread and introduction of the species of concern
3. Continually Monitor and Assess the species' impacts on the waterbody
4. Prevent species of concern impacts
5. Set Guidelines for when management action is needed
6. Use a combination of biological, cultural, physical/mechanical and chemical management tools
7. Assess the effects of target species' management
8. Change the management strategy when the outcomes of a control strategy create long-term impacts that outweigh the value of target species control.

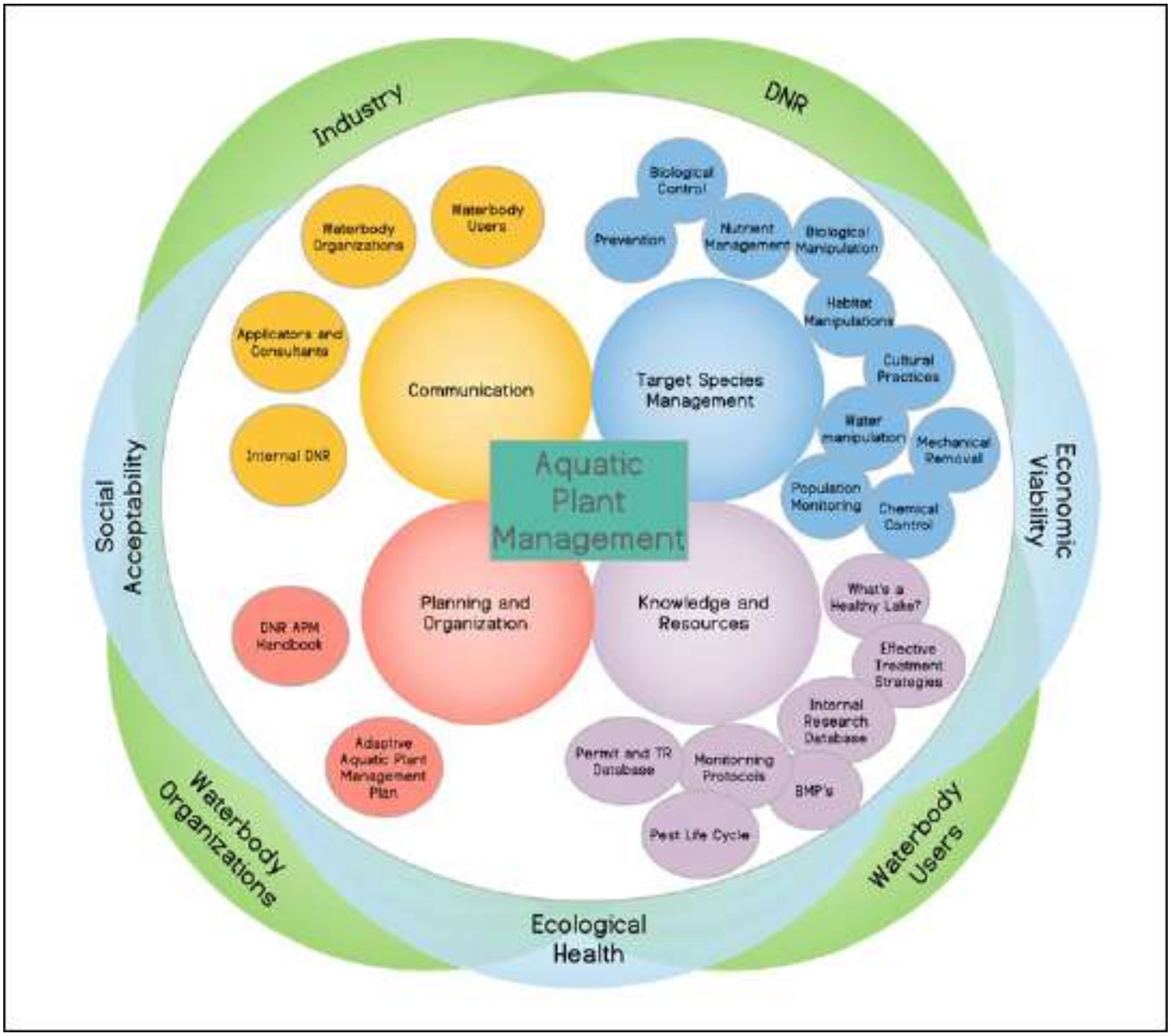



**Figure 53: WDNR: Wisconsin Waterbodies – Integrated Pest Management March 2020**

There are many options in Wisconsin for aquatic plant management. Appendix A provides a quick overview of many of the management alternatives that are implemented for aquatic plant control. Each lake and management needs are different so not all management actions are appropriate for all lakes.

## AQUATIC PLANT MANAGEMENT IN GRANITE LAKE

The Granite Lake ecosystem is home to a very limited plant community that is typical of moderate-nutrient lakes with fair to poor water clarity. Plant diversity is moderately high with a Simpson Index value of 0.89 –

up slightly from what it was in 2009. However, total richness is low with just 22 species found during the rake sampling that is done as a part of the summer point-intercept survey. This total increased to 38 species when including visuals and plants seen during the pre-survey boat survey. 2018 total rake fullness, a measurement of plant density, was only 1.69/3.00, less than it was in the last summer point-intercept survey done in 2009 (Figure 54). Results from the 2018 survey suggest that in-lake management of aquatic plants is not necessary in Granite Lake, with the possible exception in two areas: management of CLP and purple loosestrife, and areas where filamentous algae and other floating debris collects.

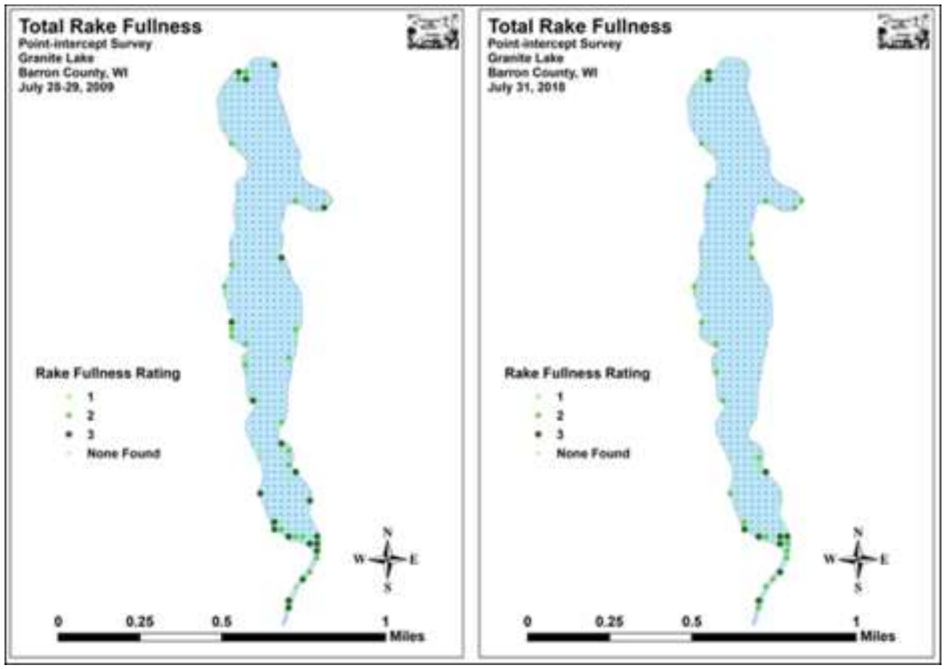



**Figure 54: 2009 and 2018 total rake fullness, a measurement of plant density** *(Berg M. , 2019)*

CURLY-LEAF PONDWEED/PURPLE LOOSESTRIFE AND OTHER AIS MONITORING AND MANAGEMENT

During the 2018 early-season point-intercept survey no CLP was found at any point, but one plant was identified and removed along the west shoreline of the west bay in about 4-ft of water. This was similar to 2009 when CLP was found at a single point along the east shoreline of the south bay (Figure 55). However, during a 2018 spring survey specific to looking for CLP in the lake, 16 additional plants were found, all of which were rake removed by the plant surveyor. These individuals plants were all located along the eastern shoreline of the south bay (Figure 56). Neither of these two clusters of plants are cause for worry related to negative impacts they might create, but should be monitored annually with physical removal if possible.

