Little Butternut Lake
Lake Management Plan, 2022-2032

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Little Butternut Lake Association

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Purpose of the Study

In December 2019, the Polk County Land and Water Resources Department applied for a Wisconsin Department of Natural Resources Lake Planning Grant in partnership with the Little Butternut Lake Association. The grant was awarded, and data collection occurred in 2020 and 2021.

Methods and activities completed through this grant award include:

- ✓ Lake resident survey
- ✓ Lake level and precipitation monitoring data
- ✓ In-lake physical and chemical data
- ✓ Tributary physical and chemical data
- ✓ Phytoplankton
- ✓ Black crappie sarcoma survey
- ✓ Spring and fall point intercept plant surveys
- ✓ Goose population survey
- ✓ Shoreline inventory
- ✓ Septic inventory
- ✓ Watershed delineation and boundaries
- ✓ Watershed modeling
- ✓ No-till and cover crop inventory
- ✓ Agricultural conservation planning framework
- ✓ Pontoon classroom

The following report details the methods and activities completed through this grant award.

Executive Summary

- Little Butternut Lake is 185 acres in size with a maximum depth of 23 feet. Butternut Creek enters Little Butternut Lake from Big Butternut Lake on the east side of the lake and exits the lake on the north side, eventually flowing to Long Trade Lake.

- A lake resident survey completed by 37 property owners (52% response rate) ranked top concerns for Little Butternut Lake as: excessive aquatic plant growth, excessive algae blooms, lack of water clarity, and poor water quality.

- In 2020 and 2021, the upper two meters of Little Butternut Lake were well oxygenated and the bottom waters became anoxic.

- Little Butternut Lake is classified as a eutrophic lake. Eutrophic lakes are generally high in nutrients and support many plants and animals. They are usually very productive and subject to frequent algae blooms. Eutrophic lakes often support large fish populations but are susceptible to oxygen depletion.

- The average summer index period (July 15th – September 15th) trophic status was 62 in 2020 (eutrophic) and 59 in 2021 (mildly eutrophic).

- Little Butternut Lake was placed on the 303(d) Impaired Waters List in 2022 for total phosphorus for recreation use and fish and aquatic life use and for chlorophyll a for recreation use. The impairment threshold for total phosphorus is greater than or equal to 40 µg/L for both recreational use and fish and aquatic life use. The impairment threshold for chlorophyll a for recreational use is exceeded if greater than 30% of the days in the sampling season have moderate algal levels (greater than 20 µg/L chlorophyll).

- The state standard for total phosphorus for streams is set at 75 ug/L. The Little Butternut Lake inlet was below the standard in 2020 (69.2 ug/L) but well above the standard in 2021 (161 ug/L). The Little Butternut Lake outlet was below this standard in both years of the study (44 ug/L in 2020 and 43 ug/L in 2021).

- The algae community was dominated by blue-green algae in both years of the study with concentrations being the greatest in July of 2020. In 2021, Little Butternut Lake had less algae (especially blue-green algae) as compared to 2020.

- Little Butternut Lake has an abundant black crappie population but unfortunately it is affected by a disease called black crappie sarcoma. In 2020, 28 of the 421 black crappies caught (7%) had symptoms consistent with black crappie sarcoma. In 2021, 85 crappies were caught and 9 had symptoms (11%).

- Twenty-four aquatic plant species were found in Little Butternut Lake. In June, plant growth covered 44% of the lake and in August plant growth covered 40% of the lake. The floristic quality index evaluates the closeness of the flora in an area to that of an undisturbed condition. Values for Little Butternut Lake were greater than the values for the North Central Hardwood Forest. Curly leaf pondweed was the only invasive species found in the survey.

- Three invasive species (curly-leaf pondweed, yellow iris, and purple loosestrife) have been documented on Little Butternut Lake.

- A Canada goose population survey was conducted four times in June of 2020 and three times in June of 2021. In 2020 the average number of adult geese was 13 and the number of goslings was 34. In 2021 the number of adults was 16 and the number of goslings was 38.

- A shoreline inventory indicated that 76% of the shoreline of Little Butternut Lake has canopy cover present and that 78% of the ground cover in the riparian buffer zone is shrubs/herbaceous plants. Twenty percent of the ground cover in the riparian buffer zone was lawn. Runoff concerns including channelized water flow, lawn/soil sloping to lake, bare soil, sand/silt deposits, and slumping banks exist on Little Butternut Lake.

- The Ascent Permit Management Suite system for tracking sanity permits was used to determine compliance for the seventy-five septic systems near Little Butternut Lake. Fifty systems (72%) were in compliance, with the remaining twenty-three systems (27%) being out of compliance. Of the non-complaint systems, six have not been serviced in eight or more years and three systems have no records on file.

- The Little Butternut Lake watershed is 6,770 acres in size. The most common land use in the Little Butternut Lake Watershed is forest (50%), followed by rural residential (10%), row crops (9%), and wetland (9%).

- The annual phosphorus load to Little Butternut Lake is 1,357 pounds of phosphorus per year. To achieve the phosphorus standard for Little Butternut Lake (40 µg/L) the external phosphorus load to Little Butternut Lake would need to be reduced by 3%, from 1,357 to 1,318 pounds of phosphorus per year.

- Overall, internal loading and septic loading is predicted to be insignificant to the nutrient budget for Little Butternut Lake.

- The Little Butternut Lake Watershed was divided into four sub watersheds: Little Butternut North, Little Butternut West, Little Butternut South, and Big Butternut Sub. The sub watershed contributing the greatest phosphorus load to Little Butternut Lake is the West Sub Watershed.

- The agricultural land base in the Little Butternut Lake Watershed consists primarily of row crops (corn and soybeans) (50%) and perennial vegetation (forage and pasture) (29%). Conventional tillage (31%) is more common than no-till (20%). Cover crops have not been adopted in the watershed. If all suitable acres in 2020 had been planted using no-till and cover crops, phosphorous loading in the Little Butternut Lake Watershed would have been reduced by 46%.

- The Agriculture Conservation Planning Framework was used to prioritize conservation practices on agricultural lands in the Little Butternut Lake Watershed. The program recommended and prioritized a variety of conservation practices for implementation including water and sediment control basins, contour buffer strips, grass waterways, farm ponds, and riparian attribute polygons.

- In 2022, stakeholders met to develop an implementation plan for Little Butternut Lake which included 3 goals:

  Goal 1. Improve water quality on Little Butternut Lake

  Goal 2. Increase natural beauty and habitat for fish and wildlife on Little Butternut Lake

  Goal 3. Use multiple strategies to ensure the goals of the plan are met

- Many of the goals in the implementation plan are eligible for grant funding through the Wisconsin Department of Natural Resources Surface Water Grants program.

Background Information on Lakes, Studies, and Management Plans

Lakes are a product of the landscape they are situated in and of the actions that take place on the land which surrounds them. Factors such as lake size, lake depth, water sources, and geology all cause inherent differences in lake quality. As a result, lakes situated near one another can differ profoundly in the uses they support.

A landscape can be divided into watersheds and sub watersheds. These areas define the land that drains to a particular lake, flowage, stream, or river. Watersheds that preserve native vegetation and minimize impervious surfaces (cement, concrete, and other materials that water can't permeate) are less likely to result in negative impacts on lakes, rivers, and streams. This arises because rain and melting snow eventually end up in lakes and streams through surface runoff or groundwater infiltration. Rain and melting snow entering a waterbody are not inherently problematic. However, water can carry nutrients, bacteria, sediments, and chemicals into a waterbody. These inputs can impact aquatic organisms such as insects, fish, and wildlife and—especially in the case of the nutrient phosphorus—fuel problematic algae blooms.

Lake studies examine the underlying factors that impact a lake's health, such as lake size, depth, water sources, and the land use in a lake's watershed. Many forms of data can be collected and analyzed to gauge a lake's health including physical data (oxygen, temperature, etc.), chemical data (including nutrients such a phosphorus and nitrogen), biological data (algae, zooplankton, and aquatic plants), geological data (soils, glacial till, and sediment chemistry) and land use within a lake's watershed.

Lake studies identify challenges and threats to a lake's health along with opportunities for improvement. Studies identify practices already being implemented by watershed residents to improve water quality and areas providing benefits to a lake's ecosystem. They also quantify practices or areas in the watershed which have the potential to negatively impact the health of a lake and identify best management practices for improvement.

The product of a lake study is a **Lake Management Plan** which identifies goals, objectives, and action items to either maintain or improve the health of a lake. Goals should be realistic based on inherent lake and watershed characteristics (lake size, depth, land use etc.) and should align with the goals of watershed residents. Lake management plans are designed to be working documents that are used to guide the actions which take place to manage a specific lake.

Introduction to Little Butternut Lake

Little Butternut Lake is in the Town of Luck in Polk County Wisconsin, approximately 60 miles northeast of the Minneapolis/St. Paul MN metropolitan area. The lake is located entirely in the Town of Luck, which is 33 square miles and had a 2018 population of 927 people. The lake is designated as an ASNRI Wild Rice Area. Nearly the entire shoreline, except for two segments along the south end of the lake, is designated into two ASNRI Sensitive Areas that merit special protection of aquatic habitat. These areas of aquatic vegetation offer critical or unique fish and wildlife habitat. According to Natural Heritage Inventory data, seven natural communities and four species[1] occur in the Town of Luck.

Little Butternut Lake is 185 acres in size with a maximum depth of 23 feet. Butternut Creek enters Little Butternut Lake from Big Butternut Lake on the east side of the lake and exits the lake on the north side, eventually flowing to Long Trade Lake.

Four invasive species (curly-leaf pondweed, narrow leaf cattail, yellow iris, and purple loosestrife) have been documented on Little Butternut Lake.

Polk County owns a parcel of land on the north end of the lake that includes the public access. Polk County maintains the landing. The Town of Luck owns a parcel of land on the south end of the lake. A parcel on the east side of the lake resides in the Village of Luck. Public use is moderate in the summer and busier in the winter. West Denmark Church owns several parcels on the west side of the lake and maintains a building for private rental. The Church hosts Family Camp each summer.

Little Butternut Lake has an active lake association that was formed in 2002.

The area of land that drains to a lake is called a watershed. Little Butternut Lake is situated within the Trade River Watershed which is 195 square miles (124,800 acres) and extends into Burnett County. The watershed has 167 miles of streams and rivers, 2,902 acres of lakes, 21,757 acres of wetlands, and is dominated by forest (46%), grassland (19%), and mixed wetlands (17%). [2]

On a smaller scale, the area of land that drains to Little Butternut Lake is also defined as the Little Butternut Lake Watershed. This study used ArcMap and LiDAR data to delineate the Little Butternut Lake Watershed, which is 6,777 acres. Land use in the Little

[1] Two threatened, one special concern fully protected by federal and state laws under the migratory bird act, and one special concern take regulated by the establishment of open-close seasons

[2] https://dnr.wi.gov/water/watershedDetail.aspx?code=SC10&Name=Trade%20River

Butternut Lake watershed is primarily forest (50%), rural residential (10%), wetland (9%), and row crops (9%).

Lakes are hydrologically classified according to their primary source of water and how that water enters and leaves the system. Little Butternut Lake is classified as a shallow mixed drainage lake. Drainage lakes receive most of their water from the surrounding watershed in the form of stream drainage, have a prominent inlet and outlet that moves water through the system, and commonly have high nutrient levels due to inputs from the watershed.

The trophic state is a measure of a lakes health which relates to the amount of algae in the water. The average summer trophic state for the last five years was 60 (eutrophic). For a shallow lowland lake this is considered good. Volunteers have been monitoring water clarity since 2014. Little Butternut Lake was placed on the Impaired Waters List in 2022 for total phosphorus for aquatic life and recreation use and for chlorophyll a for recreation use.

Little Butternut Lake Characteristics [3]

Area: 185 acres
Maximum depth: 23 feet
Mean depth: 8 feet
Bottom: 45% sand, 5% gravel, 0% rock, and 50% muck
Hydrologic lake type: drainage
Invasive species: yellow iris, curly-leaf pondweed, and purple loosestrife.
Fish: panfish, largemouth bass, northern pike and walleye
Trophic Status: eutrophic

[3] https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2640700&page=facts

Lake Classification

Lake classification in Polk County is a relatively simple model that considers:

- ✓ Lake surface area
- ✓ Maximum depth
- ✓ Lake type
- ✓ Watershed area
- ✓ Shoreline irregularity
- ✓ Existing level of shoreline development

These parameters are used to classify lakes as class one, class two, or class three lakes.

Class one lakes are large and highly developed.
Class two lakes are less developed and more sensitive to development pressure.
Class three lakes are usually small, have little or no development, and are very sensitive to development pressure.

Little Butternut Lake is classified as a class one lake with low vulnerability and moderate development.

Impaired Waters

Wisconsin lakes, rivers, and streams are managed to determine if their conditions are meeting state and federal water quality standards. Water samples are collected through monitoring studies and results are compared to guidelines designed to evaluate conditions as compared to state standards. General assessments place waters in four different categories: poor, fair, good, and excellent. The results of assessments can be used to determine which actions will ensure that water quality standards are being met (anti-degradation, maintenance, or restoration).

If a waterbody does not meet water quality standards, it is placed on Wisconsin's Impaired Waters List under the Federal Clean Water Act, Section 303(d). Every two years the State of Wisconsin is required to submit list updates to the United States Environmental Protection Agency for approval.

Waterbodies are listed as impaired based on pollutants including total phosphorus, total suspended solids, and metals. Waters are assigned four uses (fish and aquatic life, recreation, public health and welfare, and wildlife) that carry with them a set of goals.

Impairment thresholds vary for each use and based on lake characteristics such as whether a waterbody is shallow or deep and whether a waterbody is a drainage or seepage lake. Little Butternut Lake is classified as a shallow lowland drainage lake.[4]

Little Butternut Lake was placed on the Impaired Waters List in 2022 for the pollutant total phosphorus and the impairments of eutrophication and excess algal growth. The lake was listed for total phosphorus for aquatic life and recreation. Additionally, chlorophyll a data exceeded recreation thresholds.

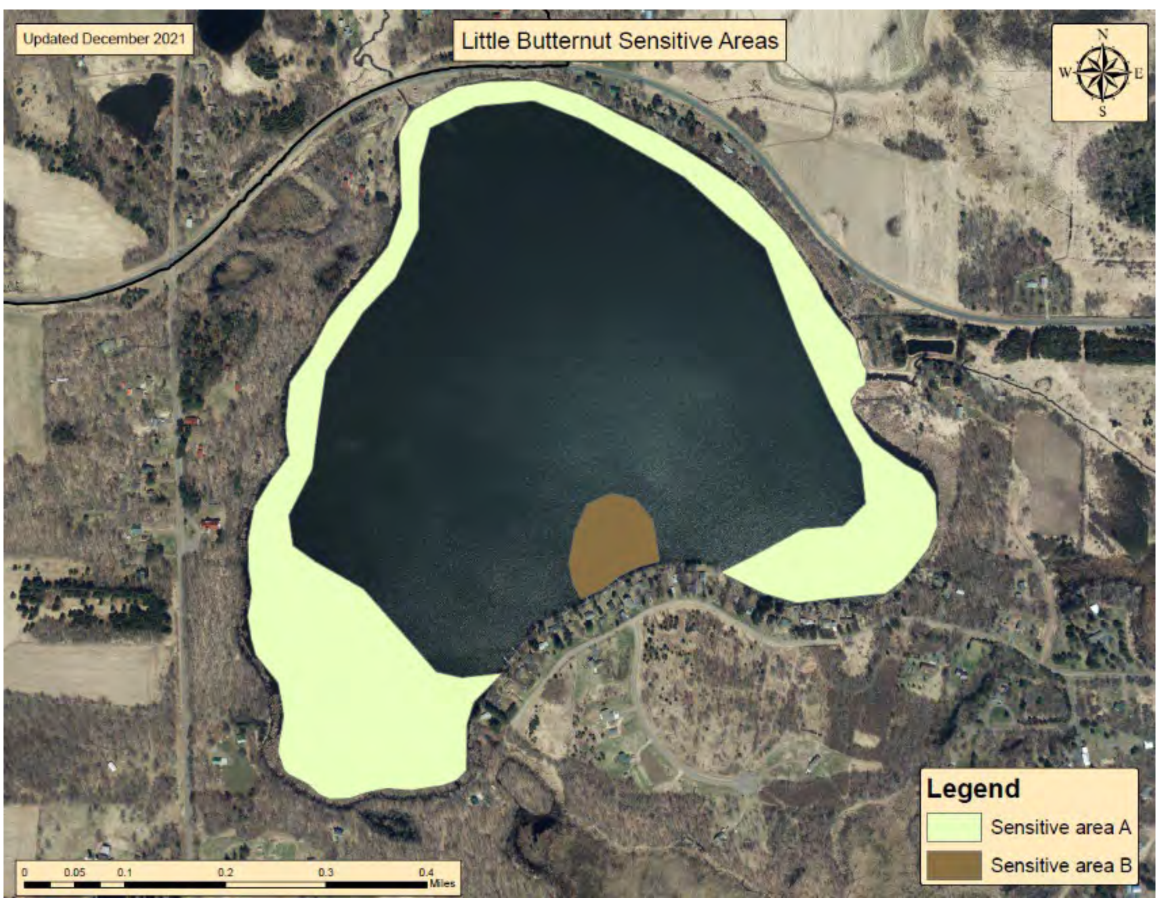
The impairment threshold for total phosphorus is greater than or equal to 40 µg/L for both recreational use and fish and aquatic life use. The impairment threshold for chlorophyll a for recreational use is exceeded if greater than 30% of the days in the sampling season have moderate algal levels (greater than 20 µg/L chlorophyll).

[4] Listing thresholds are found in Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) for CWA Section 303(d) and 305(b) Integrated Reporting, Assessment Guidance for 2021-2022, Wisconsin Department of Natural Resources, January 2021

Previous Lake Studies

This grant is the first-time award of a large-scale planning grant for Little Butternut Lake. Prior to this grant, a comprehensive study had never been done on the lake and a LMP and APM had never been developed. Existing lake data is limited and includes secchi depth (2014, 2015, 2017-2019), total phosphorus (2015), chlorophyll a (2015), and a point intercept survey (2015).

The 2000 Integrated Sensitive Area Survey Report identified two areas along the shoreline of Little Butternut Lake that merit special protection of aquatic habitat. These areas of aquatic vegetation offer critical or unique fish and wildlife habitat while providing shoreline stabilization. Sensitive area A includes much of the shoreline of the lake and is considered an open/shallow water wetland. Sensitive area B is dominated by a shallow or open water wetland on the south side of the lake. Both sensitive areas provide important habitat for forage species and wildlife in addition to spawning and nursery areas for bass, panfish, and northern pike. Wild rice was documented in sensitive area A. Chemical and mechanical plant removal are strongly discouraged in sensitive areas and should be limited to navigation channels.



Lake Resident Survey

A Wisconsin Department of Natural Resources approved survey was mailed to eighty-eight property owners on and around Little Butternut Lake in spring of 2021. Thirty-seven surveys were returned (52% response rate) and data was entered and analyzed.

Survey respondents have owned their property on Little Butternut Lake for an average of 17.5 years. Half of respondents use their property as a year-round residence (49%) and one third use their property as a weekend, vacation, and/or holiday residence (32%). Fewer respondents use their property as a seasonal residence (11%) or do not occupy the property (8%). On average, properties on Little Butternut Lake are used 209 days per year and occupied by 4.6 people.

Nearly two-thirds of respondents own property on the shoreline of Little Butternut Lake (61%). The survey asked respondents to describe the first 35 feet of their shoreland (the area located directly adjacent to the lake). Approximately two-thirds of respondents indicated their property contained mowed lawn (68%). Around three-fourths of respondents indicated that their shoreline contained un-mowed vegetation (77%), nearly two-thirds indicated that their shoreline contained shrubs/trees (59%), and a smaller number of respondents indicated their shoreland has undisturbed woods (18%). Over half of respondents indicated that they had a dock or pier (59%) and very few indicated they had stabilizing rock/rip rap (14%).

The survey asked respondents which activities they enjoy on Little Butternut Lake. The most popular activities include enjoying peace and tranquility (89%), enjoying the scenic view (84%), open water fishing (70%), observing birds/wildlife (68%) motorized boating (62%), ice fishing (46%), swimming (38%), and non-motorized boating (38%).

The survey asked how many days a month respondents use the Little Butternut Lake boat landing during the open water and ice on season. More respondents use the boat landing in the open water season (61%) as compared to the ice on season (31%). The average days per month the landing was used was approximately 2 days in both seasons.