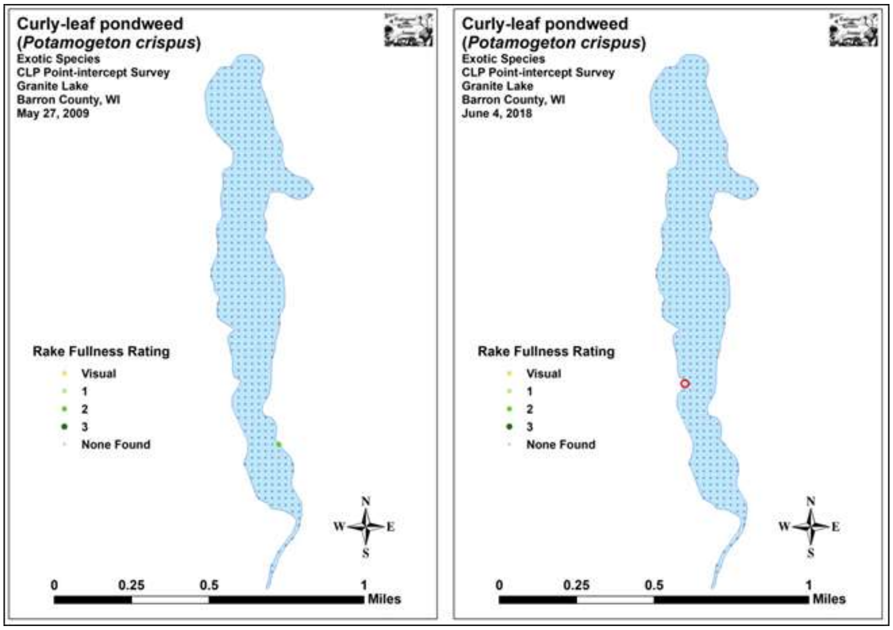



**Figure 55: 2009 and 2018 point-intercept survey results for CLP** *(Berg M. , 2019)*

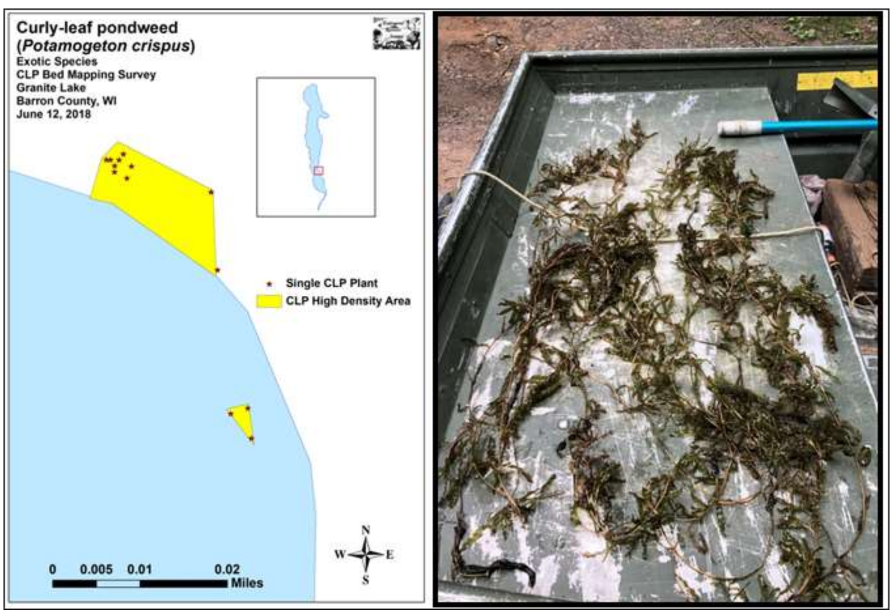



**Figure 56: 2018 Early-season Curly-leaf Pondweed High Density Areas and Rake Removed CLP – 6/12/18** *(Berg M. , 2019)*

Several other non-native plant species have been identified in Granite Lake including purple loosestrife, reed canary grass, and common forget-me-nots. Of these, purple loosestrife is likely the one to be most concerned about. Over the last few years, only individual plants have been found along the shore and these have been removed. Annual monitoring for purple loosestrife should be completed. Plants that are found can be physically pulled – roots and all, or dug out. At a minimum, when a plant is found the flowering heads should be removed to prevent seeding. Plant herbicides can also be used when the entire plant is on dry ground. Cut-stem dabbing and hand wicking are most commonly used for small-scale, chemical control of purple loosestrife.

Cut-stem dabbing is carried out by cutting stems of target species within two to four inches of the ground followed by application of herbicide to the cut surface. Treatment should occur immediately following cutting to ensure proper absorption of herbicide. A colored dye is usually added to the solution so that it is apparent as to where the herbicide has been applied.

Hand wicking involves spraying an herbicide solution on an absorbent glove and carefully wiping the herbicide onto the surface of a leaf. It's important to wear an herbicide resistant glove beneath the absorbent glove, to protect skin from the herbicide. This method is appropriate when controlling small populations of invasive species that are growing in a high-quality area, or when controlling invasive species in close proximity of endangered or threatened native species (https://muskegonlake.org/habitat-management-plan/invasive-species-control/, last accessed on August 6, 2020)

EWM has not been found in Granite Lake to date, however it is in several lakes in close proximity including Beaver Dam, Duck, Kidney, Lower Vermillion, Sand, and Shallow Lake. The GLA should continually monitor the lake for EWM, should complete watercraft inspection at the public boat landing, and make sure that aquatic invasive species signage at the landing is current and accurate.

## FILAMENTOUS ALGAE MANAGEMENT

Filamentous algae, normally associated with excessive nutrients in the water column, were common to abundant throughout the lake in both the 2009 and 2018 summer point-intercept surveys (Figure 57). In 2009, these algae were found at 30 points with a mean rake fullness of 1.93. During the 2018 survey, a moderately significant expansion in distribution to 44 points was documented, although there was also a moderately significant decline in mean rake fullness to 1.36. The worst area of the lake for the buildup of filamentous algae is the extreme north end where the main inlet is located. Filamentous algae can also trap small floating plants like duckweeds and watermeal, dislodged plant fragments, snail shells, and other floating debris decreasing the aesthetic appeal of the location.

Although upstream agricultural runoff can be a major contributor to a lake's overall nutrient load and is addressed in this report, soil erosion and nutrient inputs from along the immediate lakeshore can also have significant impacts. Because of this, all lake residents have the opportunity to help reduce runoff by evaluating how their shoreline practices may be affecting the lake. Simple things like establishing or maintaining their own buffer strip of native vegetation along the lake shore to prevent erosion, building rain gardens, bagging grass clippings, switching to a phosphorus-free fertilizer or preferably eliminating fertilizer near the lake altogether, collecting pet waste, and disposing of the ash from fire pits away from the lakeshore can all significantly reduce the amount of nutrients entering the ecosystem.

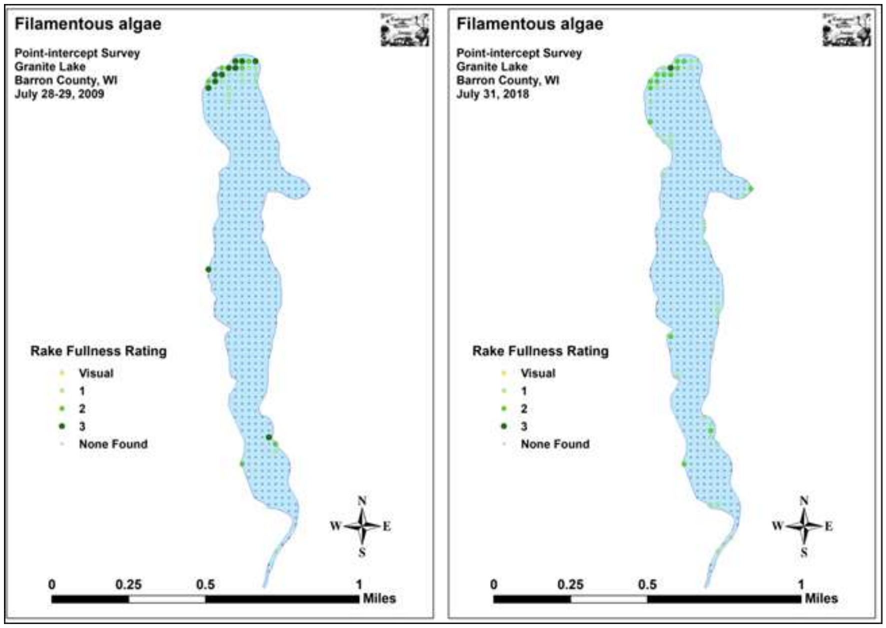



**Figure 57: 2009 and 2018 filamentous algae** *(Berg M. , 2019)*

Other than striving to reduce the nutrient load to the lake, filamentous algae and the debris captured in it could be "skimmed" from the surface in areas of the lake that are bad. While the idea sounds simple, making it happen is not. Property owners can rake this material from the lake adjacent to their docks and swimming areas. There are numerous rakes and cutters designed to help property owners physically remove vegetation from the lake (Figure 58). These management actions do not require permitting from the WDNR provided guidelines found in NR 109 (Appendix B) are followed.

**Figure 58: Example rakes and cutters (weedersdigest.com)**

There are several versions of small-scale mechanical weed cutters, lake skimmers, or beach sweepers available on the market (Figure 59), but all of these require mechanical harvesting permits from the WDNR. And like all physical removal actions, any plant material that may be cut or pulled from the lake, must also be removed from the waters and deposed of in appropriates places on shore. Managed vegetation cannot be cut and then left in the water to drift away or sink to the bottom.

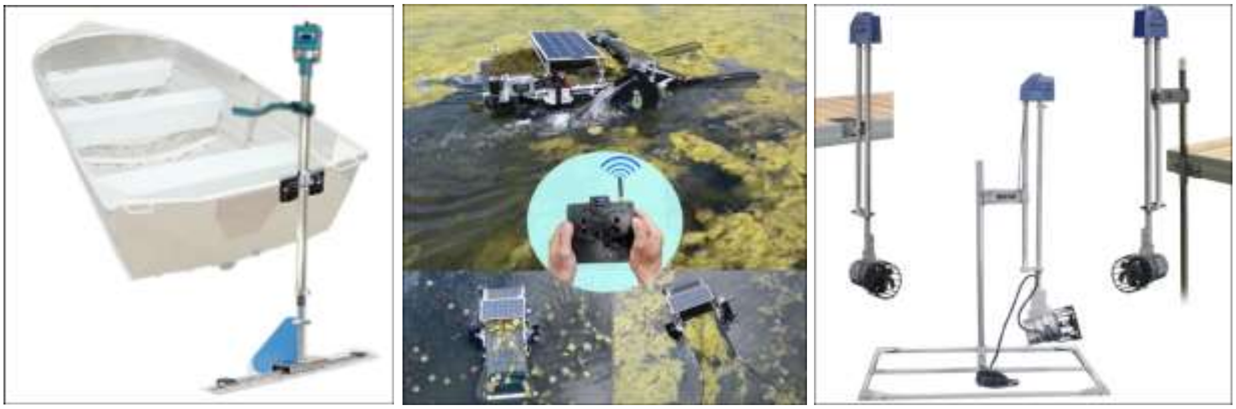


**Figure 59: Assorted aquatic plant cutters, skimmers, and beach sweepers (weedersdigest.com)**

This plan does not recommend actions that involve mechanical cutters, skimmers, or beach sweepers but recognizes that small-scale removal, along with efforts to reduce nutrient loading may make improvements along the worst parts of the shoreline.