Nearly a quarter of survey respondents (22%) do not use watercraft on Little Butternut Lake. The most common watercraft used on the lake are canoes (35%) and motorboats/pontoons that are 21-50 HP (32%). Fewer respondents use motorboats/pontoons that are greater than 50 HP (22%), motorboats/pontoons that are 1-20 HP (19%), and paddleboats/rowboats (14%).

To quantify risk of spreading aquatic invasive species, survey respondents were asked if the watercraft they use on Little Butternut Lake are used on other waterbodies. Only a small portion of boats that are used on Little Butternut Lake are used on different waterbodies (24%), with most boats (76%) only being used on Little Butternut Lake. Survey participants were asked to describe their typical cleaning routine after using watercraft on water other than Little Butternut Lake. Most respondents removed aquatic hitchhikers (86%) and around half of respondents air dry their boat for 5 or more days (57%) and drained their bilge (50%). Fewer respondents rinsed their boat (29%), power washed their boat (14%), or applied bleach to their boat (7%). Fourteen percent of respondents indicated that they do not clean their boat.

Respondents were asked to rank their degree of concern with nineteen issues as high, medium, low, issue exists but isn't a concern, and issue doesn't exist. Responses for this question were analyzed using a point system. Each issue ranked as high received 4 points, as medium received 3 points, as low received 2 points, as exists but not a concern 1 point, and as not an issue received 0 points. Total points were averaged to determine a final rank.

Issues with a final ranking of high to medium concern included: excessive aquatic plant growth, excessive algae blooms, lack of water clarity, and poor water quality. The remaining issues ranked as lower concerns.

What is your degree of concern with each issue listed below?	Rank
Excessive aquatic plant growth	3.5
Excessive algae blooms	3.4
Lack of water clarity	3.1
Poor water quality	3.1
Decrease in overall lake health	2.9
New invasive species entering the lake	2.9
Increased nutrients from failing septic systems	2.6
Presence of black crappie sarcoma in the lake	2.5
Runoff from lakeshore properties	2.5
Reduced fish abundance in the lake	2.5
Runoff from surrounding farmland	2.5
Undesired species of fish in the lake	2.1
Loss of natural scenery/beauty	2.0
Increased development	1.9
Decreased property values	1.9

Excessive noise level on the lake	1.8
Unsafe use of motorized watercraft	1.6
Decreased wildlife populations	1.5
Disregard for slow-no-wake zones	1.2

Lake levels can vary over the course of the year and from year to year. Residents were asked to describe the current lake level of Little Butternut Lake. Over half of respondents described the current lake level as just right (58%), with the remaining respondents describing the lake level as too low (42%).

When asked to describe the current water quality on Little Butternut Lake, nearly half of respondents described it as fair (42%). More respondents described water quality as very good/good (34%) as compared very poor/poor (25%). Survey respondents were asked to identify how water quality has changed in the time they have lived on/near the lake. Nearly a quarter of respondents felt that water quality has neither degraded or improved (23%), whereas half of respondents felt that the water quality has severely or somewhat degraded (49%). Nearly a third of respondents haven't been on the lake long enough to notice a change (29%). No respondents felt that water quality had improved.

The survey also asked respondents what they think of when assessing water quality. Over three-quarters of respondents think of clarity (clearness of water) (86%) and water color (80%) and two-thirds of respondents think of algae blooms (69%), aquatic plants (69%), and smell (66%). Around half of respondents think of water level (54%) when assessing water quality. Respondents were also asked to identify the two most important aspects of water quality, with the top responses being water clarity and algae blooms.

The survey asked a variety of questions regarding algae and aquatic plants. Respondents were asked to describe the amount of aquatic plants and algae in Little Butternut Lake, what months during the open water season algae and aquatic plants are a problem, and what uses are impaired as a result of algae and aquatic plants.

A large majority of respondents consider algae to be problematic in August (79%), and July (65%). Fewer respondents consider algae to be problematic in September (38%) and June (18%). Approximately two-thirds of respondents indicated that overall enjoyment of the lake (67%) and swimming (62%) are impaired by algae. Less than half of respondents indicated that boating (44%) and fishing (42%) were impaired by algae.

Three fourths of survey respondents described the amount of aquatic plants on the lake as too many (76%) and around a quarter described the amount of aquatic plants as healthy (21%). More than three fourths of respondents indicated that aquatic plant growth is a problem in July (88%) and August (88%). Fewer respondents considered aquatic plant growth to be a problem in September (42%) and June (39%). Around two thirds of respondents indicated that overall enjoyment of the lake (69%), boating (68%), swimming (65%), and fishing (63%) are limited by aquatic plants. Fewer respondents (30%) indicated that navigation was limited by aquatic plants.

Earlier in the survey, 68% of respondents indicated that the area 35 feet back from their shoreline contained mowed lawn. Later, the survey asked respondents to describe the current amount of mowed lawn across the entire shoreline of Little Butternut Lake. More than three fourths of respondents described the amount of lawn as just right (83%). Fewer respondents indicated that the amount of lawn was too much (17%) and zero respondents indicated the amount of lawn was not enough.

The survey listed five different landscaping practices designed to reduce nutrient runoff from properties. Respondents were asked to indicate if they are unfamiliar with the practice, familiar with the practice but have not installed it, have already installed the practice, or are planning to install the practice. Practices already implemented by respondents include not fertilizing/using zero phosphorus fertilizer (55%) and native shoreline plantings (27%). A small number of respondents are planning to implement these same practices (7% and 3%, respectively). In general, respondents were unfamiliar with the remaining landscape practices which included infiltration pits or trenches (83%), water diversions (74%), and rain gardens (63%).

Survey respondents were asked to provide feedback on what factors would motivate or convince them to install a practice to reduce waterfront runoff on their property. Over three fourths of respondents would be motivated to install a practice to improve the water quality of Little Butternut Lake (79%). Approximately half of respondents would be motivated by how to information about landscaping practices for water quality (45%), financial assistance that pays a portion of the cost of installation (45%), and no-cost technical assistance that would identify appropriate practices to install (42%).

Three fourths of respondents do not use fertilizer on their property (78%) and nearly one fourth use zero phosphorus fertilizer (17%). A small minority use fertilizer but are unsure of its phosphorus content (6%).

The survey also asked questions pertaining to Little Butternut Lake's Canada goose population. Just over half of respondents are annoyed by Canada geese visiting their property (56%). Less than half of respondents indicated there are too many Canada geese nesting and raising young around Little Butternut Lake lakeshore properties (44%). A third of respondents felt that the Association should take measures to reduce and/or control the number of Canada geese around Little Butternut Lake (37%).

The survey noted that geese prefer lawn over tall/native shoreline vegetation because tall vegetation impedes flight and their view of predators. The survey then asked respondents if they would convert their lawn to tall/native vegetation along the shoreline to repel geese. Combined, three fourths of respondents already have tall/native shoreline vegetation (68%) or would be interested in converting their shoreline to tall/native vegetation (10%). A quarter of respondents are not interesting in converting their shoreline from lawn to tall/native vegetation (23%).

Survey respondents were asked how they prefer to receive information from the Little Butternut Lake Association. Respondents indicated that the preferred method of communication was a newsletter (62%), followed by email (59%), and an annual meeting (41%). Fewer respondents preferred and a website (21%) or Facebook (18%) and a small percentage of respondents would prefer not to receive information (9%).

The survey asked respondents to indicate which actions should be completed by the Little Butternut Lake Association to manage the lake. Around three fourths of respondents supported programs to prevent and monitor invasive species (82%) and offering incentives for upgrades to non-conforming septic systems (72%). Over half of respondents supported efforts to reduce the Canada goose population (60%) and practices to enhance fisheries (59%). Half of respondents supported offering incentives for property owners to install shoreline buffers/rain gardens (50%). Fewer respondents supported lake fairs and workshops to share information (23%), offering incentives for farmland conservation practices (17%), and enforcement of slow-no-wake zones (16%).

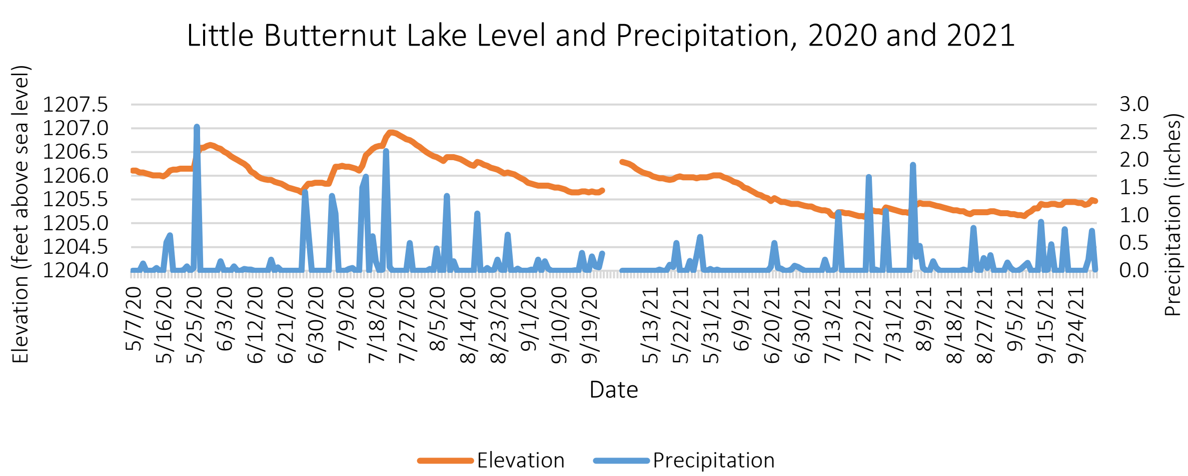
The survey asked respondents which activities they were interested in participating in to improve Little Butternut Lake. Half of respondents were interested in learning how to monitor water quality (45%) and approximately one-third were interested in learning how to identify invasive species (35%), monitoring water quality (32%), installing a shoreline buffer (29%), installing a rain garden (29%).

Lake Level and Precipitation Monitoring

Lake water-level fluctuations are important to lake managers, lakeshore property owners, developers, and recreational users because they can have significant impacts on lake water quality and usability. Although lake levels naturally change from year to year, extreme high or low levels can present problems such as restricted water access, flooding, shoreline and structure damage, and changes in near shore vegetation. Records of lake water elevations can be useful in understanding changes that may occur in lakes.

A volunteer monitored lake level and precipitation on Little Butternut Lake in 2020 and 2021. Polk County Land and Water Resources Department provided training on data collection. The Polk County Surveyor calibrated the staff gauge by referencing the numbered height on the gauge to the surveyed elevation of the water when the gauge was installed in the spring and prior to removal in the fall. Monitoring began in the spring and continued through fall.

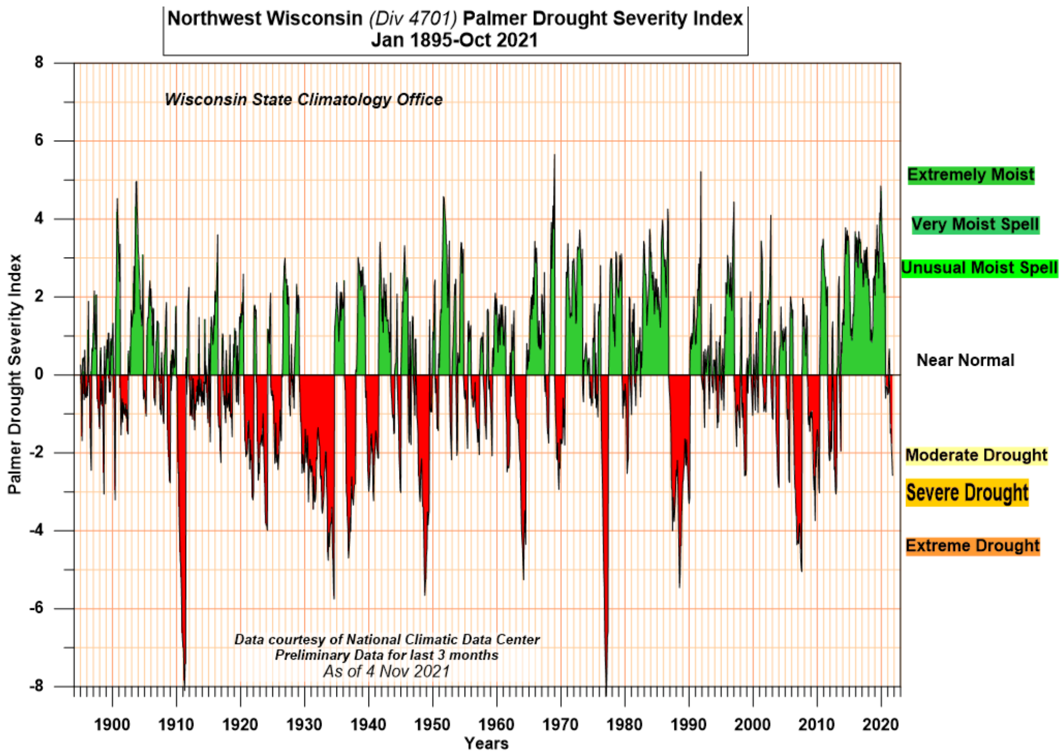
Seasonal precipitation on Little Butternut Lake totaled 21.46 inches in 2020 [5] and 14.69 inches in 2021. [6] Lake level responded to precipitation events, with levels increasing following rainfall events. This response was more pronounced in 2020 as compared to 2021. Lake level in Little Butternut Lake varied 1.78 feet over the two-year sampling period when comparing the highest (July 2020) and lowest elevation (July 2021).



[5] 147 sampling days, May 7th through September 23rd

[6] 143 sampling days, May 5th through October 4th

Wisconsin State Climatology Office data indicate that 2020 began as a period of very moist and unusually moist conditions and ended as near normal. As 2021 progressed, conditions moved from near normal to moderate and severe drought.



Lake Mixing and Stratification

Water quality is affected by the degree to which water in a lake mixes. Within a lake, mixing is impacted by the temperature-density relationship of water. When comparing why certain lakes mix differently than others, lake area, depth, shape, and position in the landscape become important factors to consider.

Water reaches its greatest density at 3.9^{o}C (39^{o}F) and becomes less dense as temperatures increase and decrease. Compared to other liquids, the temperature-density relationship of water is unusual: liquid water is more dense than water in its solid form (ice). As a result, ice floats on liquid water.

When ice melts in the early spring, the temperature and density of water will be constant from the top to the bottom of a lake. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake and nutrients are re-suspended from the sediments. This event is termed spring turnover.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. Generally, in a shallow lake, the water may remain mixed all summer. However, a deeper lake usually experiences layering based on temperature differences, called stratification.

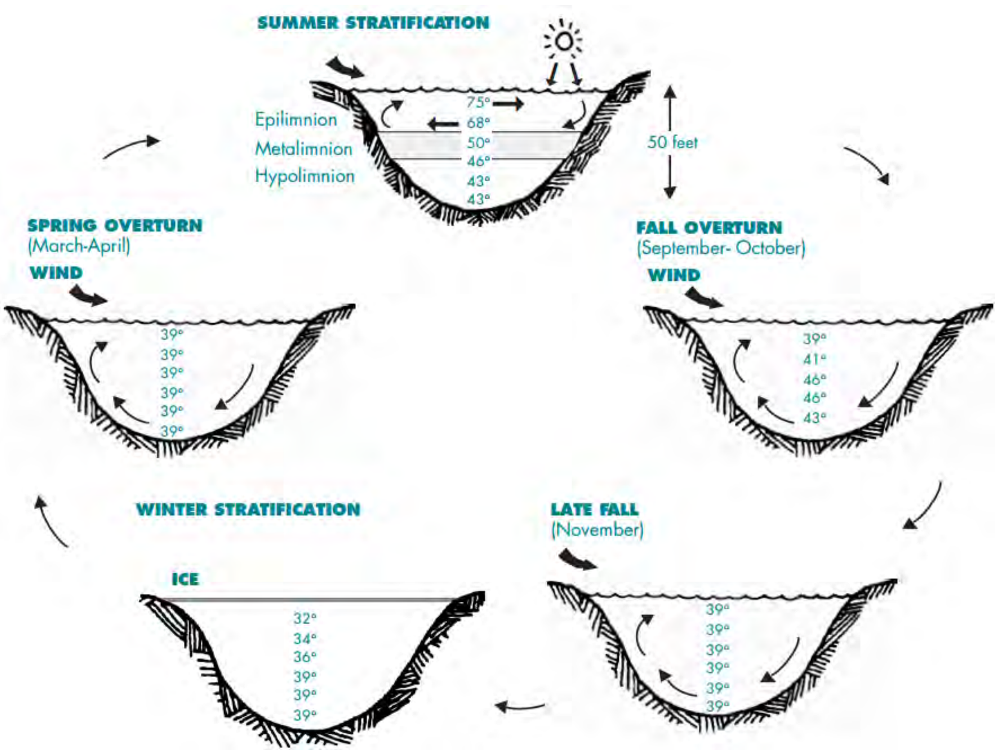
During the summer, lakes have the potential to divide into three distinct zones: the epilimnion, thermocline or metalimnion, and the hypolimnion. The epilimnion describes the warmer surface layer of a lake and the hypolimnion describes the cooler bottom area of a lake. The thermocline, or metalimnion, describes the transition area between the epilimnion and hypolimnion.

As surface waters cool in the fall, they become more dense and sink until the water temperature evens out from top to bottom. This process is called fall turnover and allows for a second mixing event to occur. Occasionally, algae blooms can occur at fall turnover when nutrients from the hypolimnion are made available throughout the water column. In the winter, stratification remains constant because ice cover prevents mixing by wind.

Variations in density arising from differences in water temperatures can prevent warmer water from mixing with cooler water. As a result, nutrients released from the sediments can become trapped in the hypolimnion of a lake that stratifies. Additionally, since mixing is one of the main ways oxygen is distributed throughout a lake, lakes that don't mix have the potential to have low levels of oxygen in the hypolimnion.

If oxygen is available in the hypolimnion, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve and phosphorus is redistributed throughout the water column with strong wind action or turnover events. The release of phosphorus from lake bottom sediments is termed internal loading.

The absence of oxygen in the hypolimnion can have adverse effects on fisheries. Species of cold-water fish require the cooler waters that result from stratification. Cold water holds more oxygen as compared to warm water. As a result, the cooler waters of the hypolimnion can provide a refuge for cold water fisheries in the summer if oxygen is present. Respiration by plants, animals, and especially bacteria is the primary way oxygen is removed from the hypolimnion. A large algae bloom can also cause oxygen depletion in the hypolimnion as algae die, sink, and decay.



[7]

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[7] Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

Deep Hole Sampling Procedure

In-lake data was collected by the Polk County Land and Water Resources Department during the 2020 and 2021 growing season.

Lake profile monitoring

Dissolved oxygen, temperature, conductivity, specific conductance, and pH were recorded at meter increments biweekly with a YSI Professional Series Pro DSS.

Secchi depth

Secchi depth was recorded with an eight-inch diameter round disk with alternating black and white quadrants called a secchi disk. To record secchi depth, the disk was lowered into the lake on the shady side of a boat until just before it disappeared from sight. This depth was measured in feet and recorded as the secchi depth. Data was collected biweekly to correspond with lake profile monitoring readings.

Chemistry and chlorophyll a

Top samples were collected once a month with a composite sampler and bottom samples were collected once a month with a Van Dorn sampler. Water samples were analyzed at the Water and Environmental Analysis Lab. Top samples were analyzed for total phosphorus, soluble reactive phosphorus, nitrate/nitrite, ammonium, total Kjeldahl nitrogen, total suspended solids, chloride, and chlorophyll a. Bottom samples were analyzed for total phosphorus and iron.

Citizen Lake Monitoring Network

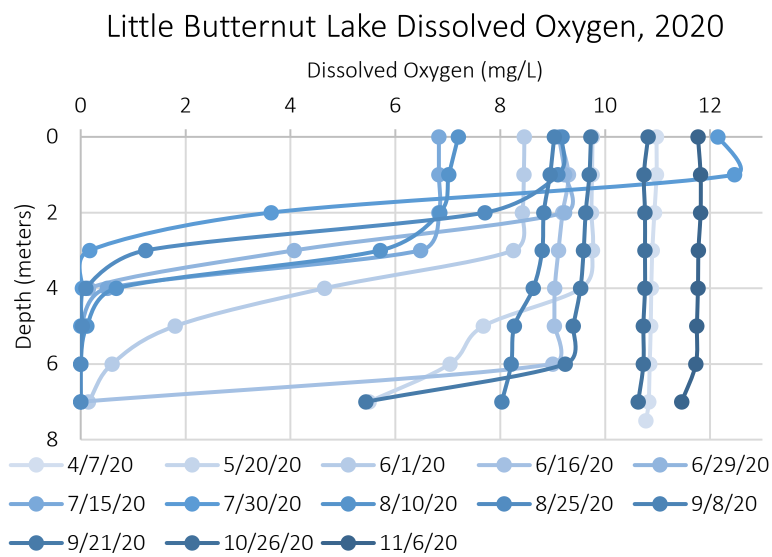
Volunteers collected secchi depth as part of the Citizen Lake Monitoring Network program.

Dissolved Oxygen

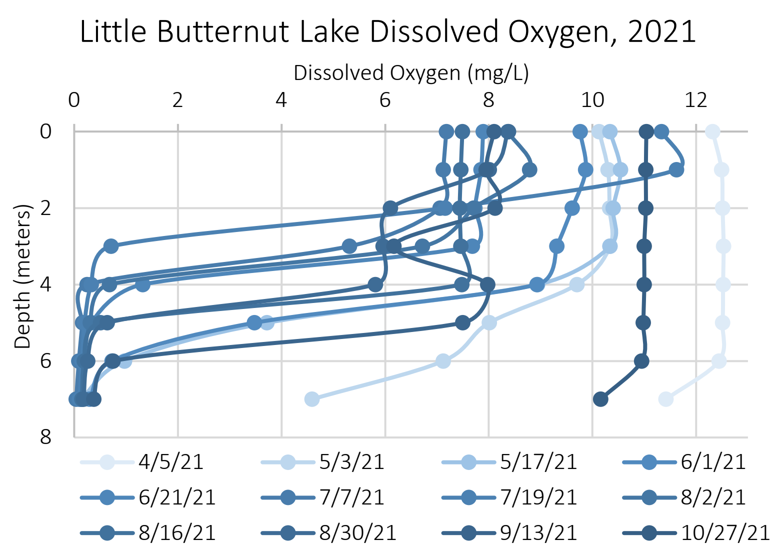
Oxygen is required by aquatic organisms for survival. The amount of oxygen dissolved in water depends on temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering a lake.

Plants produce oxygen in a process called photosynthesis. Since photosynthesis requires light, oxygen production occurs during the daylight hours at depths where sunlight can reach. During the sunlight hours, dissolved oxygen levels at a lake's surface may be quite high. Conversely, at night or early in the morning, dissolved oxygen values can be expected to be lower. Plants and animals use oxygen in a process called respiration.

It is not uncommon for oxygen depletion to occur in the hypolimnion because mixing is unable to introduce oxygen, oxygen producing photosynthesis is not occurring, and the only reaction occurring is oxygen consuming respiration.



A water quality standard for dissolved oxygen based on the minimum amount of oxygen required by fish for survival and growth in warm water lakes and streams is set at 5 mg/L. For cold water lakes supporting trout, the standard is set even higher at 7 mg/L.

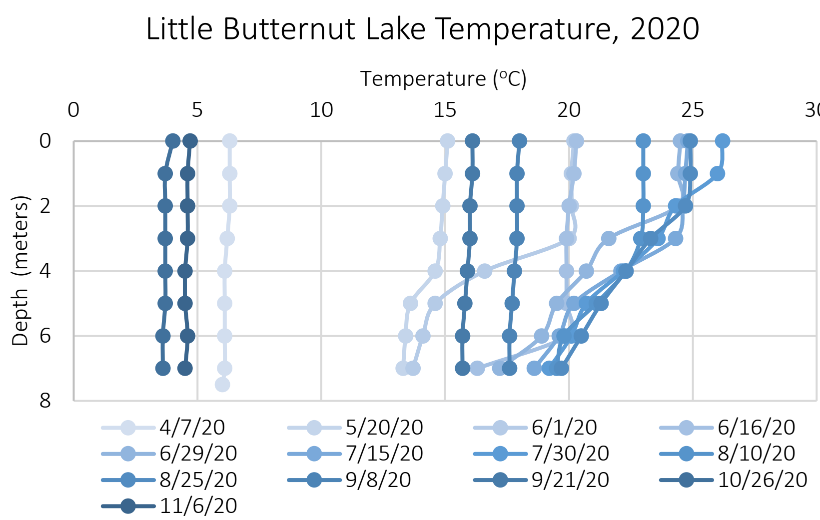


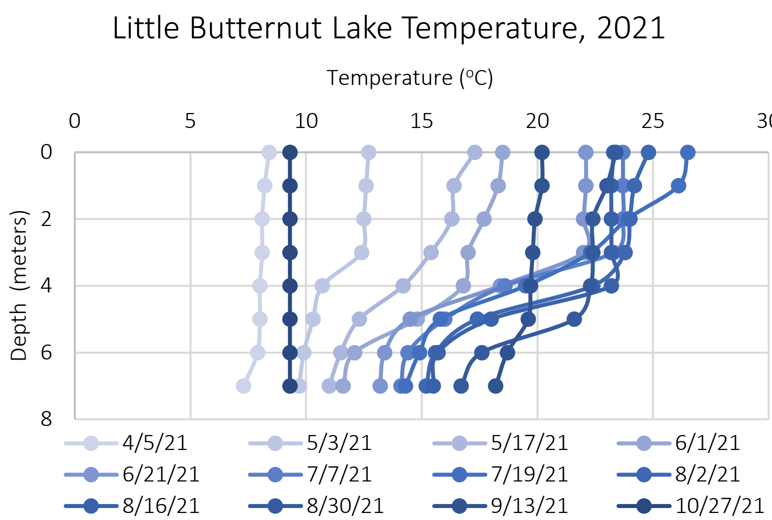
In both years of the study the upper two meters were well oxygenated and the bottom waters became anoxic.

Temperature

Little Butternut Lake weakly stratified, or set up density dependent layers, during both years of the study. The upper level of the lake, or the epilimnion, reached to a depth of two to three meters during much of the growing season. The water in this area of the lake is warmer and well mixed by wind and wave action. The cooler bottom area of the lake, or the hypolimnion, does not mix with the waters of the epilimnion.

The surface temperature was greatest in July and August in both years of the study.





Surface Temperature on Little Butternut Lake (°C)	
4/7/20	6.3
5/20/20	15.1
6/1/20	20.2
6/16/20	20.3
6/29/20	24.5
7/15/20	24.8
7/30/20	26.2
8/10/20	23.0
8/25/20	24.9
9/8/20	18.0
9/21/20	16.1
10/26/20	4.0
11/6/20	4.7
4/5/21	8.4
5/3/21	12.7
5/17/21	17.3
6/1/21	18.5
6/21/21	22.1
7/7/21	23.7
7/19/21	26.5
8/2/21	24.8
8/16/21	23.3
8/30/21	23.4
9/13/21	20.2
10/27/21	9.3

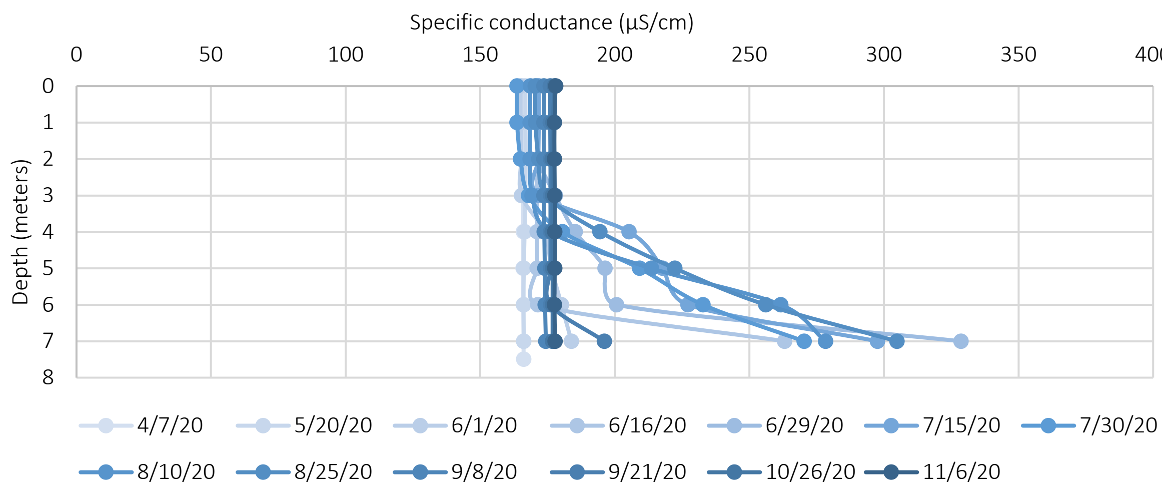
Specific Conductance (Conductivity)

Conductivity measures the ability of water to conduct an electrical current and is an indicator of the concentration of total dissolved inorganic chemicals in the water. Values increase as the concentration of dissolved minerals in a lake increase. Since conductivity is temperature related, values are normalized at 25°C and termed specific conductance.

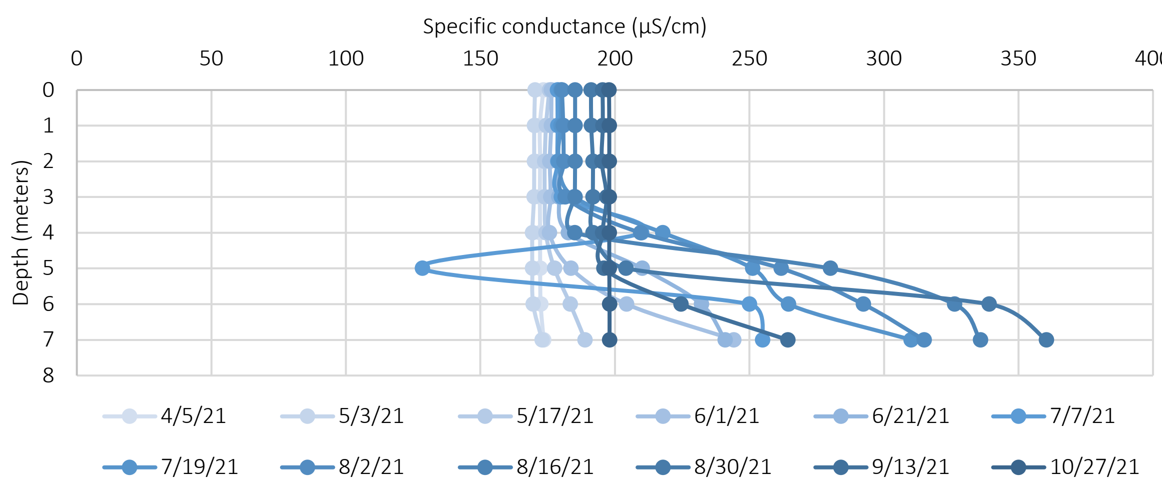
When watersheds contain easily dissolved carbonate rocks, lakes are more likely to have higher conductivity. Watersheds that contain slow-to-dissolve rocks, such as granite, are more likely to have lower conductivity. Lakes with especially low conductivity are also more likely to be precipitation dominated (rather than groundwater or runoff dominated), because precipitation contains very little dissolved minerals.

Specific conductance values at the surface of Little Butternut Lake were between 160 and 200 µS/cm. Values increased in the bottom meter of the lake during the growing season.

Little Butternut Lake Specific Conductance, 2020



Little Butternut Lake Specific Conductance, 2021



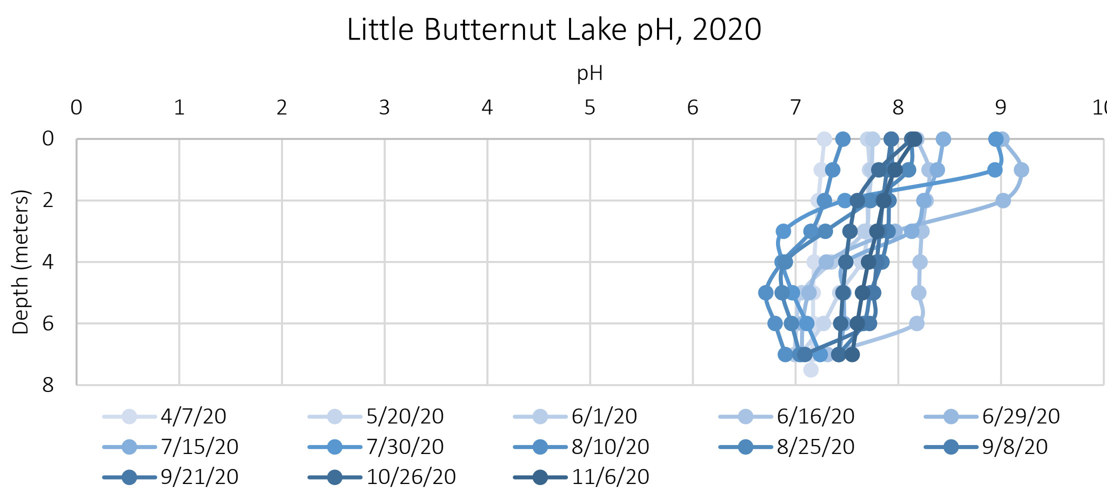
pH

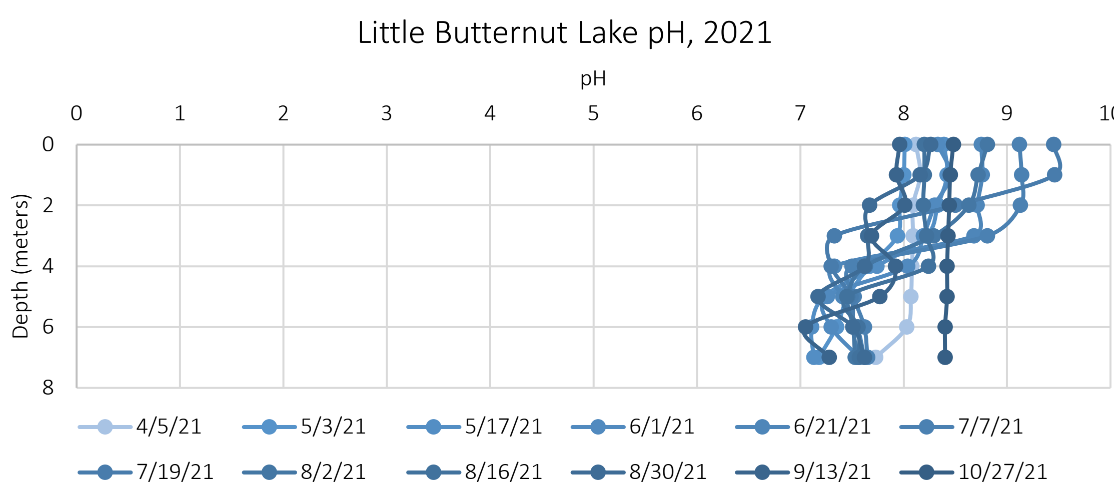
The pH is an indicator of acidity, with a value of seven being neutral. Values less than seven indicate acidic conditions and values greater than seven indicate alkaline conditions. A single pH unit change represents a tenfold change in acidity. For example, a lake with a pH of eight is ten times less acidic than a lake with a pH of seven. Across Wisconsin lakes, pH can range from 4.5 (acid bog lakes) to 8.4 (hard water, marl lakes).

Photosynthesis removes carbon dioxide from the water column which increases pH. As a result, pH generally increases during the day and decreases at night. Dense algae blooms can also cause pH levels to increase.

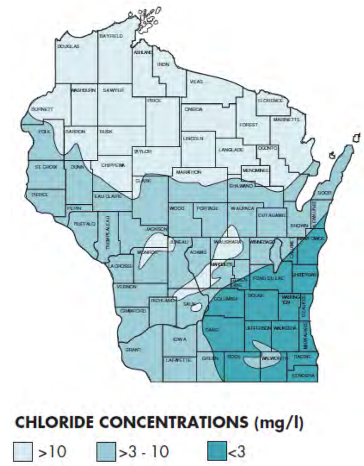
In both years of the study pH on Little Butternut Lake was between 7 and 10. Values for pH were the greatest towards the end of June and into July and August.

Values for pH were higher at the surface as compared to the bottom of the lake.





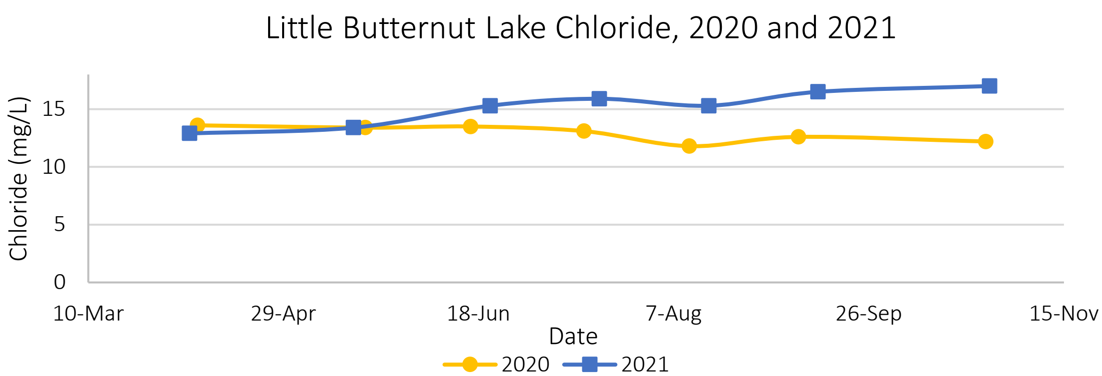
Chloride [8]



Although chloride does not directly negatively impact plants, algae, or aquatic organisms, elevated levels of chloride in a lake can indicate possible water pollution. Apart from limestone deposits, chloride is uncommon in Wisconsin soils, rocks, and minerals. Background levels of chloride are generally found in small quantities in nearly every Wisconsin lake and can be introduced to waterways through rainwater.

The watershed for Little Butternut Lake is in an area of Wisconsin where chloride concentrations can be expected to range from 3 to 10 mg/L. In both 2020 and 2021 chloride concentrations were above 10 mg/L on all sampling dates.

Growing season average (May-September) chloride was 12.9 mg/L in 2020 and 15.3 mg/L in 2021. Average summer index period (July 15-September 15) chloride was 12.5 mg/L in 2020 and 15.9 mg/L in 2021.



Total Suspended Solids

Total suspended solids quantify the amount of inorganic matter that is floating in the water column. Wind, waves, boats, and even some fish species can stir up sediments from the lake bottom re-suspending them in the water column. Fine sediments, especially clay, can remain suspended in the water column for weeks. These particles scatter light and decrease water transparency.

Total suspended solids were only above the limit of detection (4 mg/L) on one day in 2020 and two days in 2021. Total suspended solids were 7 mg/L in September 2020, 5 mg/L in August 2021, and 4 mg/L at fall turnover 2021.

[8] Figure from Understanding Lake Data, UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

Secchi Depth

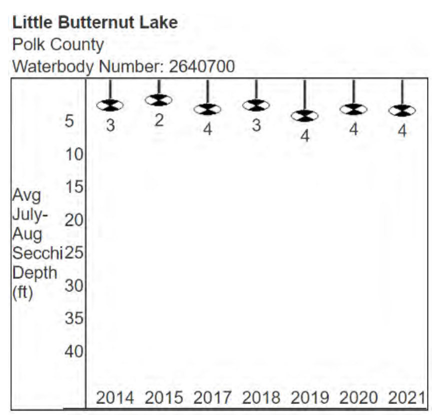
The depth light penetrates lakes is affected by suspended particles, dissolved pigments, and absorbance by water. Often, the ability of light to penetrate the water column is determined by the abundance of algae or other photosynthetic organisms in a lake.

One method of measuring light penetration is with a secchi disk. A secchi disk is an eight-inch diameter round disk with alternating black and white quadrants that is used to provide an estimate of water clarity. The depth at which the secchi disk is just visible is defined as the secchi depth. A greater secchi depth indicates greater water clarity.

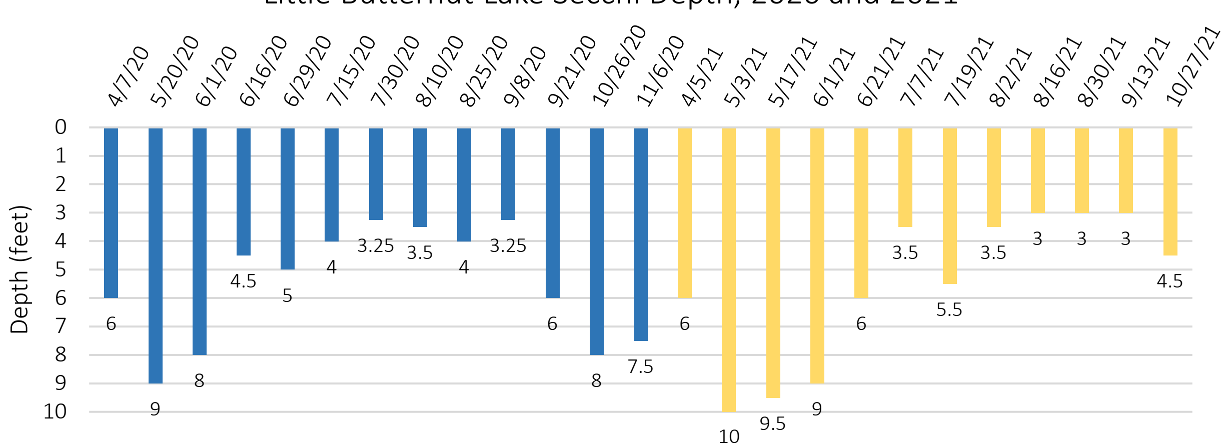
Secchi depth values on Little Butternut Lake ranged from a low of 3 feet to a high of 10 feet over the course of this study. Growing season average (May-September) secchi depth was 5.05 feet in 2020 and 5.6 feet in 2021. Summer index period average (July 15-September 15) secchi depth was 3.6 feet in 2020 and 2021.