## TARGET LOADS

It is estimated that the total amount of phosphorus in Granite Lake is around 290kg. The sources of phosphorus include: the inlet which drains the larger piece of the watershed and contains the majority of the agriculture; an unmonitored portion of the watershed that is mostly forested; contributions from internal loading; loading from the nearshore area where most of the developed land exists; from septic systems; and from atmospheric deposition. Of these sources, the larger portion of the watershed and the nearshore area provide perhaps the best opportunity to make changes that might reduce phosphorus loading to the lake.

Monitoring of the inlet indicates that it brings in nearly 134kg of phosphorus over 7 months (April-October). The nearshore area brings in another 13.9kg. The goal is to reduce the inputs from these two sources in combination by up to 20% (-58kg) in 10 years, with an interim goal of 10% (-29kg) in 5 years.

## NUTRIENT REDUCTION STRATEGIES

Much of the watershed is in a natural state, as is a significant portion of the nearshore area. In these areas, the best strategy is to try and maintain the status quo – strive for no new development around the lake and keep those areas of both the monitored and non-monitored watershed that are presently minimally disturbed in a natural state. This would include managing forest land in a way that minimizes impacts to the watershed and lake. Maintaining septic systems around the lake in working order are also important, but probably not an opportunity to significantly reduce phosphorus loading. At the present time, activities that could reduce internal loading from the sediments at the bottom of the lake, like the application of aluminum sulfate or hypolimnetic aeration are not necessary. However, minimizing disturbances in shallow water and along the shore caused by waves and boating traffic could reduce the internal load of phosphorus to some degree.

The opportunities that exist to reduce the phosphorus load into Granite Lake are mostly centered on human-caused disturbances in the watershed and in the nearshore area of the lake. In the larger watershed, agriculture, both field and barnyard, offers the best opportunity to reduce phosphorus loading. In the nearshore area around the lake, individual property owners have a great opportunity to reduce loading. As mentioned before, the public boat landing is perhaps the worst contributor of phosphorus and sediment to the lake. Other properties can likely implement projects that are inexpensive, easy to install, and effective at reducing loading, and as an added benefit, may improve fish and wildlife habitat.

The most cost-effective manner of reducing the phosphorus load to the lake is through BMP (BMPs) that infiltrate or filter runoff in both the near-shore area and throughout the watershed. Studies have found that infiltration practices, such as rain gardens and infiltration trenches reduce TP concentrations by up to 90% (Schechter, Canfield, & Meyer, 2013). Applying these figures to Granite Lake nearshore area suggests about 11kg of phosphorus can be removed using infiltration and filtering practices installed along the shoreline and near-shore area.

Minimizing or disconnecting impervious cover in the shoreland area can reduce phosphorus levels. This and the application of better site design practices (also known as low impact development) that minimize impervious cover, conserve natural areas, and improve stormwater treatment on individual parcels will reduce phosphorus loading. Using these practices at sites of new construction or retrofitting existing properties in the shoreland area can achieve nutrient load reductions of about 33%. Applying this to Granite Lake could just about eliminate loading from the nearshore area into the lake.

Runoff filtering practices, such as vegetated buffers and grassed swales, reduce TP by 59%. Installation of such practices in agricultural drainage ways could have a substantial impact on the phosphorus load to the lake. The University of Nebraska demonstrated that on a watershed scale, grassed buffers, riparian forest buffers, and other conservation practices applied on the same watershed can reduce TP loads to a seasonally flowing stream by 95% and total suspended solids were reduced by 97% (Franti, et al., 2004). This suggests up to 58-kg of phosphorus can be removed from the annual load to the lake by implementing agricultural BMP throughout the watershed drained by the main inlet.

Nutrient reduction can also be achieved through the completion of nutrient management plans for farmers in the watershed. Although primarily a County Land and Water Conservation Department led effort, the Association could help identify problem areas in the watershed, further develop relationships with farmers in the watershed, and seek funding sources to assist with plan completion.

Although difficult to quantify, motor boat activity does have a negative impact on water quality in shallow waters (less than 10 feet deep) and in areas with shorelines sensitive to erosion. Developing a lake use plan that includes scientifically and lake-user defined no-wake zones can reduce sediment re-suspension and phosphorus release, shoreline erosion, and conflict between lake users. Ordinances can be created at the Town and County level if deemed appropriate and necessary.

## BEST MANANGEMENT PRACTICES

### FORESTRY PRACTICES

Nearly 60% of the watershed is still in a forested state, some of this is Barron County Forestry land. A conscious effort should be made to preserve, protect, and enhance these properties and to preserve additional property through conservation easements, environmental land trusts, and the Wisconsin Stewardship Program. When logging is done in the watershed, the GLA and its partners should be actively working to insure logging practices minimize disturbance and protect near shore buffers along lakes and streams.

As previously mentioned, before harvest, planning to ensure water quality protection can minimize nonpoint source pollution and increase the operational efficiency. The following specific management measures should be kept in mind by all forest managers as they develop comprehensive forest management plans.

- Create streamside management areas of sufficient width and extent to reduce pollutant delivery.
- Identify and avoid high hazard areas to reduce the risk of landslides and mass erosion.
- Plan roads and skid trails carefully to reduce the amount of land disturbed by them, thereby reducing erosion and sedimentation.
- Properly design drainage systems and stream crossings to prevent system destruction by storms, thereby preventing severe erosion, sedimentation, and channel scouring.
- Pre-harvest planning of adequate road systems can greatly reduce the sources and transport of sediment. Road systems should generally be designed to minimize the number of road miles per acre, the size and number of landings, the number of skid trail miles, and the number of watercourse crossings, especially in sensitive watersheds.
- Time operations to take advantage of favorable seasons or conditions, avoiding wet seasons prone to severe erosion or other identified site-specific seasons to reduce impacts to water quality and aquatic organisms.
- Minimize drainage problems when locating roads by avoiding clay beds, seeps, springs, concave slopes, ravines, draws, and stream bottoms.

### AGRICULTURAL PRACTICES

Many agricultural BMPs exist to both reduce runoff from agricultural lands and improve the economic value of that farmland. Cropland (row crops) can be converted to conservation tillage, cover crops planted after harvest, and/or marginal land retired. Perhaps some of this land can be entered in to programs like the Environmental Quality Incentives Program (EQIP) that provides a way for the public to share in the cost of getting basic conservation practices on the land; or the Agricultural Conservation Easement Program that protects farmland and natural resources through long-term easements. As previously mentioned the installation of grassed waterways (Figure 60), stream and wetland buffers, and restored wetlands can also reduce runoff and nutrient loading. Additional practices including livestock feeding and manure management strategies could further reduce phosphorous loading. There are at least four active manure storage pits and one abandoned manure pits within the watershed of Granite Lake (Figure 61). Figure 62 shows potential stream and wetland buffer sites recognized by Barron County. Table 20 reflects cost-sharing currently available in Barron County for agricultural BMPs. The GLA could work with Barron County to offset the costs to local farmers of implementing BMPs.

**Figure 60: Newly installed grassed waterways south of Hwy 8 in Barron County (LEAPS)**

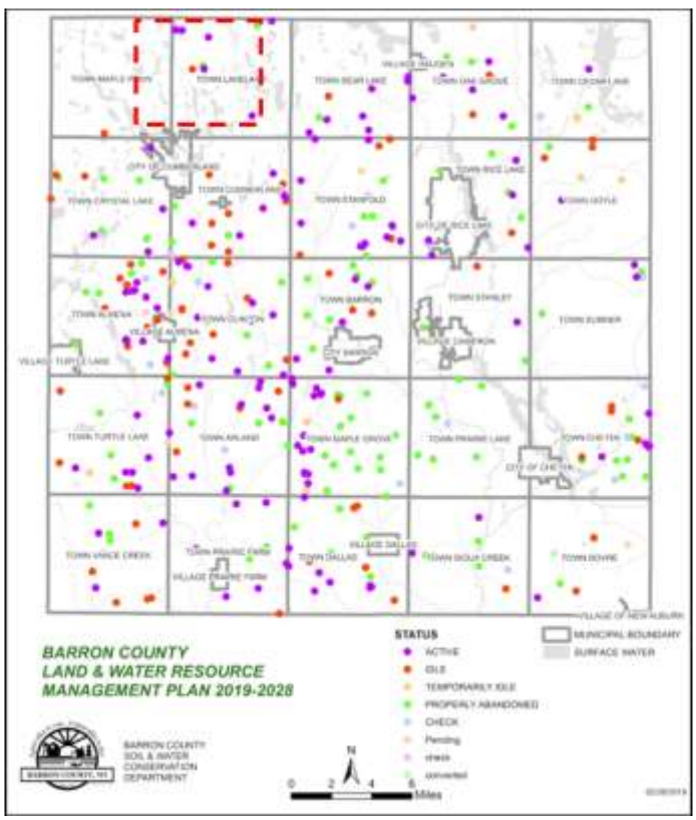



**Figure 61: Manure storage facilities in Barron County. Red dashed block – Granite Lake area** *(Barron County SWCD, 2020)*