The Wisconsin Department of Natural Resources website provides historic secchi depth averages for the months of July and August. This data exists for Little Butternut Lake from 2014, 2015, and 2017 to 2021.

The average summer secchi depth (July and August) for the Northwest geo-region was 8.7 feet in 2020 and 9.1 feet in 2021. In each year of this study, secchi depth on Little Butternut Lake was well below the geo-region average.



Past secchi averages in feet (July and August only).



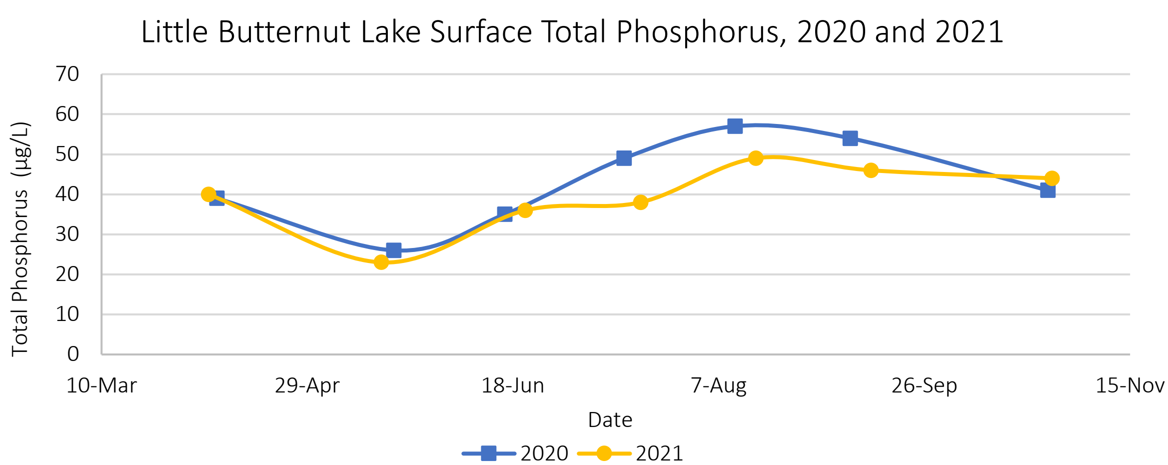
Phosphorus

Phosphorus is an element present in lakes which is necessary for plant and algae growth. It occurs naturally in soil and rocks and in the atmosphere in the form of dust. Phosphorus can make its way into lakes through groundwater and human induced disturbances such as soil erosion. Additional sources of phosphorus inputs into a lake can include external sources such as fertilizer runoff from urban and agricultural settings and internal sources such as release from sediment at the bottom of a lake. Excessive amounts of phosphorus can lead to an overabundance of algae growth which can decrease water clarity in lakes.

If oxygen is available in the hypolimnion, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve and phosphorus is redistributed throughout the water column with strong wind action or turnover events. This process is termed internal loading.

Total phosphorus is a measure of all the phosphorus in a sample of water. In many cases total phosphorus is the preferred indicator of a lake's nutrient status because it remains more stable than other forms over an annual cycle. In lakes, a healthy limit of total phosphorus is set at 20 µg/L. If a value is above the healthy limit, it is more likely that a lake could support nuisance algae blooms. On all sampling dates, surface phosphorus was above the healthy limit on Little Butternut Lake.

Total phosphorus was analyzed at the surface and bottom of Little Butternut Lake. Growing season average (May-September) surface total phosphorus was 44 µg/L in 2020 and 38 µg/L in 2021. Summer index period average (July 15-September 15) surface phosphorus was 53 µg/L in 2020 and 44 µg/L in 2021.

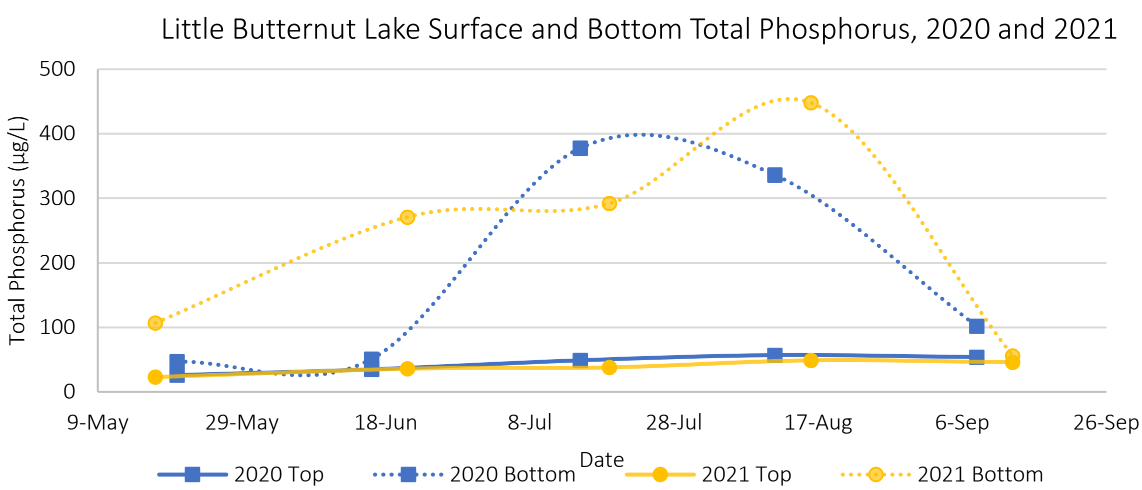


Little Butternut Lake is proposed for the 2022 Impaired Waters List because average total phosphorus is greater than or equal to 40 µg/L from June 1st to September 15th (49 µg/L in 2020 and 42 µg/L in 2021).

Growing season average (May-September) bottom phosphorus was 183 µg/L in 2020 and 235 µg/L in 2021. Summer index period average (July 15-September 15) bottom phosphorus was 272 µg/L in 2020 and 265 µg/L in 2021.

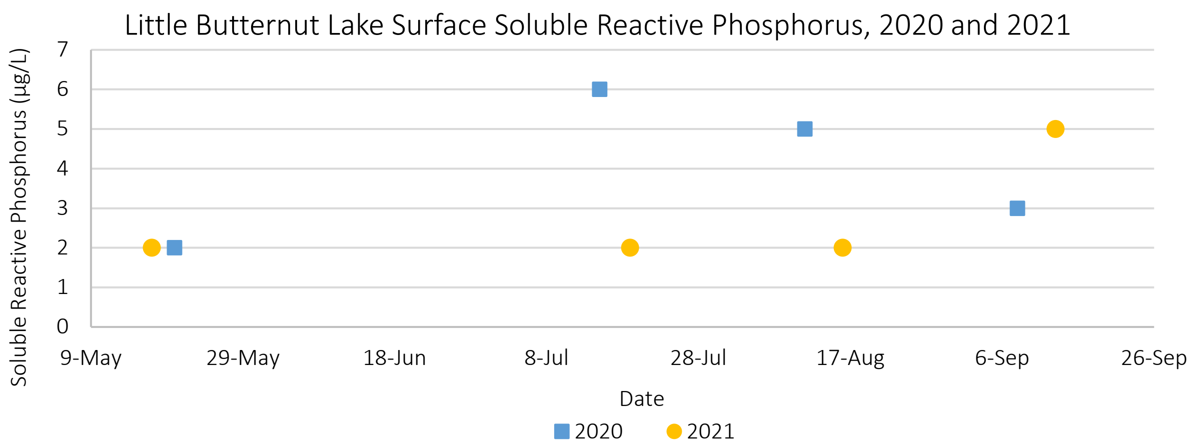
Date	Surface Total Phosphorous (µg/L)	Bottom Total Phosphorus (µg/L)
5/20/20	26	47
5/16/20	35	51
7/15/20	49	378
8/11/20	57	336
9/8/20	54	102
5/17/21	23	107
6/21/21	36	271
7/19/21	38	292
8/16/21	49	448
9/13/21	46	56

During the two years of the study, total phosphorus levels at the bottom of Little Butternut Lake were higher than at the surface. This difference was most pronounced in July and August. The data suggests that under anoxic conditions, phosphorus is being released from the sediments into the bottom waters of Little Butternut Lake.



This study also analyzed surface soluble reactive phosphorus. **Soluble reactive phosphorus** includes forms of phosphorus that are dissolved in the water and are readily available for uptake by algae and aquatic plants. In lakes, a healthy limit of soluble reactive phosphorus is set at 10 µg/L. If a value is above the healthy limit it is more likely that a lake could support nuisance algae blooms. Surface soluble reactive phosphorus was within the healthy limit in May through September in 2020 and 2021.

Growing season average (May-September) surface soluble reactive phosphorus on Little Butternut Lake was 4 µg/L in 2020 and 3 µg/L in 2021. Summer index period average (July 15-September 15) surface soluble reactive phosphorus on Little Butternut Lake was 5 µg/L in 2020 and 3 µg/L in 2021. In June of both years, soluble reactive phosphorus was below the limit of detection (2 µg/L).



Nitrogen

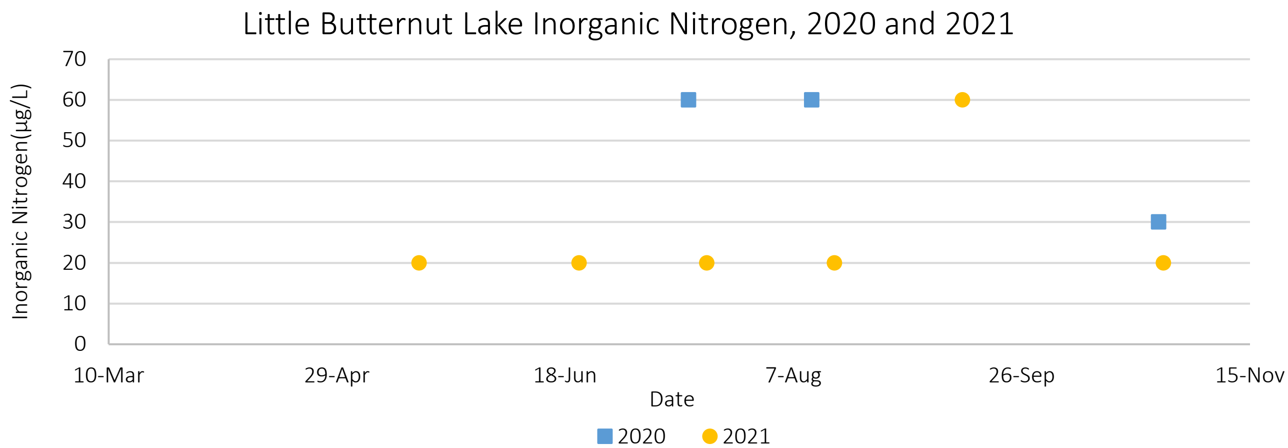
Nitrogen, like phosphorus, is an element necessary for plant growth. Nitrogen does not occur naturally in soil minerals. It is a major component of all plant and animal matter and comprises the majority (78%) of the gases in the Earth's atmosphere. Nitrogen can take several forms including nitrogen gas, ammonia, ammonium, nitrate, nitrite, and organic nitrogen (plant and animal matter). The transition between nitrogen is driven by microorganisms and results in a process called the nitrogen cycle. This reaction accelerates when water temperatures increase.

The amount of nitrogen present in a lake is a result of the natural nitrogen cycle plus inputs that are a result of land use in the watershed. Nitrogen can be introduced to a lake through rainfall and from the fertilization of lawns and agricultural fields, animal waste, or human waste from septic systems or sewage treatment plants.

Nuisance blue-green algae can use nitrogen gas within the water column. This form of nitrogen is not accessible to other types of algae and plants.

Nitrogen is divided into many components. In this study nitrate/nitrite, ammonium, and total Kjeldahl nitrogen were analyzed. Nitrate/nitrite and ammonium are inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen values above 300 µg/L can support summer algae blooms.

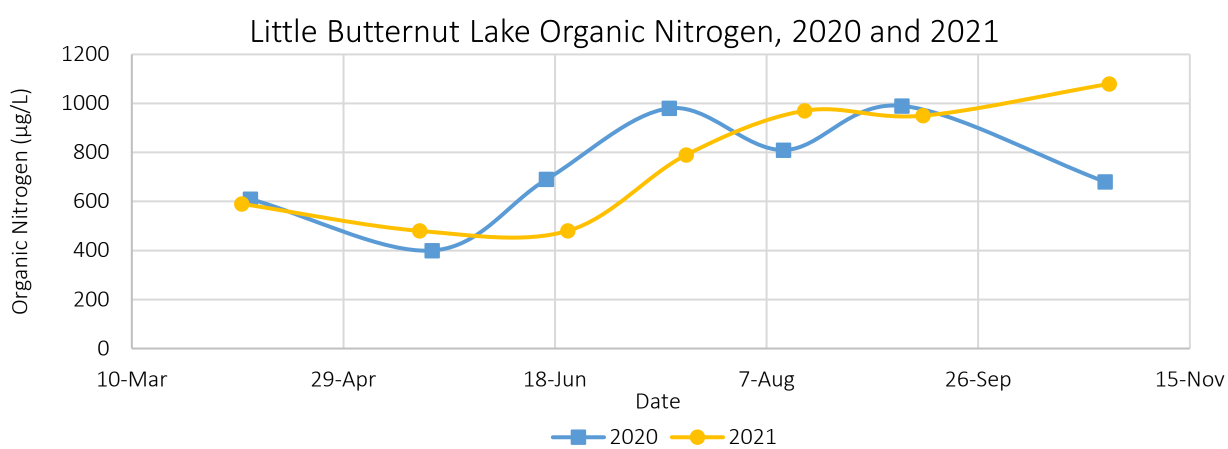
Nitrate/nitrite was below the limit of detection (or less than 100 µg/L) on all sample dates. Inorganic nitrogen concentrations were well below 300 µg/L during this study.



Total Kjeldahl Nitrogen is a measure of organic nitrogen plus ammonium. By subtracting the ammonium concentration from total Kjeldahl nitrogen, the organic nitrogen concentration found in plants and algae can be found.

Growing season average (May-September) organic nitrogen on Little Butternut Lake was 774 µg/L in 2020 and 734 µg/L in 2021. Summer index period average (July 15-September 15) organic nitrogen on Little Butternut Lake was 927 µg/L in 2020 and 903 µg/L in 2021.

Organic nitrogen was greatest in September in 2020 and greatest in October in 2021.



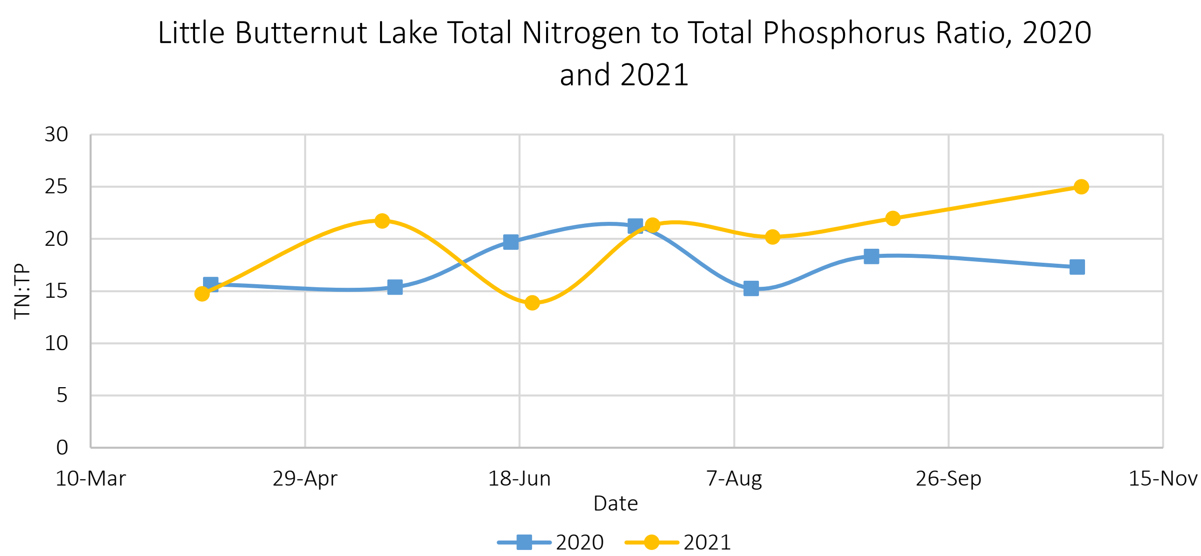
Total Nitrogen to Total Phosphorus Ratio

The total nitrogen to total phosphorus ratio (TN:TP) is a calculation that determines which nutrient limits algae growth in a lake.

Lakes are considered nitrogen limited, or sensitive to the amount of nitrogen inputs, when TN:TP ratios are less than 10. Only about 10% of Wisconsin lakes are limited by nitrogen. In contrast, lakes are considered phosphorus limited, or sensitive to the amount of phosphorus inputs into a lake, when the TN:TP ratio is above 15. Lakes with values between 10 and 15 are considered transitional. In transitional lakes it is impossible to determine which nutrient (nitrogen or phosphorus) is limiting algae growth.

Total nitrogen is found by adding nitrate/nitrite to total Kjeldahl nitrogen. As previously mentioned, nitrate/nitrite concentrations were below the limit of detection on all sampling dates. As a result, total nitrogen is largely reflective of total Kjeldahl nitrogen.

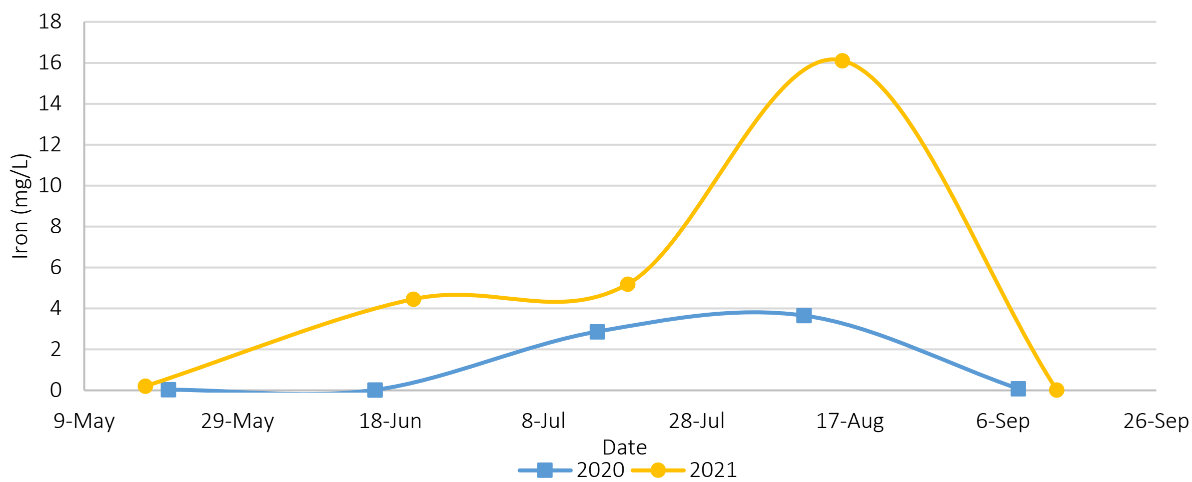
Little Butternut Lake was phosphorus limited on all sampling dates except spring turnover 2021 and June of 2021. On these two sampling dates, the lake was in a transitional state.



Iron

Iron is a micronutrient required by living organisms in lakes. It is an abundant metal in the Earth's crust although its concentration in lakes is typically low due to low solubility. In the presence of oxygen, iron and phosphorus bind to one another in lake sediments. Under low oxygen conditions, iron and phosphorus are released into the water column from the bottom sediments.

Growing season average (May-September) iron at the bottom of Little Butternut Lake was 1.3 mg/L in 2020 and 5.2 mg/L in 2021. Bottom iron levels increased over the course of the growing season and peaked in August in both 2020 and 2021. However, 2021 had a much larger increase during the growing season.



Chlorophyll a

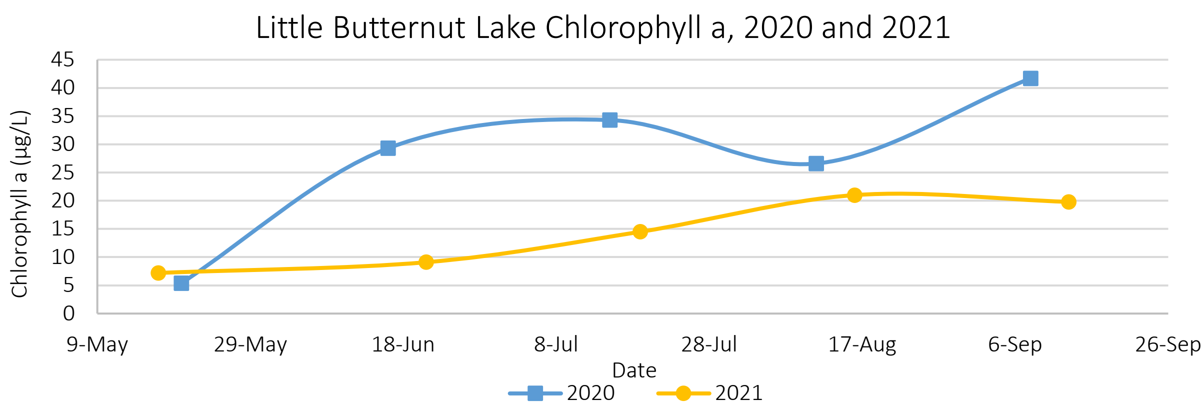
Chlorophyll a is a pigment in plants and algae that is necessary for photosynthesis and is an indicator of water quality in a lake. Chlorophyll a gives a general indication of the amount of algae growth in a lake, with greater values for chlorophyll a indicating greater amounts of algae. However, since chlorophyll a is present in sources other than algae—such as decaying plants— it does not serve as a direct indicator of algae biomass.

Chlorophyll a seems to have the greatest impact on water clarity when levels exceed 30 µg/L. Lakes which appear clear generally have chlorophyll a levels less than 15 µg/L.

Growing season average (May-September) chlorophyll a on Little Butternut Lake was 27.5 µg/L in 2020 and 14.3 µg/L in 2021. Summer index period average (July 15-September 15) chlorophyll a on Little Butternut Lake was 34.2 µg/L in 2020 and 18.4 µg/L in 2021.

Little Butternut Lake is proposed for the 2022 Impaired Waters List because greater than 30% of the days in the sampling season (June 1st to September 15th) have moderate algae blooms, or chlorophyll a levels greater than 20 µg/L (100% of days in 2020 and 33% of days in 2021).

Chlorophyll a values were greater in 2020 as compared to 2021. In 2020, values were above or close to 30 µg/L in June through September. In 2021 values remained below 15 µg/L through July and remained below 30 µg/L for the entire growing season.



Trophic State Index

Lakes are divided into three categories based on their trophic states: oligotrophic, eutrophic, and mesotrophic. These categories reflect a lake's nutrient and clarity level and serve as an indicator of water quality. Each category is designed to serve as an overall interpretation of a lake's primary productivity.

Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms. These types of lakes are often low in nutrients and are unable to support large populations of fish. However, oligotrophic lakes can develop a food chain capable of supporting a desirable population of large game fish.

Eutrophic lakes are generally high in nutrients and support many plants and animals. They are usually very productive and subject to frequent algae blooms. Eutrophic lakes often support large fish populations but are susceptible to oxygen depletion.

Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

All lakes experience a natural aging process which causes a change from an oligotrophic to a eutrophic state. Human influences that introduce nutrients into a lake (agriculture, lawn fertilizers, and septic systems) can accelerate the process by which lakes age and become eutrophic.

[9]

A common method of determining a lake's trophic state is to compare total phosphorus (important for algae growth), chlorophyll a (an indicator of the amount of algae present), and secchi disk readings (an indicator of water clarity). Although many factors influence these relationships, the link between total phosphorus, chlorophyll a, and secchi disk readings is the basis of comparison for the trophic state index (TSI).

TSI values range from 0 to 110. Lakes with the lowest numbers are oligotrophic and lakes with the highest values are eutrophic. Three equations for summer index period TSI were examined for Little Butternut Lake. [10]

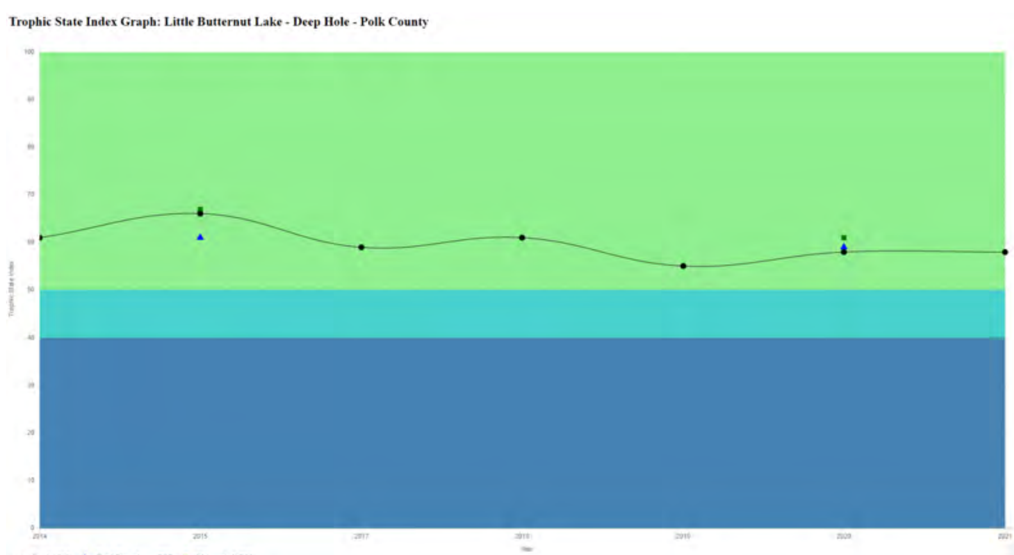
Average Summer Index Period Trophic State Index, 2020 and 2021 respectively
Total phosphorus = 61 and 59
Chlorophyll a = 65 and 59
Secchi depth = 59 and 59
Trophic State Index = 62 and 59 = eutrophic and mildly eutrophic

[9] Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

[10] TSI (P) = 14.42 * Ln [TP] + 4.15 (where total phosphorus is in µg/L)
TSI (C) = 30.6 + 9.81 Ln [Chlor-a] (where chlorophyll a is in µg/L)
TSI (S) = 60-14.41 * Ln [Secchi] (where secchi depth is in meters)

TSI	General Description
<30	**Oligotrophic** clear water, high dissolved oxygen throughout the year/lake
30-40	**Oligotrophic** clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	**Mesotrophic** moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	**Mildly eutrophic** decreased water clarity, anoxic near the bottom, may have macrophyte problem, warm-water fisheries only
60-70	**Eutrophic** blue-green algae dominance, scums possible, prolific aquatic plant growth, full body recreation may be decreased
70-80	**Hypereutrophic** heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

Monitoring the trophic state index of a lake gives stakeholders a method to gauge lake productivity over time. TSI data exists for Little Butternut Lake for secchi depth for 2014-2015, 2017-2021 and for total phosphorus and chlorophyll for 2015, 2020, and 2021. The historic data indicates that Little Butternut Lake is eutrophic.

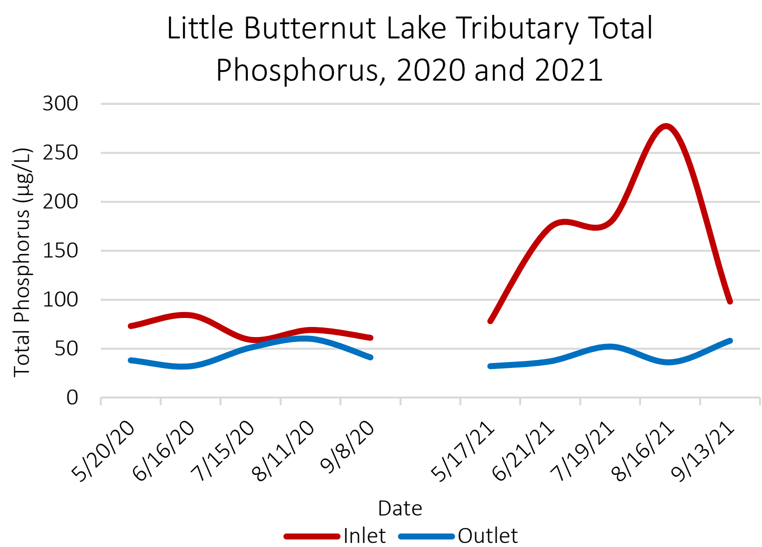


Tributary Monitoring

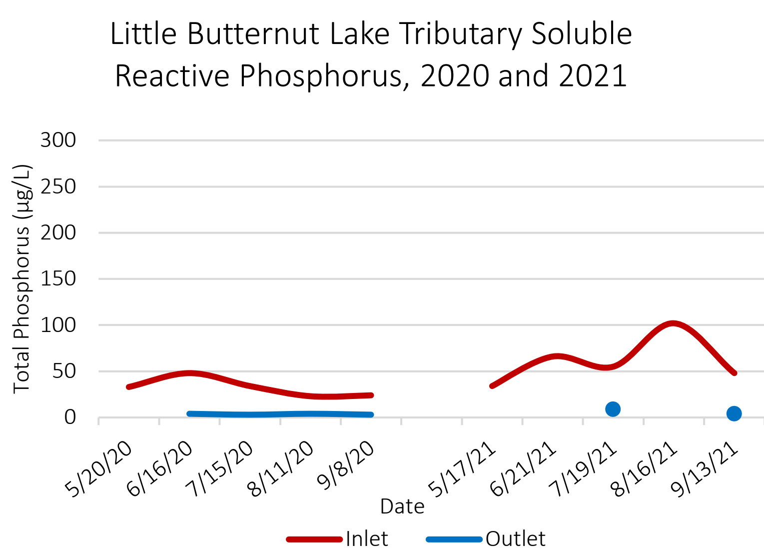
Data was collected on the two tributaries of Little Butternut Lake: Little Butternut Outlet and the Inlet from Big Butternut Lake through Butternut Creek.

Flow data was collected bi-weekly at each tributary with a Marsh McBirney Flo-Mate ™ velocity flowmeter. At foot intervals across each tributary, depth (feet) and velocity (ft/s) were measured. Grab samples were collected once a month on each tributary and analyzed at the Water and Environmental Analysis Lab for total phosphorus, soluble reactive phosphorus, and total suspended solids.

Growing season average (May-September) total phosphorus in the inlet was 69.2 µg/L in 2020 and 161 µg/L in 2021. Values in the outlet were 44 µg/L in 2020 and 43 µg/L in 2021.

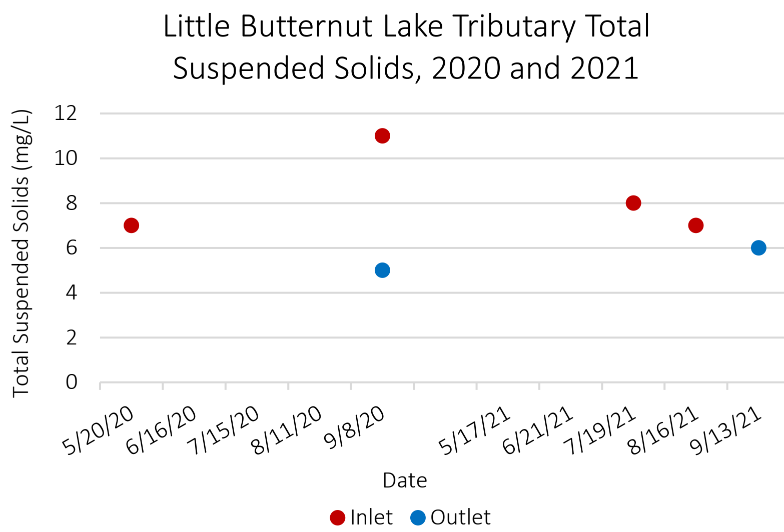


Growing season average (May-September) soluble reactive phosphorus in the inlet was 32.4 µg/L in 2020 and 61 µg/L in 2021. Values in the outlet were 3.5 µg/L in 2020 and 7 µg/L in 2021 (only two samples were above the limit of detection in 2021).



Total phosphorus and soluble reactive phosphorus values were elevated in the inlet in 2021, with the greatest peak occurring in August.

The state standard for streams is set at 75 ug/L. The outlet was below this standard in 2020 and 2021. The inlet was below the standard in 2020 but well above the standard in 2021.

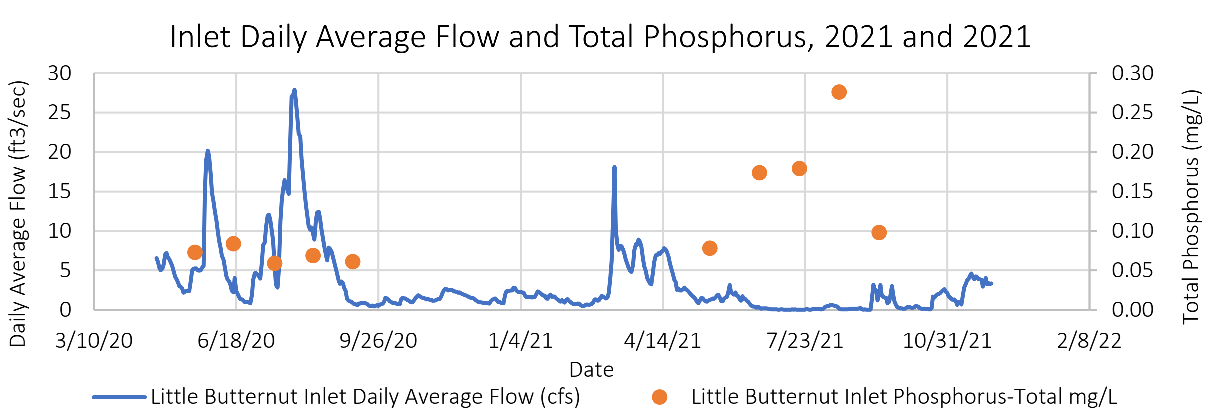


Growing season average (May-September) total suspended solids were 9 µg/L in 2020 and 7.5 µg/L in 2021 (only two samples were above the limit of detection in each year). Values in the outlet were below the limit of detection on all sample dates except for September when values were 5 mg/L in 2020 and 6 mg/L in 2021.

Tributary Annual Phosphorus Load

HOBO data loggers were installed at the inlet and outlet of Little Butternut Lake. Each hour the loggers collected data for temperature and atmospheric pressure. Staff gages were installed at each tributary and surveyed so that an actual water elevation could be determined. Data for total phosphorus, corresponding flow measurements, and mean daily flow were input into a model called FLUX to estimate the phosphorus load to Little Butternut Lake from the inlet.

Flux determines an annual total phosphorus load using six methods. When averaging the total phosphorus load across the methods, FLUX determined an annual total phosphorus load from the inlet of 430 pounds per year.



Algae

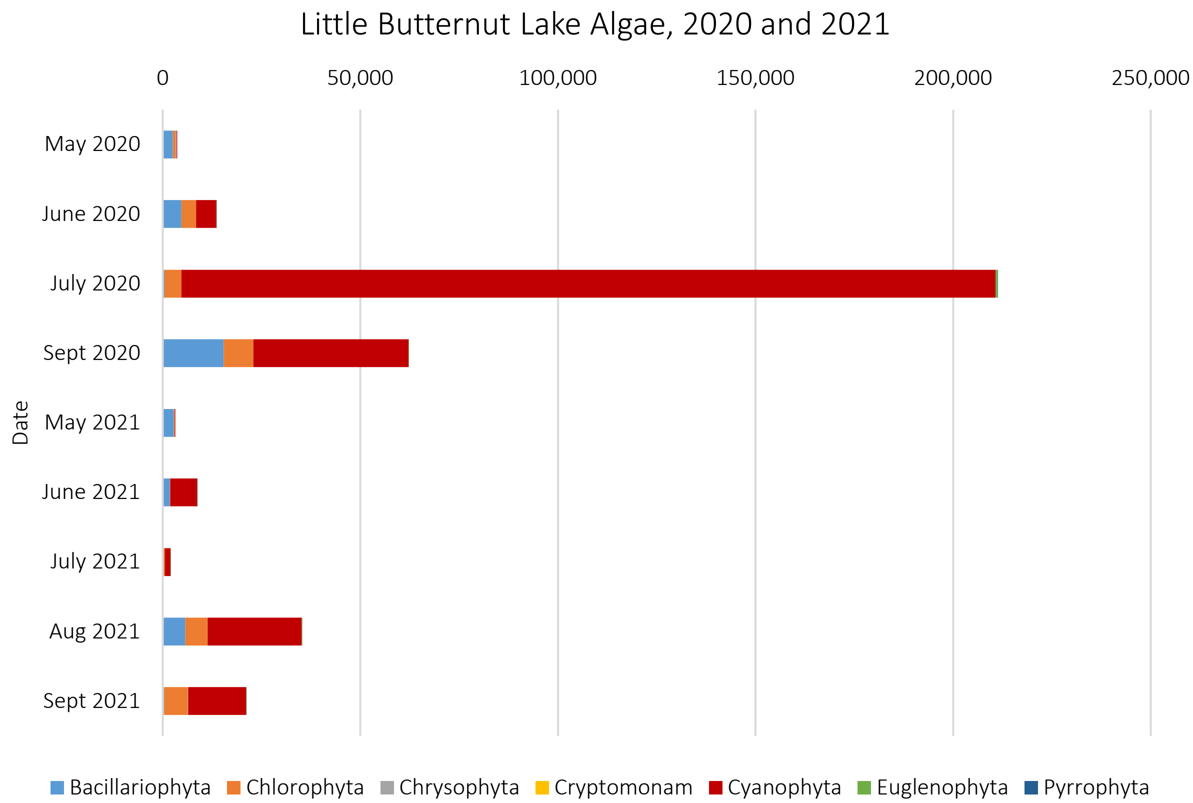
Algae, also called phytoplankton, convert sunlight and nutrients into biomass and form the base of the food chain. Algae are consumed by zooplankton which are, in turn, eaten by fish. Algae can live on bottom sediments and substrate, in the water column, and on plants and leaves.

The types of algae present in a lake will change over the course of a year and are influenced by many environmental factors (climate, nutrients, silica, substrate, etc.). Typically, there is less algae in winter and spring because of ice cover and cold temperatures. As a lake warms up and sunlight increases, algae communities begin to increase. When high levels of nutrients are available, blue green algae often become predominant and create light limited conditions for other groups of algae. Blue green algae are not true algae but are a type of photosynthetic bacteria known as cyanobacteria. Although blue green algae are a natural part of the lake ecosystem, they are not an important part of the food chain because they are not a preferred food source. Additionally, under nitrogen limited conditions, blue green algae have a competitive advantage over other algae because of their unique ability to fix nitrogen from the atmosphere.

Chlorophyll a is a pigment in plants and algae that is necessary for photosynthesis. Chlorophyll a gives a general indication of the amount of algae growth in the water column; however, it is not directly correlated with algae biomass. To obtain accurate algae data, composite samples from a two-meter water column were collected monthly, preserved with formaldehyde, placed on ice, and sent to UW-Oshkosh for identification and enumeration of algae species. Sampling was conducted in 2020 and 2021.

Seven algal divisions were found in Little Butternut Lake: Bacillariophyta (diatoms), Chlorophyta (green algae), Chrysophyta (golden-brown algae), Cryptomonam (cryptomonads), Cyanophyta (blue green algae), Euglenophyta (euglenoids), and Pyrrophyta (dinoflagellates).

The algae community was dominated by blue-green algae in both years of the study with concentrations being the greatest in July of 2020. Of the other divisions of algae present in Little Butternut Lake, the green algae and diatoms formed the largest components of the algae community. In 2021, Little Butternut Lake had less algae (especially blue-green algae) as compared to 2020.



The algae data for Little Butternut Lake suggests that the lake is mesotrophic but that it may not take much to change the character of the lake to a less desirable eutrophic state or, through careful management of nutrients, to a lake that experiences fewer algal blooms.

Blue Green Algae Toxin Risk

Blue green algae, or cyanobacteria, have been around for billions of years and typically bloom during the summer months. Blue-green algae blooms become more frequent with increased nutrient concentrations.