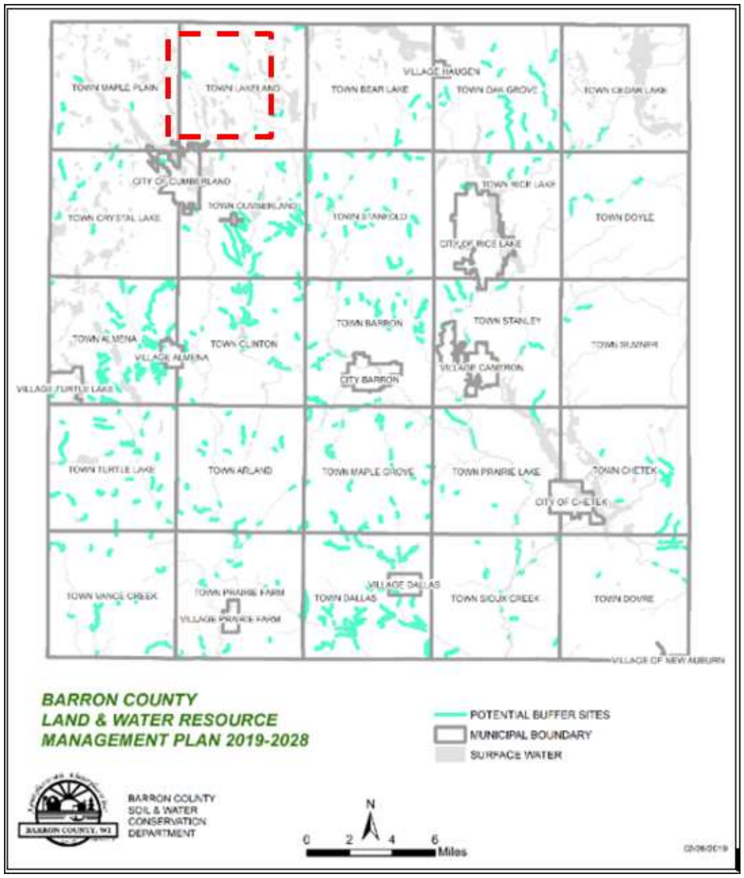



**Figure 62: Potential buffer sites Red dashed block – Granite Lake area** *(Barron County SWCD, 2020)*

**Table 20: Barron County conservation practices and cost-sharing** *(Barron County SWCD, 2020)*

| PRACTICE | COST SHARE RATE | FUNDING SOURCE | ANNUAL OUTCOMES |
|---|---|---|---|
| No-till?? | $15.00/acre | County, Nutrient Trading Programs, Lake Grants | 2000 acres |
| Cover Crop | $25/acre | County, Nutrient Trading Programs, Lake Grants | 300 acres |
| Nutrient Management Planning | Varies per program | State SEG Funds, UWEX NMFE Grants, NRCS | 5110 acres |
| Grass Waterway | 70% | SWRM Cost Share, NRCS | 5 |
| AWSF Closure | 70% | SWRM Cost Share, NRCS | 5 |
| Well Decommissioning | 70% | SWRM Cost Share, NRCS | 5 |
| Diversion | 70% | SWRM Cost Share, NRCS | 2 |
| Streambank/Shoreline Fencing | 70% | SWRM Cost Share, Lake Grants, NRCS | 2 |
| Stream Crossing | 70% | SWRM Cost Share, NRCS | |
| Wetland Restoration | 70% | SWRM Cost Share, NRCS | 1 |
| Critical Area Stabilization | 70% | SWRM Cost Share, NRCS | 1 |
| Headland Planting | $95.00/acre | SWRM Cost Share, NRCS | 10 |
| Buffers | TBD | SWRM Cost Share, NRCS | |
| Barnyard Runoff System | 70% | SWRM Cost Share, NRCS | As needed |
| Lakeshore Restoration | 70% | SWRM Cost Share, Lake Grants | 2 |

NEARSHORE PRACTICES

As in agriculture, there are many BMPs that can be implemented by property owners in the nearshore area of the lake. Restoring disturbed shorelines, leaving "no mow" or more substantial buffer strips along lake and stream edges, using no fertilizer or phosphorous free fertilizers, diverting runoff form hard surfaces and rooftops, preventing shoreland erosion, and maintaining septic systems in properly working order will all reduce phosphorous, sediment, and other pollutants getting into the lake. The WDNR currently offers a grant program that provides funding for a set of nearshore area BMPs that property owners are encouraged to implement. These include native plantings, rain gardens, water diversions, rock infiltration trenches, and installation of Fishsticks fish habitat improvement projects (Figure 63).

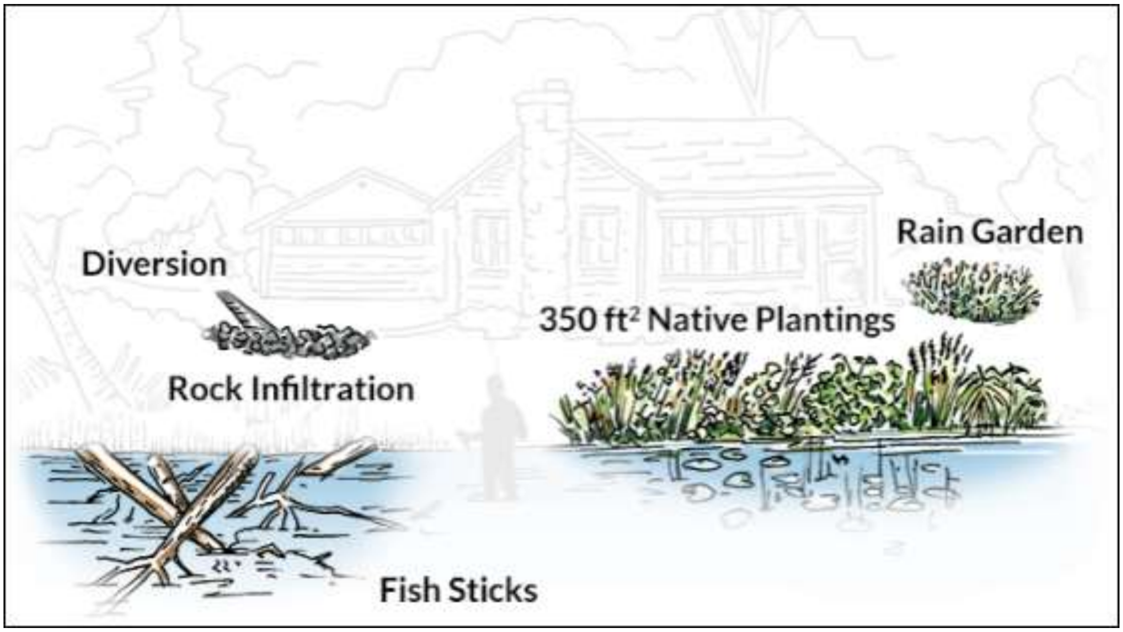



**Figure 63: Healthy Lakes and Rivers Projects ([https://healthylakeswi.com/best-practices/](https://healthylakeswi.com/best-practices/))**

## GOALS, OBJECTIVES, AND ACTIONS

There are four main goals associated with this project. Each goal has multiple objectives, and actions that support each objective. The following narrative provides detail for each goal, objective, and the actions that support the objective. A condensed version of the goals, objectives, and actions is located in Appendix C. An Implementation Matrix for the next ten years is included in Appendix D.

### GOAL ONE

The first goal in this plan has two parts: to maintain TP (TP) concentrations in Granite Lake below the WI State Phosphorus Standard for stratified drainage lakes of 30-µg/l; and, to reduce the mean percent of lake use days that have moderate algal levels by at least 1/3 in five years and by 2/3 in ten years.

This goal echoes the main goal of this entire project: to remove Granite Lake from the Wisconsin Impaired waters list for exceeding Chl-A levels for recreational use. This goal has two parts because the listing of Granite Lake in the impaired waters list is based on two parameters – the mean concentration of TP in the lake; and the number of days during the open water season where lake use may decline due to perceived water quality issues.

OBJECTIVES

This goal has two objectives: 1) to reduce external loading of TP by 10% in five years and 20% in ten years; and 2) to fill in data gaps that exist that will improve water quality management planning adaptability over the next ten years.

Objective 1 is directly related to reducing external sources of phosphorus to the lake. Three areas will be targeted in the actions – the nearshore area, the lake, and the watershed.

ACTIONS

#### ***Nearshore Area***

The largest project in the nearshore area is coming up with a plan for and then making improvements to the public boat landing that will reduce its contribution of sediment and nutrients to the lake. A larger landing renovation will likely take a couple of years to make happen, however, there are small things like installation of water diversions and infiltration basins to catch runoff and prevent it from going directly into the lake that could be installed in the short-term.

Most of the shoreland around Granite Lake is in a natural state however there are some properties that might be candidates for small projects to reduce runoff and improve habitat including native plantings, rain gardens, diversion, and infiltration trenches. All of these projects can be funded by WDNR Healthy Lake and Rivers grants.

Through the WDNR Fee Simple Land Easement & Acquisition grant fund and other land preservation agencies properties on and around Granite Lake could be protected from development by placing easements or outright purchase of the properties by the GLA.

Coarse woody habitat along the shores of and extending into Granite Lake is fairly prevalent around the lake, but with the amount of undeveloped shoreline, there could be a lot more. Fishsticks projects can be funded by Healthy Lakes and Rivers grants. Aquatic vegetation along the shore and the presence of coarse woody habitat can dampen the effect of boat-generated or natural waves on the shore.