In addition to the negative aesthetics posed by algae, blue green algae are of specific concern because of their ability to produce toxins that when ingested or inhaled can cause short- and long-term health effects. Toxin producing algae such as *Aphanizomenon, Microcystis*, and *Anabaena* were present during the 2020 and 2021 sampling season. Toxin data was not collected as part of this study.

It is not known what environmental conditions cause cyanobacteria to produce toxins, but scientists have found that when blue green algae are present at concentrations over 100,000 cells/mL toxin production is more likely to occur. Blue green algae can produce a variety of toxins which can affect health differently. Symptoms are related to how much of the toxin a person is exposed to and how a person is exposed.

Federal guidelines for blue green algae cell densities do not exist. The Wisconsin Harmful Algal Bloom (HAB) Surveillance Program uses guidelines of the World Health Organization to determine the probability of adverse health effects. In Wisconsin, an advisory exists if a scum layer is present or if algae cell densities are greater than 100,000 cells/mL.

Blue green algae cell density (cells/mL)	Probability of adverse heath effect
Less than 20,000	Low
20,000 to 100,000	Moderate
100,000 to 10,000,000	High
More than 10,000,000	Very High

Based on blue green algae cell density, the probability of adverse health effects from blue-green algae was high in July 2020 and moderate in September 2020 and August 2021. The probability of adverse health effects was low on all other sampling dates.

Fisheries [11]

The most recent fisheries surveys conducted on Little Butternut Lake were in 2003 (electrofishing) and in 2005 (spring game fish stocking). These surveys are outdated but serve as a historical reference. A WDNR fisheries survey is scheduled for summer 2022.

At that time of the 2003 and 2005 surveys, Little Butternut Lake had bluegill and pumpkinseed populations with moderate size structure and moderate abundance. Largemouth bass had low abundance and high size structure. Despite northern pike not sampling well with electrofishing, they were caught at a decent rate, resulting in a fairly abundant pike population. The walleye numbers were low with very few fish caught during the survey.

Black Crappie Sarcoma

Little Butternut Lake has an abundant black crappie population but unfortunately it is affected by a disease called black crappie sarcoma. The disease is suspected to be widespread across the state but seems to mainly affect black crappie in the Northwest portion of Wisconsin. There are thirty-nine lakes with the suspected disease within Polk, St. Croix, Pierce, and Barron County. Black crappie sarcoma appears in the form of a tumor or reddened area on the body, fins, head, or face of the fish. The lesions usually appear as raised red masses and are often fragile and bloody. The lesions are suspected to be a type of cancer classified as a sarcoma that can affect the skin and invade underlying muscle. Anecdotally the disease tends to affect bigger more mature fish. Causes other than black crappie sarcoma could result in similar looking lesions and testing is required to confirm diagnosis.

[12]

The WDNR is actively researching the underlying cause, with preliminary results suggesting the cause is viral. Since a definitive cause is not known at this time, WDNR recommends euthanizing affected fish and disposing of them either in the trash or by

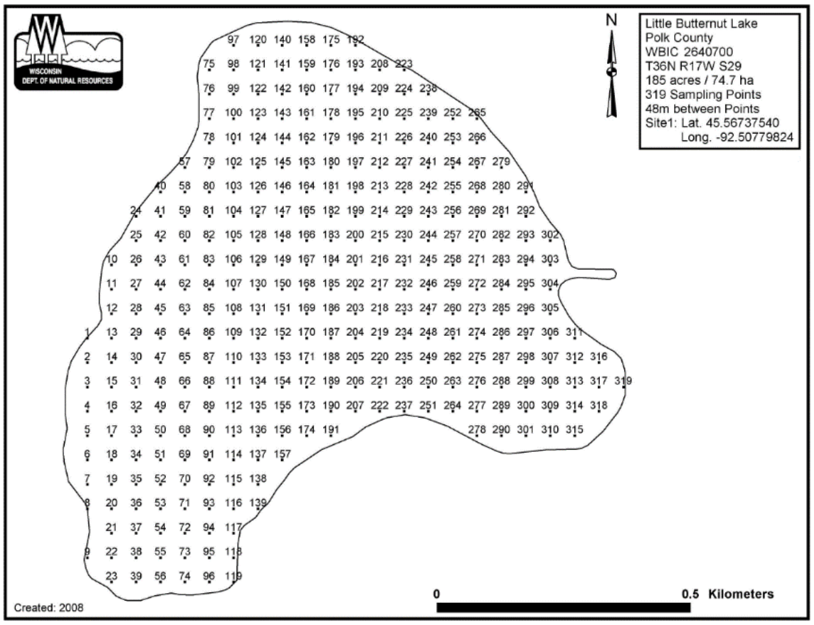
[11] Information provided by Aaron Cole, Fisheries Biologist, Wisconsin DNR
[12] Image from Wisconsin DNR

burying them in the ground away from any body of water to potentially limit the spread of the disease. Any fish that is disposed of or kept by the angler **still counts towards the daily bag limit.**

A protocol and datasheet to determine the extent of black crappie sarcoma in Little Butternut Lake was created by the Polk County Land and Water Resources Department and approved by WDNR. The data sheet was available to anglers to fill out while fishing. The sheet documented hours spent fishing, number and length of fish caught, and if each fish caught appeared normal or had lesions. Lab testing is required to confirm if a fish has sarcoma since lesions can be caused by other factors. In this study, lab testing was not completed and a fish identified as affected would reflect an abnormality rather than a verified occurrence of black crappie sarcoma.

Data was collected on forty-six days in 2020 and six days in 2021. The average fish length was 8.4 inches in 2020 and 8.8 inches in 2021. Fish ranged from six to twelve inches in length. In 2020, twenty eight of the 421 black crappies caught had symptoms consistent with black crappie sarcoma (7%). In 2021, nine of the eighty-five crappies caught had symptoms (11%). The symptoms appeared to be more prevalent in larger fish. The average length of affected fish was 9.5 inches in 2020 and 9.4 inches in 2021.

Point Intercept Plant Surveys



Full point intercept aquatic macrophyte surveys were conducted on Little Butternut Lake on June 9th and August 27th, 2020 using the Jessen and Lound Rake Method. A previous survey was completed on September 2nd, 2015.

Three hundred and nineteen sampling points were established in Little Butternut Lake by the Wisconsin Department of Natural Resources using a standard formula that considers the shoreline shape and length, water clarity, depth, and total lake acres. Sampling points were generated in ArcGIS and downloaded to a GPS unit.

A GPS unit was used to locate each sampling point in the field. At each sampling point a depth finder was used to determine depth and a pole or rope rake was used to sample the plant community of an approximately one-meter section of the benthos.

All plants on the rake, as well as any that were dislodged by the rake, were identified to species and assigned a rake fullness value of 1 to 3 to estimate abundance. Visual sightings of plants within six feet of the sample point were also recorded. The lake bottom substrate was assigned at each sampling point where the bottom was visible or it could be reliably determined using the rake.

Data was collected at each sampling point, except for those that were too shallow or terrestrial. Although three hundred and nineteen sampling points were established in Little Butternut Lake, it was only possible to sample three hundred and eighteen points during the spring survey and three hundred and seventeen during the fall survey. In the 2015 survey, two hundred and eighty-one points were sampled.

Data collected was entered into a standard spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Maximum depth of plants
- Sample points with vegetation
- Species richness
- Number of species per site
- Number of sites where each species was found
- Average rake fullness
- Frequency of occurrence
- Relative frequency
- Simpson's Diversity Index
- Floristic Quality Index

The following are explanations of the various analyses with data from Little Butternut Lake for the spring and fall 2020 and fall 2015 surveys.

Maximum depth of plants

All lakes have a maximum depth at which plants are present. Typically, clearer lakes have a greater depth at which plants can exist, since sunlight can reach to greater depths. In Little Butternut Lake, the maximum depth of plants was 9 feet in the spring survey and 7 feet in the fall survey. This is compared with a maximum depth of 12.5 in 2015.

Sample points with vegetation

This value shows the number of sites where plants were collected and gives an approximation of the plant coverage of a lake. If 10% of all sample points had vegetation, then it is implied that approximately 10% of the lake is covered with plants.

One hundred and forty sample sites had plants present in June, indicating that plant growth covered approximately 44% of the lake. One hundred and twenty-six sample sites had plants present in August, indicating that plant growth covered approximately 40% of the lake. In 2015, ninety-three sites had plants present in September, indicating plant growth covered 33% of the lake.

In June, one hundred and seventy-one sample sites were shallower than the maximum depth of plants. Plant growth covered approximately 82% of the area of the lake with depths 9 feet or less. In August, one hundred and thirty-five sample sites were shallower than the maximum depth of plants. Plant growth covered approximately 93% of the area of the lake with depths of 7 feet or less. This is compared with the 2015 survey where one hundred and forty-four sites were shallower than the maximum depth of plants and plant growth covered 65% of the area of the lake with depths 12.5 feet of less.

Species richness

Species richness is a measure of the number of different species found in a lake. Species richness is computed based on plants sampled or based on plants sampled/visually located during the survey.

Twenty-four species were found in Little Butternut Lake in the spring and fall survey. Of these species twenty were on the rake head during the spring survey and twenty-two were on the rake head during the fall survey. In the 2015 survey, there were twenty-five species found in the lake (nineteen on the rake head).

Number of species per site

In June, an average of 2.16 species were present at sites 9 feet in depth or less and an average of 2.64 species were present at the one hundred and forty sample where plants were found. In August, an average of 2.84 species were present at sites 7 feet in depth or less and an average of 3.05 species were present at the one hundred and twenty-six sample sites sample sites where plants were found. In 2015, an average of 1.49 species were present at sites 12.5 feet in depth or less and an average of 2.31 species were present at the ninety-three sample sites where plants were found.

Number of sites where each species was found

Fern pondweed, the most common species in Little Butternut Lake, was found at 87 sites in both June and August in 2020. Flat stem pondweed, coontail, spatterdock, and white water lily were the next most common species. Curly-leaf pondweed, the only invasive species found in the survey, was found at 15 sites during the June survey. The most common species in 2015 was also fern leaf pondweed (being found at 51 sites) followed by flat-stem pondweed and coontail. Curly-leaf pondweed was found at 10 sites.

Average rake fullness

Average rake fullness was between 1 and 2 for fern pondweed, flat stem pondweed, coontail, spatterdock, and white water lily in 2020. In 2015, average rake fullness for fern leaf pondweed, flat-stem pondweed was between 2 and 3.

Frequency of occurrence

Two values are computed for frequency of occurrence: the frequency of occurrence within vegetated areas and the frequency of occurrence at sites shallower than the maximum depth of plants. In both instances, the greater the value, the more frequently the plant would be encountered in the lake.

Frequency of occurrence within vegetated areas is defined as the number of times a species was sampled in a vegetated area divided by the total number of vegetated sites. This value shows how often the plant would be encountered everywhere vegetation was found in the lake.

Frequency of occurrence at sites shallower than the maximum depth of plants is defined as the number of times a species was sampled divided by the total number of sites shallower than the maximum depth of plants. This value shows how often the plant would be encountered within the depths plants can potentially grow (9 feet or less in June 2020 and 7 feet or less in August 2020).

In June, the most frequent species found was fern pondweed, occurring at 61% of the sites with vegetation and 50% of the sites where plants could potentially grow. Other frequent species were coontail (41% and 33%), forked duckweed (22% and 19%), and yellow water lily (19% and 15%) (sites with vegetation and sites where plants could potentially grow, respectively).

In August, the most frequent species found was fern pondweed, occurring at 69% of the sites with vegetation and 64% of the sites where plants could potentially grow. Other frequent species were coontail (66% and 61%) and yellow water lily (23% and 21%) (sites with vegetation and sites where plants could potentially grow, respectively).

In 2015, the most frequent species found was fern pondweed, occurring at 55% of the sites with vegetation and 35% of sites where plants could potentially grow. Other frequent species were flat-stem pondweed (42% and 27%) and coontail (41% and 26%) (sites with vegetation and sites where plants could potentially grow, respectively).

Relative frequency

Relative frequency is the frequency of a particular plant species relative to other plant species. This value is independent of the number of points sampled. Relative frequency can be used to show which plants are the dominant species in a lake. The higher the value a species has for relative frequency, the more common the species is compared to others. The relative frequency of all plants will always add up to 100%. If species A has a relative frequency of 30%, this species occurred 30% of the time compared to all the species sampled or makes up 30% of all species sampled.

Relative frequency example: Suppose 10 points were sampled in a small lake with the following results: plant A present at 3 sites, plant B at 5 sites, plant C at 2 sites, and plant D at 6 sites. Plant D is the most frequently sampled at all sites, with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency of plant D is compared to other plants, without considering the number of sites. This value is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. All the individual frequencies added together (3+5+2+6) gives a sum of 16.

Relative frequency is calculated by dividing individual frequencies by the sum of all frequencies:

Plant A = 3/16 = 0.1875 or 18.75%
Plant B = 5/16 = 0.3125 or 31.25%
Plant C = 2/16 = 0.1250 or 12.50%
Plant D = 6/16 = 0.3750 or 37.50%

Now the plants can be compared to one another. Plant D is still the most frequent, but the relative frequency tells us that of all plants sampled 37.50% of them are Plant D. This is much lower than the frequency of occurrence (60%) because although Plant D was sampled at 6 of 10 sites, many other plants were also sampled.

The most dominant plant species in Little Butternut Lake in the spring 2020 as indicated by relative frequency were fern pondweed (23%), flat-stem pondweed (16%), coontail (15%), forked duckweed (9%), spatterdock (7%), and common waterweed (6%). In the fall 2020 survey, the most dominant species in Little Butternut Lake as indicated by relative frequency were fern pondweed (23%), coontail (22%), spatterdock (8%), flat-stem pondweed (7%), white water lily (7%), and northern water milfoil (6%). In the fall 2015 survey relative frequency was greatest for fern pondweed (24%), flat-stem pondweed (18%), and coontail (18%).

Simpson's Diversity Index

Simpson's Diversity Index[13] is used to determine how diverse a plant community in a lake is by measuring the probability that two individuals randomly selected from a sample will belong to the same species. The Simpson's Diversity Index ranges from zero to one, with greater values representing more diverse plant communities.

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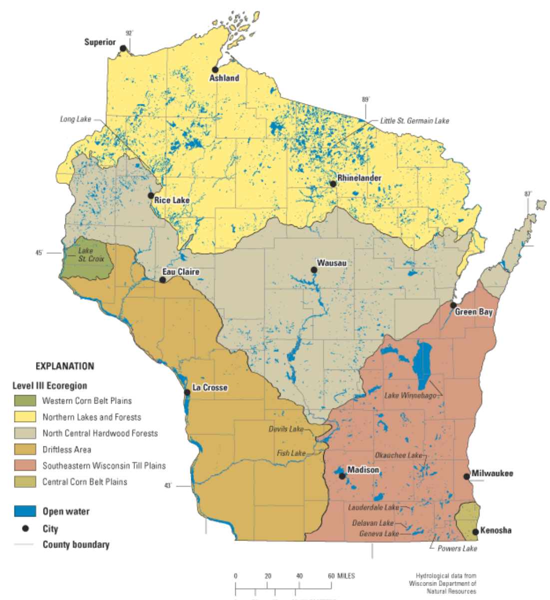
[13] Simpson's Diversity Index can be calculated by using the equation: $D = \frac{\sum n(n-1)}{N(N-1)}$
Where: D = Simpson's Diversity Index; n= the total number of organisms of a particular species; and N=the total number of organisms of all species

In theory, the value for Simpson's Diversity Index is the chance that two species that are sampled will be different. An Index of one means that the two plants sampled will *always* be different (very diverse) and an Index of zero means that the two plants sampled will *never* be different. The Simpson's Diversity Index on Little Butternut Lake was 0.87 in June and August 2020. In 2015, the Simpson's Diversity Index was 0.86.

Floristic Quality Index

The Floristic Quality Index (FQI) [14] is designed to evaluate the closeness of the flora in an area to that of an undisturbed condition. The FQI considers the species of aquatic plants found and their tolerance for changing water quality and habitat modification.

Each plant species has an assigned coefficient of conservation which ranges from 1 to 10. A high value indicates a plant is intolerant of change and a low value indicates a plant is tolerant of change. Plants with higher values are more likely to respond adversely to water quality and habitat changes. Invasive species have a conservatism value of 0. A higher FQI indicates a healthier plant community.



Summary of North Central Hardwood Forest FQI:
Mean species richness = 14
Mean average conservatism = 5.6
Mean Floristic Quality = 20.9

Summary of Little Butternut Lake 2020 and 2021:
Mean species richness = 19 and 20
Mean average conservatism = 6.4 and 6.3
Mean Floristic Quality = 28 and 28

The FQI for Little Butternut was greater than the value for the North Central Hardwood Forest.

In 2015 the mean species richness was 18, the mean average conservatism value was 6.1, and the mean floristic quality was 25.7. Although these values are lower than those in 2020, they are still greater than the values for the North Central Hardwood Forest.

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[14] The Floristic Quality Index can be calculated using the equation: $I = \overline{C}\sqrt{N}$
Where: I is the Floristic Quality Index; $\overline{C}$ is the average coefficient of conservation (http://www.botany.wisc.edu/wisflora/FloristicR.asp); and $\sqrt{N}$ is the square root of the number of species

Aquatic Invasive Species

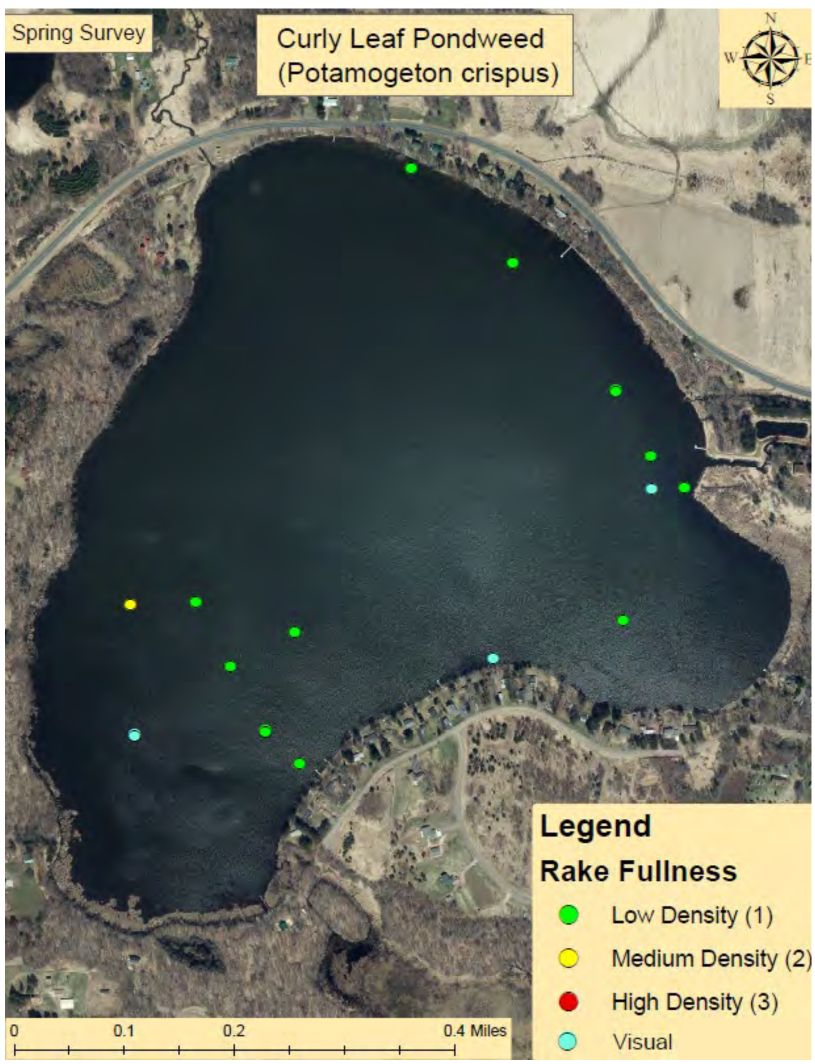
Three aquatic invasive species are present in Little Butternut Lake: curly-leaf pondweed, purple loosestrife, and yellow iris.

Curly Leaf Pondweed is a submerged aquatic invasive plant. The leaves of curly leaf pondweed are easily distinguished by their rounded tip, prominent mid-vein, and finely toothed edges. In most growing conditions, the leaves appear wavy.

Curly leaf pondweed is found in a wide variety of habitats, although it prefers alkaline and high nutrient waterbodies and typically grows in less than 3 meters of water.

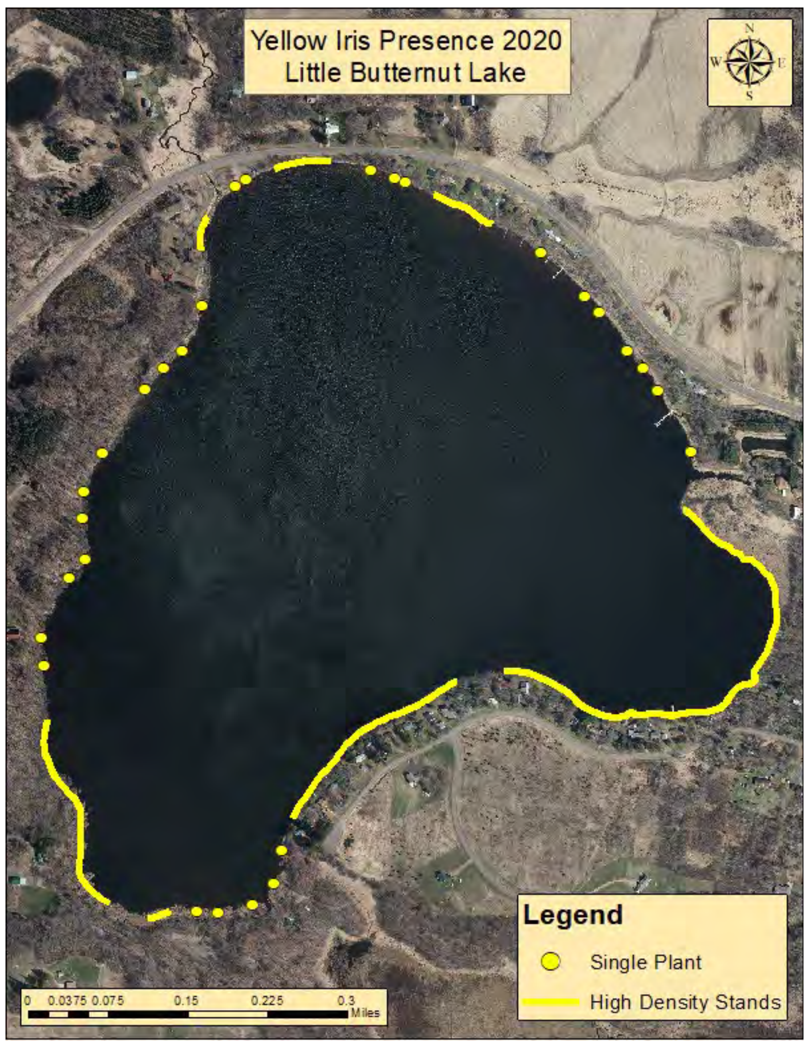
Curly leaf pondweed outcompetes native aquatic plants because it exhibits rapid growth in the early spring, sometimes growing beneath ice cover. Curly leaf pondweed forms large, dense mats on the surface of waterbodies inhibiting the light necessary for native plant growth and interfering with navigation and recreational activities.

A spring 2020 plant survey on Little Butternut Lake found curly-leaf pondweed at 15 sites, scattered throughout the lake. Most sites were low density, with only one site having plants at a medium density.



Yellow Iris is a perennial aquatic invasive plant that grows up to 6 feet tall and spreads by thick rhizomes and seeds that can float. Yellow iris is most easily identified by its yellow flower; however, when the plant is not flowering it can be easily confused with the native blue flag iris.

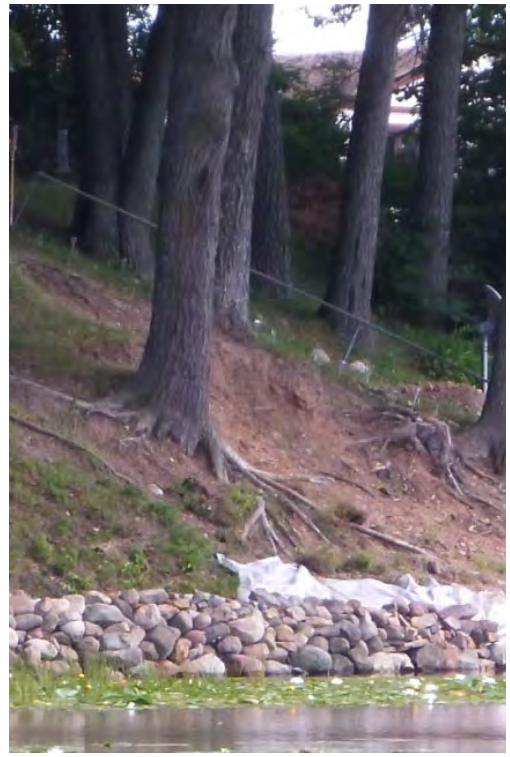
Dense stands of yellow iris crowd out native plants and reduce habitat. The plant can cause skin irritation, so caution should be used if hand pulling is undertaken. Yellow iris is a relatively new species in Polk County. Much of the shoreline of Little Butternut Lake has yellow iris, making this species a priority for removal.



Purple Loosestrife is an invasive perennial plant that grows 3-7 feet tall and develops a spike of small purple flowers in late summer. The leaves are oblong and arranged oppositely along a square shaped stem. Purple loosestrife spreads rapidly and colonizes wetlands, shorelines, and roadside ditches. Thick stands of purple loosestrife crowd out native vegetation and reduce food, shelter, and nesting sites for a variety of wildlife.

This plant, native to Europe and Asia, was introduced in North America in the 1800's for beekeeping and as a garden ornamental. Purple loosestrife has been present in Polk County for many years. Purple loosestrife was found on Little Butternut Lake in 2016 and 2020. In both years, plants were found on the northeast side of the lake and removed. Large stands of purple loosestrife exist in Luck making this species a priority for monitoring and removal.

Land Use and Water Quality



The health of water resources depends largely on the decisions that landowners make on their properties. When waterfront lots are developed, a shift from native plants and trees to impervious surfaces and lawn often occurs. Impervious surfaces are hard, man- made surfaces such as rooftops, paved driveways, and concrete patios that make it impossible for rainwater to infiltrate into the ground.

By making it impossible for rainwater to infiltrate into the soil, impervious surfaces increase the volume of rainwater that washes over the soil surface and runs off directly into lakes and streams. Rainwater runoff can carry pollutants such as sediment, lawn fertilizers, and car oils directly into a lake. Native vegetation can slow the speed of rainwater, giving it time to soak into the soil where it is filtered by soil microbes.

In extreme precipitation events, erosion and gullies can result. The signs of erosion are unattractive and can cause decreases in property values. Sediment can also have negative impacts on aquatic life. Fish eggs will die when covered with sediment and sediment influxes to a lake can decrease water clarity making it difficult for predator fish species to locate food.

Increases in impervious surfaces and lawns cause a loss of habitat for birds and other wildlife. Over ninety percent of all lake life is born, raised, and fed in the area where land and water meet. Overdeveloped shorelines remove critical habitat which species such as loons, frogs, songbirds, ducks, otters, and mink depend on. Impervious surfaces and lawns can be thought of as biological deserts which lack food and shelter for birds and wildlife. Nuisance species such as Canada geese favor lawns over taller native grasses and flowers. Lawns provide geese with a ready food source (grass) and a sense of security from predators (open views).

Additionally, fish species depend on the area where land and water meet for spawning. The removal of coarse woody habitat, or trees and branches that fall into a lake, cause decreases in habitat for fish and aquatic organisms.

Common lawn species, such as Kentucky bluegrass, are often dependent on chemical fertilizers and require mowing. Excess chemical fertilizers are washed directly into the adjacent water during precipitation events. The phosphorus and other nutrients in fertilizers, which produce lush vegetative growth on land, are the same nutrients which fuel algae blooms and decrease water clarity in a lake. Additionally, since common lawn species have very shallow root systems, when lawns are located on steep slopes, soil capacity is reduced and the impacts of erosion can be intensified.

Avoiding establishing lawns can provide direct positive impacts on lake water quality. The creation of a buffer zone of native grasses, wildflowers, shrubs, and trees where the land meets the water can provide numerous benefits for water quality and restore valuable bird and wildlife habitat.

Removal of vegetation is regulated in the shoreland protection area, or the area within 35 feet of the ordinary high water mark [15] landward on navigable lakes, rivers, and streams. Each property is allowed a viewing corridor (area cleared of vegetation) of no more than 35% of the lot width within the shoreland protection area. Creating or maintaining a viewing corridor requires a Land Use Permit from the Polk County Zoning Office. Viewing corridors cannot be expanded or moved once established. A lot with an existing viewing corridor that does not comply with current standards can be maintained if no additional trees and shrubs are removed within the shoreland protection area. However, if mowing ceases for one year, then the vegetative buffer zone must be allowed to reestablish and be maintained. Tree trimming is allowed in the shoreland protection area without a permit if the trimming does not result in the vegetation dying. Piers, wharfs, temporary boat shelters, and boatlifts must be located within or immediately adjacent to the viewing corridor.

The WDNR offers property owners up to $1,000 to install a 350 square foot shoreline buffer through the Healthy Lakes grant program. Larger plantings can be funded at 75% through the WDNR Lake Protection grant program.

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[15] The ordinary high water mark is defined as the point on the bank or shore up to which the water leaves a distinct mark (erosion, change in vegetation, etc.)

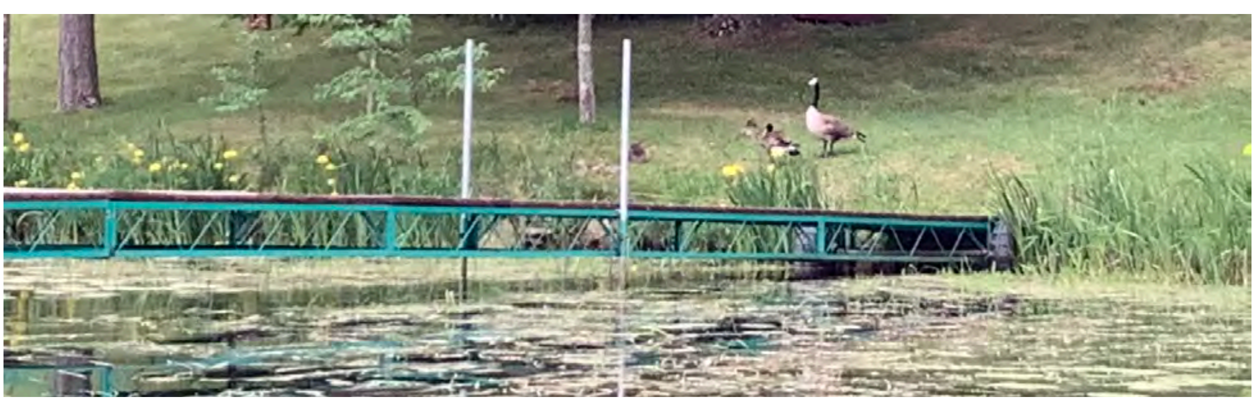
Goose Survey

Shoreline development and increases in the amount of manicured lawn provides ideal habitat for nuisance species such as Canada geese. Canada geese desire lawns on lake shores because they provide food, safety from predators, and visibility. Canada geese are considered a nuisance by residents on Little Butternut Lake which prompted a survey to see the extent of the nesting population of Canada geese on Little Butternut Lake.

A Canada goose survey protocol was developed by the Polk County Land and Water Resources Department and approved by the Wisconsin Department of Natural Resources. The survey was done in the early summer when Canada geese are molting (unable to fly) and the goslings are not mature enough to fly. Adults and juveniles are easy to distinguish from one another during this time of year because the adults have the typical brown body, black neck, and white patch on the head. The goslings are one color, starting as yellow when newly hatched and turning to gray for most of the summer.

The survey involved driving a boat around the perimeter of Little Butternut Lake counting all geese within 100 yards of the lake. Data was recorded for the number of adults, number of juveniles, and the location of each goose.

The survey was conducted four times in June of 2020 and three times in June of 2021. In 2020 the average number of adult geese was 13 and the average number of goslings was 34. In 2021 the average number of adults was 16 and the average number of goslings was 38. Little Butternut Lake sustains an abundant Canada goose population during the summer months. The conditions on Little Butternut Lake are favorable for nesting and raising goslings. The implementation of shoreline buffers at the lake edge will reduce favorable conditions for geese. Shoreline buffers play a vital role in shoreline stabilization, reduce nutrients entering the lake, and reduce desired habitat for Canada geese.



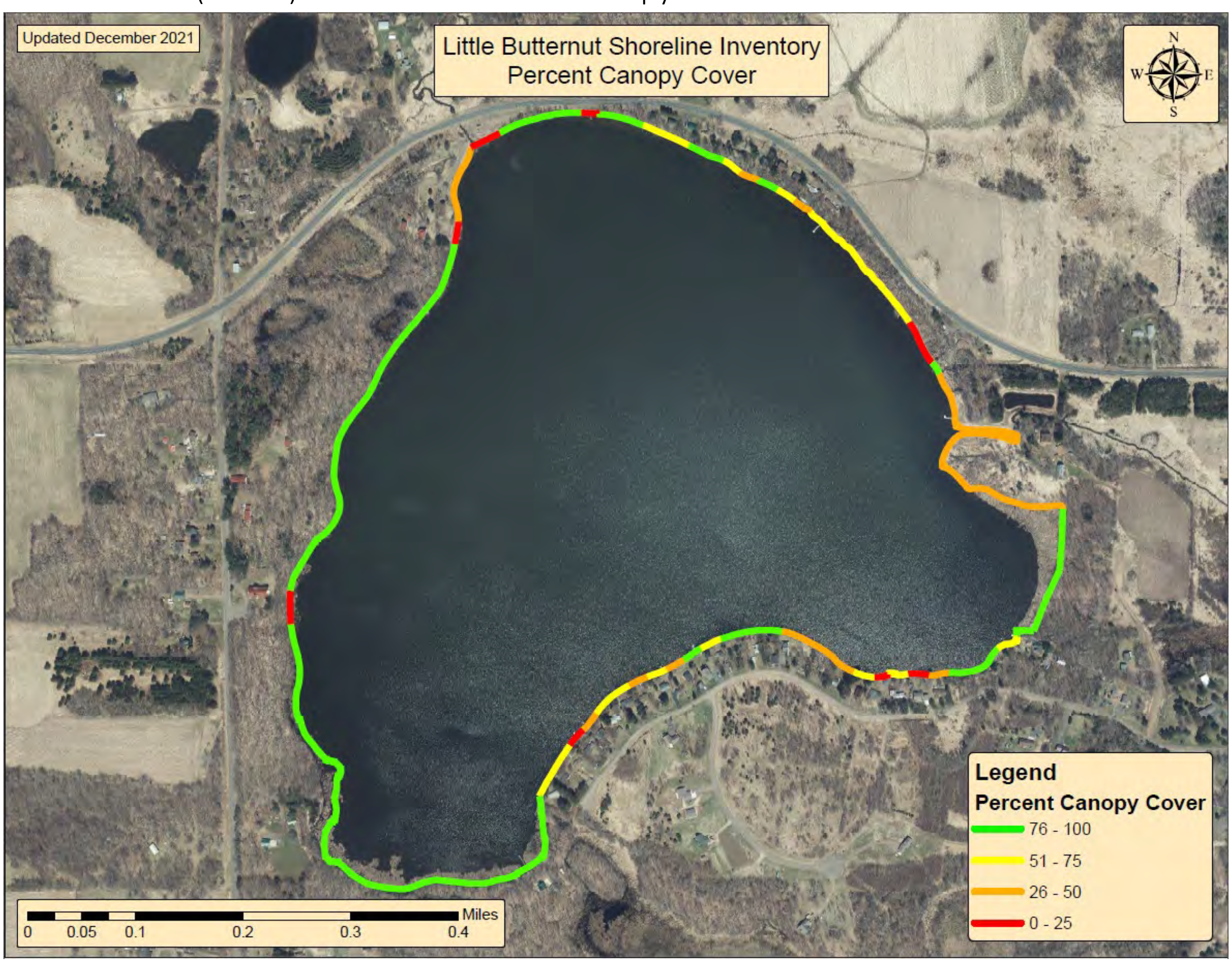
Shoreline Inventory

A shoreline inventory was completed using the Lake Shoreland and Shallows Habitat Monitoring Field Protocol developed by the Wisconsin Department of Natural Resources. The Land and Water Resources Department completed the survey on June 18th and 22nd, 2021.

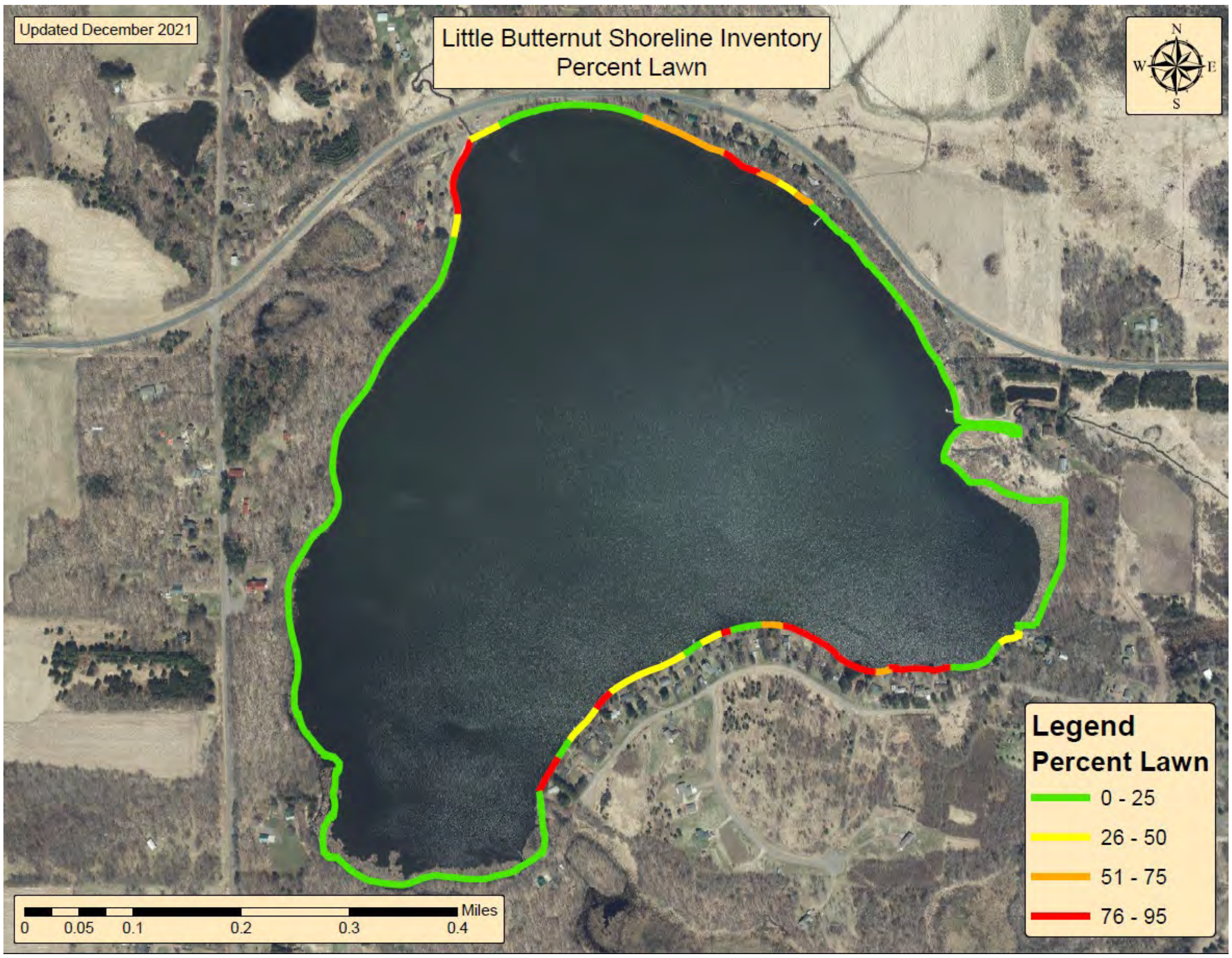
For each parcel on Little Butternut Lake, percent cover, human structures, runoff concerns, and bank zone factors were documented in the riparian buffer zone. Human structures and aquatic plants were documented in the littoral zone for each parcel.

Percent canopy cover was determined for the first 35 feet of shoreline at each parcel on the lake. Any large trees at least sixteen feet in height were considered. Three-quarters of the shoreline of Little Butternut Lake (76%) was determined as having canopy cover present. Canopy cover is important because trees intercept rainfall and reduce the potential for soil erosion.

Parcels in red (below) have less than 25% canopy cover.