It is anticipated that if boat landing project and enough shoreland improvement projects are implemented over the course of this plan, that overland runoff and the pollutants it contains can be almost eliminated from the nearshore area.

### *Lake*

One of the big issues affecting many lakes is wakes and large waves created by watercraft. Granite Lake is a long, narrow lake. When a boat that makes a large wake cruises up and down the lake, even in the middle, there is not enough time for these waves to dissipate before they crash into the shore where they may cause erosion, damage structures along the shore, or even wash over docks and boats moored by them. When more than one of these boats is operating on the same lake at the same time, the issues are compounded. Furthermore, while the mid-section of the lake is relatively deep, turn-around areas on either end are not. Prop wash from any boat operating in shallow areas of the lake can stir up bottom sediment and re-introduce nutrients that can negatively impact water quality and clarity.

Other lakes in the area have similar issues including Sand Lake and Beaver Dam Lake as they too are long and narrow. Just recently the Town of Bass Lake in Sawyer County, WI passed an ordinance requiring wakeboard boats to stay at least 700-ft from shore while operating. It is recommended in this plan that an education and awareness campaign be implemented first to see if some of the issues caused by boat use can be minimized. Consideration of an ordinance to restrict certain boat use should be a last resort only. Whatever the ordinance, it would have to be approved by the Town of Lakeland and may be specific to Granite Lake or apply to all lakes in the Town.

### *Watershed*

Within the watershed, the implementation of BMP (BMPs) for forestry and agriculture will be pursued. The GLA will have to work closely with Barron County to address problems already identified and to identify new problems that can be addressed. Barron County has said that there isn't a lot in the watershed that needs immediate attention, but further assessments can and are being made. Forestry practices in the watershed can be scrutinized with the goal being to make sure BMPs already recognized by the forestry industry are being implemented. Prior to the publishing of this report, the author made site visits to many of the wetland areas immediately adjacent to the lake that have been identified as potential restoration sites, only to find most of them in pretty decent shape. At least a couple of stream bank buffers and manure storage facilities have been identified by Barron County that may be a place to start.
Determining land use and monitoring runoff events from smaller areas of the watershed may help identify future projects as well.

Objective 2 is to collect data that will improve water quality management planning as it relates to internal loading of phosphorus.

Two areas that have a direct effect on Granite Lake and where additional data is needed are internal loading of phosphorus, and groundwater movement into and out of the lake. An In-lake phosphorus release study would collect sediment samples from the bottom of the lake and then set them up in a lab to mimic common lake conditions like no oxygen and high pH. The same study would need more information related to the concentration of phosphorus throughout the water column and more data related to when and for how long the lake stratifies and/or mixes. A groundwater study would likely include analysis of which way groundwater flows through the system and how much. It would also include analysis of water samples collected from wells around the lake for phosphorus.

Both of these studies could be funded by additional surface water planning grant funds. UW-STOUT's Center for Limnological Research and Rehabilitation could complete a sediment release study. Depending on the scope of a groundwater study, a local consultant or perhaps a state organization could complete it.

MEASUREMENT

Regular monitoring of water quality in Granite Lake will be the main measurement to determine whether this first objective is being met. Changes in land and how they impact phosphorus and Chl-A concentration can be modeled. The number of Healthy Lakes and River projects can be documented. Data from additional studies can be used to adapt current management strategies. A renovated boat landing would be the most visible measurement for these objectives.

**GOAL TWO**

Goal two is to keep new AIS from entering the lake and existing AIS from increasing their distribution and density. Currently Granite Lake is relatively free from aquatic invasive species with only a few instances of CLP, purple loosestrife, and Chinese mystery snails. No EWM has been found despite there being EWM in several of the lakes within just a few miles of the Granite Lake boat landing. No zebra mussels have been found. Unfortunately, not having EWM or zebra mussels could change on any given day. This goal has two objectives. The first is to implement prevention strategies including watercraft inspection at the boat landing, constituency education and awareness, and frequent monitoring. The second objective is to monitor for and remove pioneering plants of CLP and purple loosestrife regularly.

OBJECTIVES

This goal has two objectives: 1) to implement actions to prevent new AIS from entering and becoming established in the lake; and 2) to prevent existing AIS in the lake from increasing in distribution and density.

ACTIONS

The actions included under these objectives are simple and straight-forward. The first actions are to put in place programs that will help reduce the risk of new AIS entering the lake and that will educate lake users, hopefully raising their concern about AIS and pushing them in a direction that adds additional levels of protection for the lake. The WDNR and UW-Extension Lakes has a well-developed watercraft inspection program called Clean Boats Clean Waters (CBCW). CBCW places people at the landing during busy times to talk to and remind boaters of basic precautions they can take to prevent the spread of AIS from lake to lake.
Boaters use the landing even when a CBCW inspector is not present. As such there should be good AIS information at the landing in a very conspicuous location. Updated signage could include the installation of a "decontamination station" or maybe just signage with a more direct, less complicated message. Or, maybe it would be the opposite – greater detail to provide more information.

The boat landing on Granite Lake is due for renovation and will likely be one of the first actions completed in the first year or two of implementation of this plan. Under that scenario, updated signage could be one component built into the renovation plan.

Keeping AIS at bay depends on having a lot of people consciously thinking about them – whenever they are on or near the lake. An AIS Public Awareness and Education Campaign should be on-going. It could involve notes in a newsletter or on a web or Facebook page. It could involve annual AIS workshops or training events, or just materials handed out during GLA events. The point is to bring AIS up enough to always keep it on the minds of property owners and lake users.

The second objective associated with this goal builds on what is done as a part of the first objective. Trained lake volunteers can look for and remove pioneering AIS. The CLMN has an AIS monitoring component to it. The program offers materials and training for volunteers to be effective AIS monitors. Monitoring is not enough, particularly if what is found is left in the lake. Physical removal, in its many forms, including rake-removal from a boat, swimming and snorkeling, scuba diving, and keeping one's own lakefront free from AIS is an important part of lake protection. There are currently no AIS at a level in the lake that requires the use of chemical herbicides or other large-scale management alternatives.

MEASUREMENT

The measurement of a successful AIS prevention and education project is simply keeping new AIS out as long as possible and preventing existing AIS from being more than what it already is. Participation in CBCW and AIS monitoring can be tracked. At the end of a specified frame of time, data can be collected relative to the amount of awareness and involvement lake property owners and users have. In the 2018 Lake Use Survey, more than 50% of the respondents knew about AIS. If that survey were completed again in 5 or 10 years the responses could be used as a form of measurement.

## GOAL THREE

Goal Three is to manage aquatic plants in Granite Lake in a way that maintains lake use and reduces the impacts of non-native, invasive species. The aquatic plant community in Granite Lake is not overly detrimental to lake use. Except in a few areas, the littoral zone or plant growing area of the lake is narrow and drops fairly rapidly to deep water which minimizes the amount of dense growth vegetation. The exception to this is in the north and south ends of the lake where a mucky bottom and shallow water support greater plant growth. In these areas, filamentous algae is moderate to heavy in density. Filamentous algae causes some navigational impairment in this area, but mostly it is an aesthetic nuisance to those few property owners along the shore.

This goal also sets a threshold for when CLP likely reaches a level where physical removal should be augmented with other management alternatives including DASH, application of herbicide, and harvesting. And finally, this goal encourages the development of a Rapid Response Plan for other AIS that might be introduced into the lake.

OBJECTIVES

This goal has three objectives: 1) to implement actions to control native aquatic vegetation including filamentous algae that is causing nuisance or navigation; 2) to implement CLP management appropriate for the scale of infestation; 3) and to develop a plan to deal with new AIS if and when they get introduced to Granite Lake.

ACTIONS

As mentioned, native aquatic plant growth as a whole has not reached a level where many consider it a problem. Less than 50% of respondents in the 2018 survey felt that management to control aquatic plant growth might be necessary, 24% felt it was not needed at all. Still, there are likely times and places where there is a problem with plant growth. When that occurs, the best management action to implement is physical removal, primarily using a rake or rake/cutter combination. This is legal without a permit when the rake is operated by human power and all plants cut are removed from the lake.

One method of mechanical removal that may be of use in Granite Lake is a portable, remote controlled, small-scale harvester/skimmer. Removing the offending plant material floating on the surface is often enough to improve conditions. The remote controlled skimmer would do that, but would also require a mechanical harvesting permit from the WDNR to be legal. It is the belief of this consultant, that a permit for this activity would be approved. There is not enough of impairment on the lake to warrant contracted harvesting or skimming, or to spend tens of thousands of dollars to purchase their own full scale harvester.

Under Objective 2, aquatic plant management actions are specifically focused on CLP. At the present time, there have only been a few isolated CLP plants found in the littoral zone around the lake. In 2018, the plants found were rake-removed by the plant survey specialist. This is not difficult to do, and could be learned by a few or many GLA constituents. If physical removal by rake, snorkeler, and/or scuba diver is combined with monitoring, much can be done to prevent the expansion of CLP in the lake. If the density and/or distribution of CLP becomes too great, physical removal could be augmented by a more aggressive diver-aided suction harvest (DASH) provider or small-scale use of herbicides. Both of these activities may be eligible for grant funding support.

The objective lays out criteria for when to consider alternative management actions. The criteria are based on the number of plants found in what would amount to an acre of the lake. Individual CLP plants up to and around 50, could be the stepping point to the next management action. The number of plants is somewhat arbitrary and could be modified based on what is experienced in the lake. Moving from physical removal to the use of herbicides is conditioned on exceeding an acre of water having a significant amount of CLP. For the purposes of this plan, a significant amount means more than an acre of either high-density or bed forming CLP. High-density means an area with a recognizable boundary and where at least 25% of all plants are CLP. A bed is an area with a recognizable boundary and where at least 50% of all plants are CLP. This determination would be made in the year prior to any proposed chemical treatment.

CLP harvesting could also be implemented as an alternative to the use of herbicides. A higher threshold was set at >2 acres of high-density or bed forming CLP simply because contracted harvesting is quite expensive and not easily implemented.

The final action for this goal is to develop a rapid response plan for other AIS including EWM and zebra mussels to guide immediate planning if and when a new infestation is documented. This type of plan need not be very complicated. Its primary goal would be to identify who does what to immediately address a new infestation. This could be put together by the GLA following plans developed by other groups and with guidance from the WDNR and UW-Extension Lakes program.

MEASUREMENT

Measuring the parameters that would determine the type of aquatic plant management to be implemented in any given year is a product of having people living on Granite Lake trained to do it. Or, it is the money spent to hire an outside contractor to do it instead. Looking for CLP is not difficult if one knows what to look for and when. Physical removal does require some strength and stamina particularly if larger areas of the shoreline actually need to be cleaned up to improve navigation and reduce nuisance conditions. Working with all property owners to help secure assistance for those in need is a measurement that can be documented annually. Successful removal of CLP and other AIS can be measured by how much is found and how much is removed. The measurement for a Rapid Response Plan is the plan itself.

## GOAL FOUR

Goal four is to put in place a monitoring and evaluation program that support adaptive management for Granite Lake. The focus of this entire plan has been maintaining or improving water quality in the lake. Granite Lake is currently on the Wisconsin Impaired Waters list, being placed there in 2020 for water quality conditions based on Chl-A concentration (a measurement of the amount of algae in the lake water), that exceed the number of days the lake experiences algae levels that may be reduce lake use. Wisconsin is required to update the Impaired Waters list every two years. By the end of the next ten years, it is the goal to get Granite Lake off the list entirely. To do this means collecting enough data to accurately reflect what is going on in Granite Lake.

Aquatic plant growth, including algae is indicative of improving or worsening water quality. Monitoring changes in the aquatic plant community, native and non-native, is relative to the over health of Granite Lake. While this plan makes no recommendations for wide-scale aquatic plant management, it does open the door for management on a much smaller scale. There are a few properties that are impacted by dense growth vegetation and/or algae and management to provide relief on some level is included in this plan. Managing CLP and purple loosestrife is included in this plan, with most of the focus being on physical removal.

OBJECTIVES

This goal has two objectives: 1) to continue to document trends in water quality; and 2) to document changes in the aquatic plant community.

ACTIONS

The first action included under these objectives is to continue involvement in the CLMN expanded water quality monitoring program offered through the WDNR. CLMN covers water clarity, TP, and Chl-a sampling at one site in Granite Lake through the month of August. That one site is representative of the water quality in Granite Lake as a whole. Water sampling via CLMN for TP and Chl-a is not continued through the fall season, but it should be added. Granite Lake stratifies during the summer with stratification often lasting into Sept and October. Previous sampling results have indicated high phosphorus levels in October, likely the result of, or at least due in part, to internal loading.

Stratification is documented by collecting temperature and DO profiles throughout the open water season of the lake. The more time the lake is stratified and the depth at which stratification occurs directly relates to how much phosphorus may be recycled into the water column with the potential to reach the epilimnion or surface waters. In a somewhat shallow lake like Granite, stratification can be disrupted during a mixing event that may only last a few days or even a few hours. Unfortunately, past data really only includes one or at most two profiles taken during any given month. It has been speculated that this limited amount of profiling has missed mixing events during the summer season that might explain some of the algae blooms. Increasing the number of profiles to at least one per week for several years would provide greater detail and perhaps change recommended management actions to reduce phosphorus.

If the GLA were to sponsor a sediment nutrient release study on Granite Lake, it is likely that more sampling of different depths in the water column would be necessary to get a more accurate account of the phosphorus in the lake.

It is recommended that changes in the aquatic plant community be determined at least every five years by completing a whole-lake, point-intercept, aquatic plant survey. To date, two of these surveys have been done on Granite Lake, one in 2009 and one in 2018. This plan recommends the next survey be completed in 2025 unless between now and then a more active aquatic plant management plan is implemented or EWM is discovered in the lake.

MEASUREMENT

Measurements of the objectives associated with this goal are documentation that each of the actions has been completed or are on-going as the case may be. The data collected will be used on an annual basis and on a more long-term basis to implement adaptive management strategies. The measurement of any good management plan is whether or not it is adaptable or can be adapted to changing situations quickly and efficiently.

## GOAL FIVE

The fifth goal of this project is to follow through with implementation of this plan. Not every action in the plan is intended to be implemented immediately. Some are intended to be implemented on an annual basis throughout the entire timeframe covered by the plan. Others have a specified time frame. Some actions will require additional support from consultants and the WDNR through its grant funding programs, and some can be done by the GLA with little implementation costs.

Included in the Implementation Matrix, Appendix D is a list of all the individual goals, objectives, and actions that are to be implemented over the course of the next ten years and a when during that ten year period, each actions should be implemented. It will be important for the GLA to view this schedule and determine what parts of it are of highest priority to them so both human resources and financial support can be appropriated. The Implementation Matrix provides a place for the GLA to prioritize the actions. Once that has been done, implementation begins leading to the objectives associated with this goal.

### OBJECTIVES

There are three objectives associated with this goal: 1) to complete annual project and assessment reports annually; 2) to complete and mid- and end-of-project reports; and 3) to develop and maintain the necessary partnerships to support implementation of this project over time.

### ACTIONS

Under the first objective is preparing annual summary reports of the actions implemented in each year of the project. In some cases the action may be completed in the same year, in others, it may take several years for an action to be completed. The success of any plan depends on its adaptability. The purpose of the annual reports is to use that information to adapt whatever parts of the Plan that needs it to improve successive year planning and implementation.

Under the second objective, a more long-term approach to summary reporting is taken. Midway through the implementation of this plan, around 2025, the GLA and its partners should take stock in what has been accomplished and what has not. This assessment can be used to modify approaches or focus for the second half of the project. And, at the end of the project, a full assessment will determine if long-term goals have been met. It would also set in motion an update of the Comprehensive Plan for the next 10 years.

Under the third objective, the GLA will develop, maintain, and improve partnerships with those outside entities that are needed to support successful implementation of the entire 10 year project. Communication by the GLA with the community that Granite Lake is in, its constituents, its partners, and the WDNR are critical to the efficient and effective implementation of this plan.

### MEASUREMENT

Measurement to determine whether this goal has been met is continuous. If implementation occurs in a sensible, coordinated way that makes it possible to accomplish each objective there will be improvements in Granite Lake. If the plan seems like it is going to end up sitting on a shelf for lack of implementation, it is inherent upon the GLA to recognize this and take steps to change the course.

## EVALUATION AND MONITORING

Listing and delisting of a lake on the Impaired Waters list is dependent on an evaluation of appropriate data from the most recent 10-yr period, with data from the most recent 5-yrs given preference as it is more likely to be representative of the current conditions (Bureau of Water Quality Program Guidance, 2020). For both TP and Chl-A, it is the goal of the WDNR to have at least three samples per year over at least two qualifying years for both TP and Chl-A that meet the following data requirements:

- Sampling season for TP is June 1 - Sept 15.
  - For TP samples in May and/or late September may be added if it can be demonstrated that the lake is thermally stratified during that time period.
- Sampling season for Chl-A is July 15 - Sept 15
- One sample per month, taken as close to the middle of the month as possible
- Sample dates must be spaced at least 15 days apart to evenly represent the season
- Field collection, preservation and storage should follow procedures outlined in the WDNR Filed Procedures Manual and the Citizen Lake Monitoring Manual
- Laboratory analysis should follow standard methods (WSLH 1993)
- Only surface samples taken from the top 2 meters of the lake collected using grab (not at the surface) or depth-integrated methods.
- Both TP and Chl-A results should be expressed in μg/l.

It is important that the water quality data collected by the GLA and other entities meet these requirements so evaluations of change over time can be completed. Ultimately, delisting of Granite Lake will be dependent on the quality of the data collected.

### CLMN (CLMN)

This volunteer-based monitoring network provides an opportunity for citizens to take an active role in monitoring and helping to maintain water quality. Through this network, lake volunteers and resource professionals can learn more about individual lakes across Wisconsin.

Secchi disk monitoring is the backbone of CLMN and is the most common type of monitoring. Secchi volunteers collect water clarity information on their lakes throughout the open water season. After collecting Secchi data for one or more years, some volunteers choose to get involved in other types of monitoring. Secchi volunteers may be asked by their Lakes Coordinator to collect chemistry data on their lake. This more extensive volunteer monitoring allows WDNR lake managers to assess the nutrient enrichment state for their lakes. In addition, some volunteers also collect temperature and DO data for their lakes. Other types of monitoring activities include aquatic invasive species monitoring and native aquatic plant monitoring.

Chemistry volunteers collect phosphorus and chlorophyll samples four times a year in addition to collecting Secchi data. Chemistry volunteers collect a phosphorus sample during spring overturn (or turnover) which happens within two weeks after ice out; and phosphorus and chlorophyll samples the last two weeks of June, July, and August. The Network provides all of the equipment and training needed to collect the water samples and data. Volunteers are responsible for providing distilled water for cleaning water sampling equipment, and ice for shipping the water samples to the State Lab of Hygiene (WSLH). Volunteers also provide the boat and fuel to get to the sampling location. Chemistry monitoring requires a fairly substantial time commitment. Although Secchi disk sampling may only take a few minutes, lake chemistry sampling may take up to several hours to complete. Table 21 provides more detail about when CLMN water samples, Secchi readings, and temperature and DO profiles should be taken. To get even better data on potentially polymictic lakes, temperature and DO profiles could be collected weekly, particularly once the lake is showing stratification.

**Table 21: Recommended seasonal schedule for chemistry, temperature, and dissolved oxygen as a part of the CLMN program for Wisconsin lakes** *(Betz & Howard, 2020)*

**Season Schedule for Chemistry, Temperature and Dissolved Oxygen Monitoring**

| Parameters | April/May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| **Secchi** | Every 10 to 14 days check satellite dates | Every 10 to 14 days check satellite dates | Every 10 to 14 days check satellite dates | Every 10 to 14 days check satellite dates | Every 10 to 14 days check satellite dates | 1 to 3 times if possible |
| **Phosphorus** | Yes within 2 weeks of ice off | Yes last 2 weeks of June | Yes last 2 weeks of July | Yes last 2 weeks of August or early September | No | No |
| **Chlorophyll** | No | Yes last 2 weeks of June | Yes last 2 weeks of July | Yes last 2 weeks of August or early September | No | No |
| **Temp. Profile** | Yes | Yes | Yes | Yes | Yes | optional |
| **D.O. Profile** (If collecting) | Yes | Yes | Yes | Yes | Yes | optional |

It is important to collect the April/May phosphorus sample when the lake is still "turning over" – ideally within two weeks of ice out.

If possible, there should be about one month between the summer chemistry (total phosphorus, chlorophyll) dates.

Ice out and ice on dates can be entered into the CLMN database.

**Satellite dates and paths are listed on the CLMN web page.**

Granite Lake volunteers are already collected water quality data as a part of the CLMN expanded monitoring program. This involvement should continue, with more focus on staying within the guidelines in Table 21. Taking Secchi readings and temperature/DO profiles on a weekly basis beginning in mid-June through at least the end of September would provide much more usable data.

## STEWARDSHIP AND CONSERVATION EASEMENT GRANTS

Wisconsin law recognizes that certain nonprofit conservation organizations may play a role in managing lakes. These NCOs are eligible to receive funds under the Surface Water Grant Program and under the state Stewardship Fund Program if their purposes include the acquisition of land for conservation purposes and if they are recognized as federal tax-exempt organizations under section 501(c)(3) of the Internal Revenue Code. Under all of these programs, the WDNR can award matching grants to these organizations for certain land or conservation easement purchases and for some habitat restoration activities. Lake associations can qualify as NCOs if their purposes include the acquisition of land for conservation purposes and if they are recognized as federal tax-exempt organizations under section 501(c)(3) of the Internal Revenue Code.

Nonprofit conservation organizations (NCOs) may apply for funding from eight Stewardship grant subprograms to help fund the acquisition of land and conservation easements. Four of these grant subprograms are only open to NCO applicants. GLA Eligibility - Maybe

- **Habitat Area Grants** - Habitat area grants are awarded to conserve wildlife habitat in Wisconsin in order to expand opportunities for wildlife-based recreation such as hunting, trapping, hiking, bird watching, fishing, nature appreciation and wildlife viewing. Land purchased with habitat area grants must be open to the public for low-impact nature-based recreation. Habitat areas are not intended for intensive recreational use such as mountain biking, motorized vehicle use, horseback riding or camping.
- **Natural Area Grants** - Stewardship natural area grants complement the State Natural Areas (SNA) Program, dedicated to the preservation of Wisconsin's native natural communities and habitat for rare plant and animal species. Land purchased with natural area grants must be open to the public for low-impact nature-based recreation and scientific study. Natural areas are not intended for intensive recreational use such as mountain biking, motorized vehicle use, horseback riding or camping.
- **Streambank Protection Grants** - Streambank protection grants are awarded to protect water quality and fish habitat. Priority is given to land or easement purchases along designated Outstanding or Exceptional Resource Waters, projects that connect sections of protected stream corridor, and projects that will mitigate the impact of agricultural runoff.
- **State Trail Grants** - State trail grants are awarded to purchase lands or easements identified as part of the State Trail system including designated State Water Trails. Priority is given to lands along nationally designated Ice Age and North Country trail corridors and to lands that connect established trail systems.

## SURFACE WATER RESTORATION AND MANAGEMENT GRANTS

Healthy Lakes & Rivers is a subprogram of the Surface Water Management grant program that focuses on shoreland landowners that want to install practices on their property to improve habitat and water quality. Healthy Lakes & Rivers grants support five simple and inexpensive best practices that may be installed in the littoral, transition/buffer, and upland zones of shoreland properties. Practices must follow department guidelines published in the Healthy Lakes and Rivers Action Plan and supporting technical guidance. GLA Eligibility - Yes

Surface water restoration grants help you implement protection and restoration actions. Choose from a set of best practices to make a difference right away. Unlike plan implementation grants, these projects don't require a management plan, however, projects shall follow the appropriate NRCS standards and shall be submitted with a project design plan. The following is a list of projects eligible for funding under this grant program. GLA Eligibility - Yes

- Critical area stabilization
- Diversions
- Filter strips
- Grade stabilization structures on artificial or non-navigable watercourses
- Riparian buffers
- Water bars
- Sediment and water basins
- Pervious pavement
- Rain gardens
- Vegetation planting
- Urban pollution and runoff control
- Streambank or shoreline protection
- Impervious area removal within 35 feet of the ordinary high-water mark

In-water management projects protect or improve in-water conditions. Eligible activities include the installation of department-approved habitat structures, culvert or road crossing removal or modification, and aquatic re-vegetation. Aeration projects are eligible if dissolved oxygen levels are below water quality standards and the project will provide adequate supply. Aeration for sediment translocation is not eligible. Other projects are subject to department approval. GLA Eligibility - Maybe

Wetland Restoration projects will help restore or enhance a prior converted or existing wetland. Projects must occur on hydric soils and implement the best practices for wetland restoration or enhancement. Projects must follow the NRCS standards for either Wetland Restoration or Wetland Enhancement. Eligible activities included drainage tile disablement, ditch plugs and fills, water level manipulation or vegetation enhancement, but cannot be necessary to achieve mitigation standards. GLA Eligibility - Yes

Wetland Incentives are available for grantees that have completed a comprehensive land use plan that includes a recommendation for wetland enhancement or restoration. Incentive grants are $10,000 each with no cost-sharing required. Activities are the same as those for Wetland Restoration projects, above. GLA Eligibility - Yes

Ordinance Development projects help a grantee develop local regulations to support water quality, aquatic life, and habitat. Ordinances include lake use, boating, conservancy, wetland, shoreland, floodplain, construction erosion control and others. Eligible activities include development, legal fees, facility rental, training for compliance and enforcement, and presentation for adoption as well as an assessment of the administrative and enforcement capacity and implementation costs. GLA Eligibility - Yes

Management plan implementation projects will always implement an approved recommendation found in a surface water management plan. Projects will improve or protect surface water or aquatic ecosystems. Eligible activities include the actions necessary to implement the recommendation. Management plan implementation grants support a broad range of projects, some examples are below. GLA Eligibility - Yes

- **Nonpoint Source Pollution Control** projects reduce the loading of nutrients and sediment into the waterbody. A wide range of BMP are available depending on the pollution source and location. For additional examples, see the list of practices outlined under s. NR 154.04. Applications should be specific as to the BMPs proposed and their location.
- **Habitat Restoration** projects improve the shoreline, nearshore or upland habitat in a way that will significantly improve the ecological condition of surface water or aquatic life.
- **Water Quality** projects address problems related to water quality that remain after BMP have

controlled nonpoint source pollution. Activities include alum treatments or other solutions that support a return to the natural characteristics of a lake, wetland or river.

- **Management Staffing** grants provide funding for implementation and support. The project must result in the implementation of one or more approved recommendations in one or more management plans. Applications must be submitted with a position description, including goals, objectives and tasks, and the percentage of time assigned to each activity. For grants of over 1,000 hours, the department may require semi-annual performance reviews.
- **Applied Management** studies employ a research-based approach to increase understanding of surface water management. Projects must implement an approved recommendation from a management plan; some will involve close collaboration with community groups. Projects will employ innovative approaches, experiments, or otherwise increase understanding waterbody protection and restoration.
- **Landowner Incentives** encourage the implementation of an approved management plan recommendation. Payments may provide incentive for installing conservation best practices, participating in program-approved initiatives, or taking agricultural land out of production. Landowner incentive costs do not include the cost of implementation of the best management practice. Applications must include a justification, a description of the payment and documentation process, and expected outcomes. Incentive payments may make up no more than 10% of total project cost of a grant. One-time or annual incentive payments should include compensation for a period no greater than 3 years or the duration of the grant period.

More information about these grant programs can be found in Appendix E.

## WORKS CITED


Allenby, K. (1981). Some analyses of Aquatic Plants and Their Waters. *Hydrobiologia*, 177-189.

Apslund, T. R. (2000). *The Effects of Motorized Watercraft on Aquatic Ecosystems.* Madison: Wisconsin Department of Natural Resources.

Barron County SWCD. (2020). *Barron County Land and Water Resource Management Plan 2020-2029.* Barron: Barron County.

Berg, M. (2008). *2008 Big Chetac Lake Summer Point-intercept Aquatic Plant Survey.* St, Croix Falls: Endangered Resources Services, LLC.

Berg, M. (2013). *2013 Big Chetac Lake Post-treatment, Point-intercept Aquatic Plant Survey.* St. Croix Falls.

Berg, M. (2017). *Warm-water Point-intercept Macrophyte and Fall Eurasian Water-milfoil Bed Mapping Surveys Red Lake- WBIC 2492100 Douglas County Wisconsin.* St. Croix Falls, Wisconsin: Endangered Resource Services, LLC.

Berg, M. (2019). *Curly-leaf pondweed Point-intercept and Bed Mapping Surveys, and Warm-water Macrophyte Point-intercept Survey Granite Lake.* St. Croix Falls: Endangered Resource Services.

Berg, M. S. (2017a). *2017 Big Chetac Lake PI Macrophyte Survey.* St. Croix Falls, WI: ERS, LLC.

Betz, C., & Howard, P. (2020). *Wisconsin Citizen Lake Monitoring Training Manual (Chemistry Procedures)*. Madison, WI, USA: Bureau of Science Services.

Bureau of Water Quality Program Guidance. (2020). *Wisconsin 2020 Consilidated Assessment and Listing Methodology (WisCALM) for CWA Section 3030(d) and 305(b) Integrated Reporting.* Madison: Wisconsin Department of Natural Resources.

Caffrey, A. J., Hoyer, M. V., & Canfield, D. E. (2007). Factors affecting the maximum depth of colonization by submersed macrophytes in Florida lakes. *Lake and Resevoir Management*, 287-297.

Center for Limnology. (2019). *AIS Smart Prevention Tool 2.0*. Retrieved from https://uwlimnology.shinyapps.io/AISSmartPrevention2/

Christensen, D., Hewig, B., Schindler, D. E., & Carpenter, S. (1996). Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. *Ecological Applications 6 (4)*, 1143-1149.

Cooke, C. D., & Kennedy, R. H. (1981). *Precipitation and Inactivation of Phosphorus as a Lake Restoration Technique.* Corvallis: EPA Research and Developmenet.

*Data USA.* (2017). Retrieved December 21, 2019, from https://datausa.io/profile/geo/sawyer-county-wi

Eichler, L., Bombard, R., Sutherland, J., & Boylen, C. (1993). Suction harvesting of Eurasian watermilfoil and its effect on native plant communities. *Journal of Aquatic Plant Management 31*, 144-148.

Florida LAKEWATCH. (2001). *A Beginner's Guide to Water Management - Water Clarity.* Gainesville: University of Florida/Institute of Food and Agricultural Sciences - Department of Fisheries and Aquatic Services.

Franti, T., Eisenhauer, D., McCullough, M., Stahr, L., Doskey, M., Snow, D., et al. (2004). *Watershed Scale Impacts of Buffers and Upland Conservation Practices on Agrochemical Delivery to Streams.* Lincoln: USDA Forest Services/UNL Faculty Publications.

Fulton, S., & West, B. (2002). Forestry Impacts on Water Quality. In D. N. Wear, & J. G. Greis, *Southern Forest Resource Assessment* (pp. 501-518). Asheville, NC: United States Department of Agricluture.

Garrison, P., & LaLiberte, G. (2010). *2010 Paleoecological Study of Lake Chetac, Sawyer County.* Wisconsin Department of Natural Resources, Bureau of Science Services.

Gensemer, R. W., & Playle, R. C. (1999). The Bioavailability and Toxicity of Aluminum in Aquatic Enviroments. *Critical Reviews in Environmental Science and Technology*, 315-450.

Hansen, J., Reitzel, K., Jensen, H., & Anderson, F. (2003). Efects of aluminum, iron, oxygen and nitrate additions on phosphorus release from teh sediment of a Danish softwater lake. *Hydrobiologia*, 139-149.

Hunt, M., Herron, E., & Green, L. (2012, March). *The University of Rhode Island.* Retrieved December 18, 2018, from URI Watershed Watch: http://cels.uri.edu/docslink/ww/water-quality-factsheets/Chlorides.pdf

Huser, B. J., Egemose, S., Harper, H., Hupfer, M., Jensen, H., Pilgrim, K. M., et al. (2015). Longevity and effectiveness of aluminum addition to reduce sediment phophorus release and restore lake water quality. *Water Research*.

James, W. (2013). *Phosphorus Budget Analysis and Alum Dosage Estimation for Big Chetac Lake, Wisconsin.* Menomonie, WI: University of Wisconsin - Stout Discovery Center - Sustainabbility Sciences Institute.

James, W. (2016). Internal P Loading: A Pesistent Management Problem in Lake Recovery. *Lake and Reservoir Management - NALMS*.

Jennings, M., Emmons, E., Hatzenbeler, G., Edwards, C., & Bozek, M. (2003). Is littoral habitat affected by residential development and land use in watersheds of Wisconsin lakes? *Lake Reservoir Management, 19 (3)*, 272-279.

Keller, D. (2017). Low-Speed Boating...Managing the Wave. *NALMS - LakeLine - Fall*, 10-11.

*Lake Access*. (2018). Retrieved December 17, 2018, from http://www.lakeaccess.org/

Madsen, J. (1997). *Methods for management of nonindigenous aquatic plants.* New York: Springer.

Madsen, J. (2000). *Advantages and disadvantages of aquatic plant management techniques.* Vicksburg, MS: US Army Corps of Engineers Aquatic Plant Control Research Program.

NALMS. (2004). *The Use of Alum for Lake Management.* Madison: North American Lake Management Society.

Newman, R., Holmberg, K., Biesboer, D., & Penner, B. (1996). Effects of the potential biological control agent, Euhrychiopsis lecontei, on Eurasian watermilfoil in experimental tanks. *Aquatic Botany 53*, 131-150.

Nichols, S. (1999). Floristic Quality Assessment of Wisconsin Lake Plant Communities wiht Example Applications. *Journal of Lake and Reservoir Management*, 133-141.

Nurnberg, G. K. (2009). Assessing internal phosphorus load - Problems to be solved. *Lake and Resevoir Management*, 419-432.

Osgood, R. (1988). Lake mixix and internal phosphorus dynamics. *Hydrobiologia*, 629-638.

Peterson, S. (1982). Lake Restoration By Sediment Removal. *Journal of American Water Resources Association*, 423-436.

Pine, R., & Anderson, W. (1991). Plant preferences of Triploid grass carp. *Journal of Aquatic Plant Management 29*, 80-82.

Roesler, C. (2008). Unpublished data. WI, USA: WDNR.

Sass, G. (2009, Volume 1). Coarse Woody Debris in Lakes and Streams. *Encyclopedia of Inland Waters*, pp. 60-69.

(2010). *Sawyer County Comprehensive Plan.* Northwest Regional Planning Commission.

Schechter, S. P., Canfield, T. J., & Meyer, P. M. (2013). *A Meta-Analysis of Phosphorous Attenuation in Best Management Practices (BMP) and Low Impact Development (LID) Practices in Urban and Agricultural Areas.* Ada: EPA.

Scheffer, M. (1998). *Ecology of Shallow Lakes.* Norwell, MA: Kluwer Academic Publishers.

Sebolt, D. (1998, January). *Galerucella calmariensis and G. pusilla:Biological Control Agents of Purple Loosestrife*. Retrieved January 3, 2017, from Midwest Biological Control News Online: http://www.entomology.wisc.edu/mbcn/kyf501.html

Sorsa, K., Nordheim, E., & Andrews, J. (1988). Integrated control of Eurasian wataer milfoil by a fungal pathogen and herbicide. *Journal of Aquatic Plant Management 26*, 12-17.

Stadelmann, T. H., Brezonik, P. L., & Kloiber, S. (2001). Seasonal Patterns of Chlorophyll a and Secchi Disk Transparency in Lakes of East-Central Minnesota: Implications for Design of Ground- and Satellite-Based Monitoring Programs. *Lake and Reservoir Management, 17*(4), 299-314.

Tobiessen, P., Swart, J., & Benjamin, S. (1992). Dredging to control curly-leaf pondweed: a decade later. *Journal of Aquatic Plant Management*, 71-72.

Vassios, J., Nissen, S., Koschnick, T., & Heilman, M. (2014). Triclopyr Absorption and Translocation by Eurasian Watermilfoil (Myriophyllum spicatum) Following Liquid and Granular Applications. *Weed Science*, 22-28.

Waisel, Y., Oerteli, J., & Stahel, A. (1990). The Role of Macrophytes in Phosphorous Turnover: Sources and Sinks. *Proceedings of the 8th Symposium on Aquatic Weeds*, 243-248.

WDNR. (2018). 2020 WisCALM Public Comment Period: Update Supplemental Information. Madison: Wisconsin Department of Natural Resources.

WDNR. (2019-20). *Creel Survey Report Granite Lake, Barron County.* Spooner: WDNR.

WDNR. (2020). *Guidance for Implementing Wisconsin's Phosphorus Water Quality Standards for Point Source Discharges.* WDNR.

WDNR. (n.d.). *Watersheds and Basins*. Retrieved December 31, 2019, from https://dnr.wi.gov/water/watershedDetail.aspx?key=924649

Wisconsin Groundwater Coordinating Council. (2002, July). Groundwater and Its Role in Comprehensive Planning. WI.

Wolter, M. (2012). *Lakeshore Woody Habitat in Review.* Hayward, WI: Wisconsin Department of Natural Resources.

Zimmerman, R. C., Pasini, A. C., & Alberte, R. S. (1994). Modeling Daily Production of Aquatic Macrophytes from Irradiance Measurements: A Comparative Analysis. *Marine Ecoloy Progress Series*, 185-196.

# Appendix A – Aquatic Plant Management Alternatives

# Appendix B – NR 109

# Appendix C – Granite Lake Comprehensive Plan: Goals, Objectives, and Actions

# Appendix D – Granite Lake Implementation Matrix

# Appendix E – WDNR Surface Water Grants Program