Percent ground cover for shrub/herbaceous, impervious surface, and manicured lawn were determined for the first 35 feet of shoreline (riparian buffer zone) of each parcel. Seventy-eight percent of the ground cover in the riparian buffer zone on Little Butternut Lake was shrubs and herbaceous plants. Only 20% of the ground cover in the riparian buffer zone was lawn. Parcels in red (below) have greater than 75% of the ground cover as lawn.

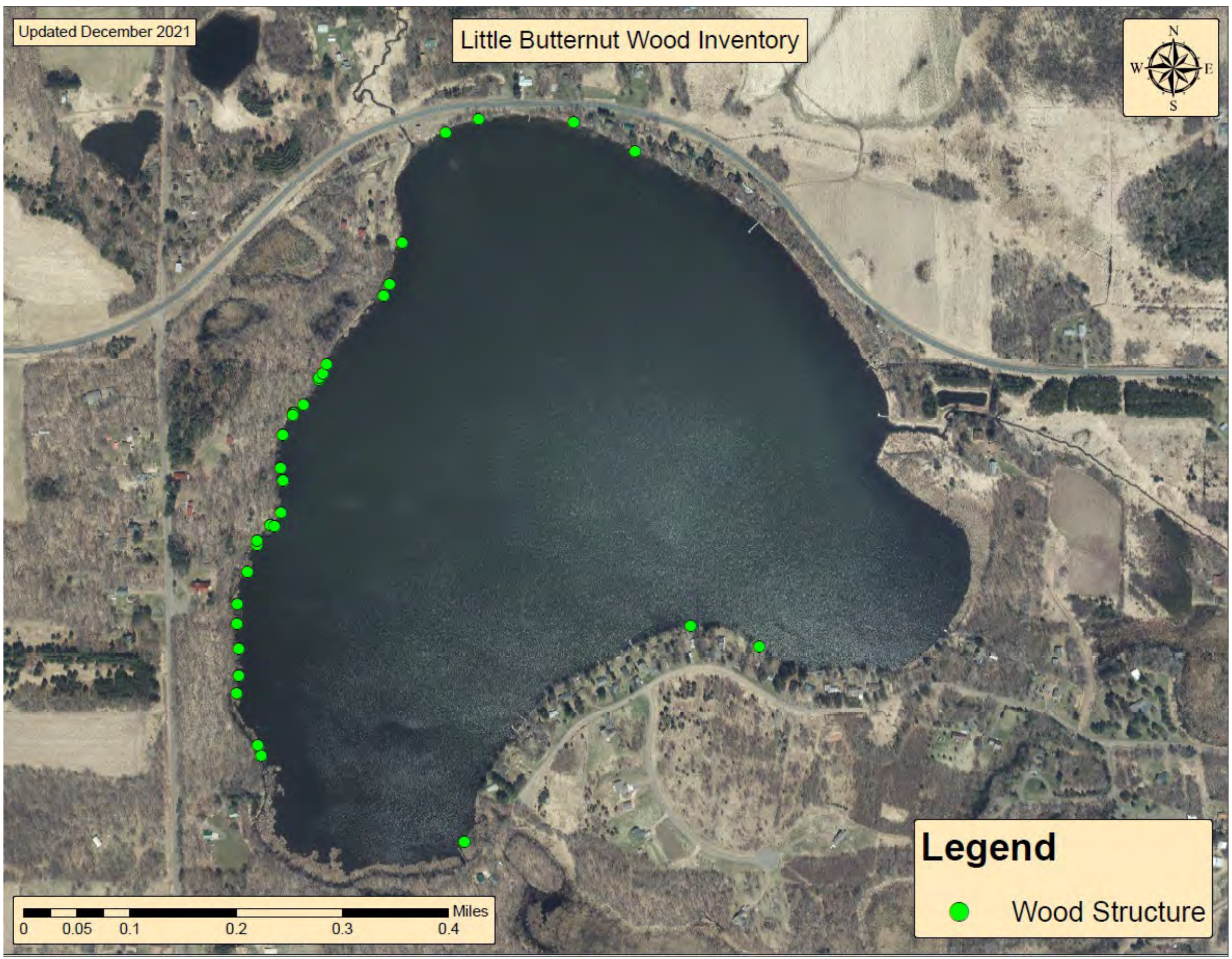


The shoreline inventory characterized human structures in the riparian buffer zone. In total there were 5 buildings, 11 firepits, and 2 landings (one gravel, one concrete).

Runoff concerns were also identified in the riparian buffer zone. One parcel had channelized water flow/gully, 28 had lawn/soil sloping to the lake, 18 had bare soil, 5 had sand/silt deposits, and 15 had slumping banks. Nineteen parcels had a stair/trail/road to the lake. Thirteen parcels had a total of 345 feet of rip rap and 1 parcel had an artificial beach. The survey also determined human structures in the littoral zone. In total, 35 parcels had piers, 7 had boat lifts, 1 had a boat house.

When trees fall into a lake, fish and aquatic organisms use them as habitat. Over time, humans have greatly reduced the number of fallen trees along the shoreline of lakes. Undeveloped lakes have nearly 900 logs per mile of shoreline.

The shoreline inventory identified large pieces of wood in the water. To be counted, wood need to be greater than four inches in diameter and at least five feet long. There were forty-six pieces of large wood along the shoreline of Little Butternut Lake (about 18.16 trees per mile of shoreline). Ninety-eight percent of the wood touched the shoreline of Little Butternut Lake and 57% of the wood had at least five feet of length underwater. Branchiness of each piece of large wood was also determined. Forty-eight percent of the pieces of large wood had no branches, 28% had a few branches, and 24% were a tree trunk with a full crown.



Septic Inventory

Private septic systems are regulated under Chapter 40 of the Polk County Code of Ordinances. To stay in compliance with the ordinance, all septic tanks must be visually inspected by a plumber, POWTS inspector, or person licensed under Wisconsin Statutes 281.48 and pumped within 3 years of the date of installation and at least once every 3 years thereafter.

The Ascent Permit Management Suite system for tracking sanity permits was used to determine compliance for the seventy-five septic systems near Little Butternut Lake. Fifty systems (72%) were in compliance, with the remaining twenty-three systems (27%) being out of compliance. Of the non-complaint systems, six have not been serviced in eight or more years and three systems have no records on file.

Proper septic upkeep is important to protect surface water and groundwater. Nutrients from septic systems move through the soil profile either leaching out directly to the lake or entering ground water.

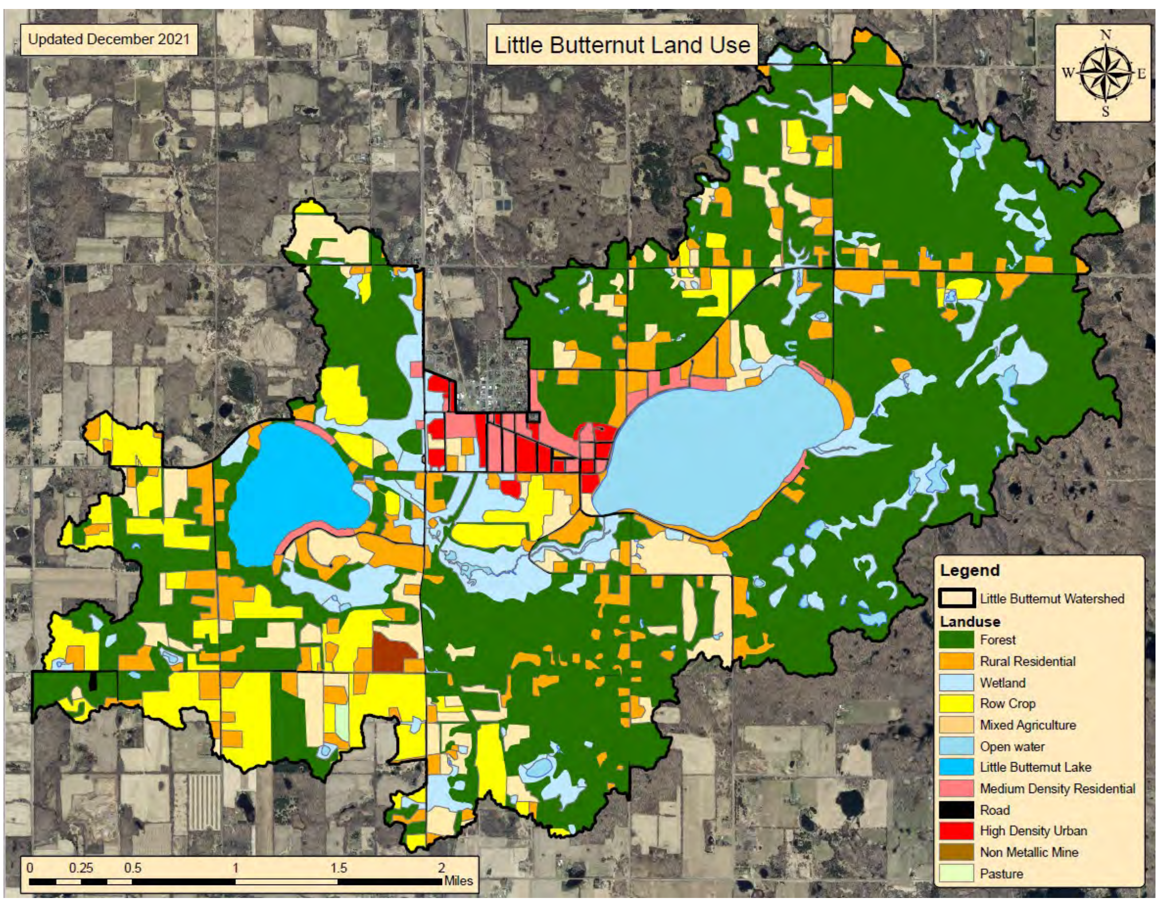
Keep your septic system working property and help extend its life by following these maintenance tips.

- ✓ INSPECT Have your system inspected and pumped at least every 3 years.
- ✓ CONSERVE Use water wisely to avoid overloading your septic system. Fix leaky faucets, check that the float in your toilet is adjusted correctly, and consider installing low flow shower heads and dual flush toilets.
- ✓ DISPOSE Grease, paints, solvents, and other materials should be disposed of properly rather than poured down a drain. Items such as diapers, coffee grounds, and feminine hygiene products should never be flushed down the toilet.
- ✓ PROTECT Care for your drainfield. Driving or parking on your drainfield increases compaction and shortens the life of your system. Keep trees and other deep-rooted vegetation from establishing above your drainfield. Point drain spouts away from your system since runoff can overload your system.

Little Butternut Lake Watershed Land Use

The area of land that drains to a lake is called a watershed. The ArcGIS Spatial Analyst Toolbox and LiDAR elevation data was used to delineate the watershed for Little Butternut Lake. The identification of culverts underneath roads is an important aspect of watershed delineation. When delineating watersheds from elevation data, computer software perceives roads as dams which prevent the flow of water. Field verification was used to identify culvert locations within the watershed to allow for accurate watershed delineation. The Little Butternut Lake Watershed is 6,770 acres in size. Land use was delineated using spring 2020 aerial imagery. The most common land use in the watershed is forest (50%).

Land Use	Acres	Acres (%)
Forest	3,406	50%
Rural residential	669	10%
Wetland	619	9%
Row crop	599	9%
Mixed agriculture	502	7%
Open water	468	7%
Little Butternut Lake surface	187	3%
Roads	114	2%
Medium density urban	113	2%
High density urban	67	1%
Non metallic mine	19	0.3%
Pasture	7	0.1%



Watershed Modeling and Nutrient Reductions

The Wisconsin Lake Modeling Suite (WiLMS) was used to model current conditions for Little Butternut Lake, verify monitoring, and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algae growth in most lakes. WiLMS can be used to estimate the amount of phosphorus being contributed from the watershed (external load) and from the lake sediments (internal load).

WiLMS uses average evaporation and precipitation data along with runoff coefficients for various land uses [16] to determine the annual nonpoint source load of phosphorus to a lake. WiLMS determined the annual phosphorus load to Little Butternut Lake as 1,357 pounds of phosphorus per year. Overall, internal loading is predicted to be insignificant to the nutrient budget for Little Butternut Lake (1%). Septic loading was estimated as less than 1% of the total nutrient budget.

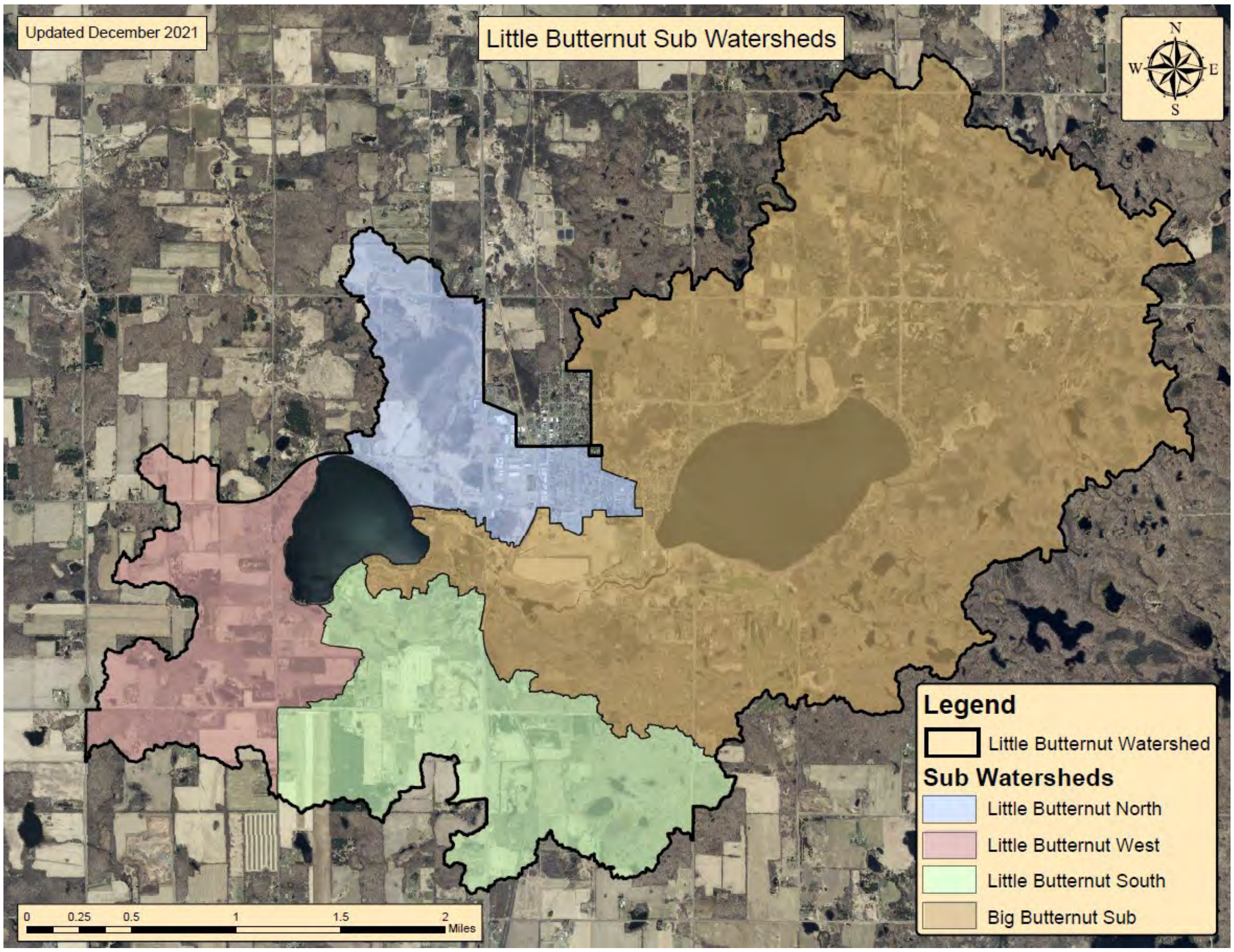
Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Forest	3,406	50%	273	20%
Rural residential	669	10%	60	4%
Wetland/open water	1,087	16%	97	7%
Row crop	599	9%	534	39%
Pasture/grassland	509	8%	137	10%
Medium density urban	246	4%	110	8%
Little Butternut Lake surface	187	3%	51	4%
High density urban	67	1%	90	7%

The Lake Phosphorus Models with the best fit for Little Butternut Lake were Vollenweider, 1982 Shallow Lake/Res and Nurnberg, 1984 Oxic. When averaged, these models predict that to achieve the phosphorus standard for Little Butternut Lake (40 µg/L) the external phosphorus load to the lake would need to be reduced by 3% or by 39 pounds per year. This would be a reduction from 1,357 to 1,318 pounds of phosphorus per year.

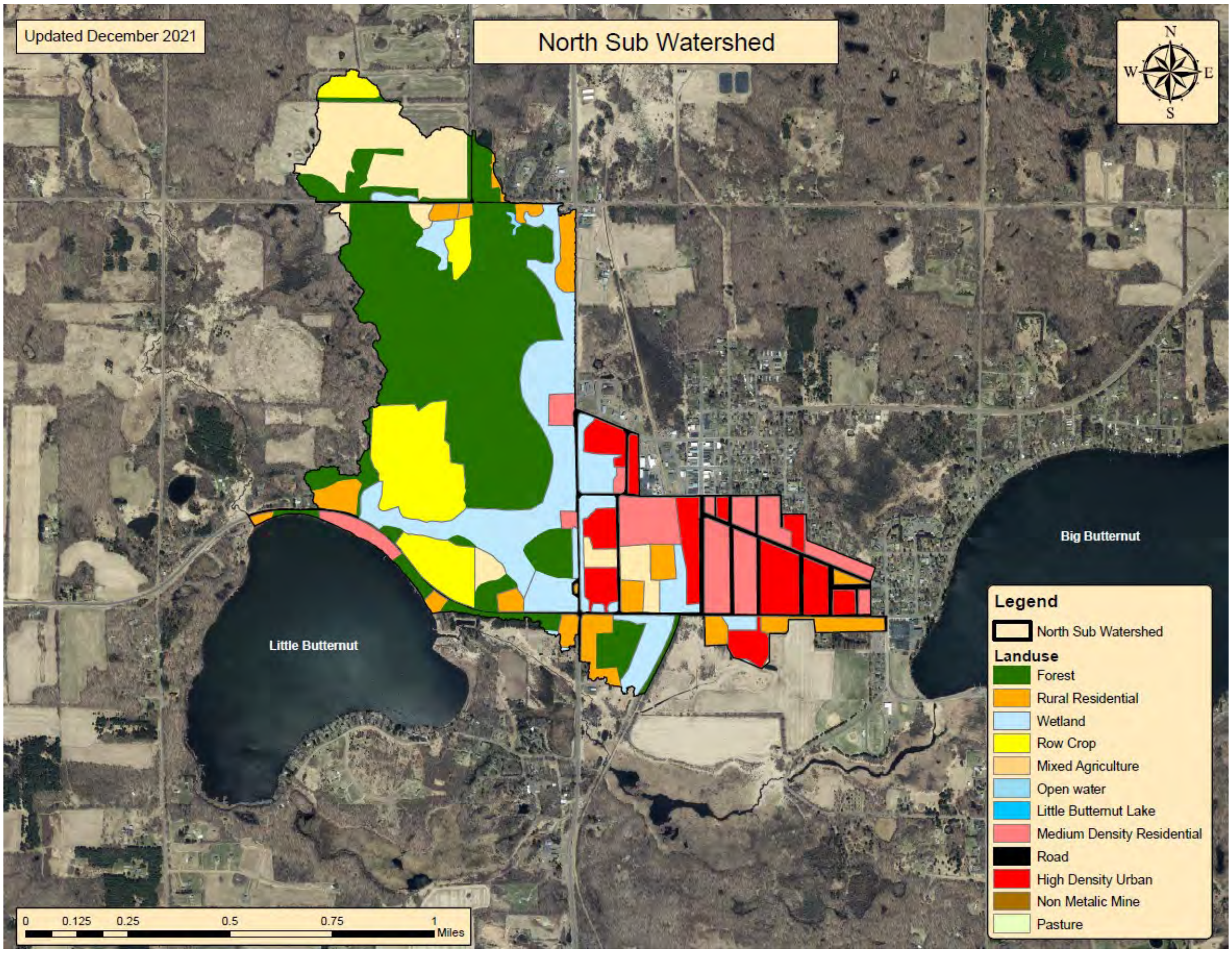
[16] Mixed agriculture and pasture were combined and termed pasture/grassland
Medium density urban, roads, and non-metallic mine were combined and termed medium density urban

Sub Watershed Modeling

To prioritize where the Association should allocate efforts and/or money when available, the watershed was divided into four sub watersheds: Little Butternut North, Little Butternut West, Little Butternut South, and Big Butternut Sub. Land use and phosphorus loads for each of the sub watersheds was calculated.



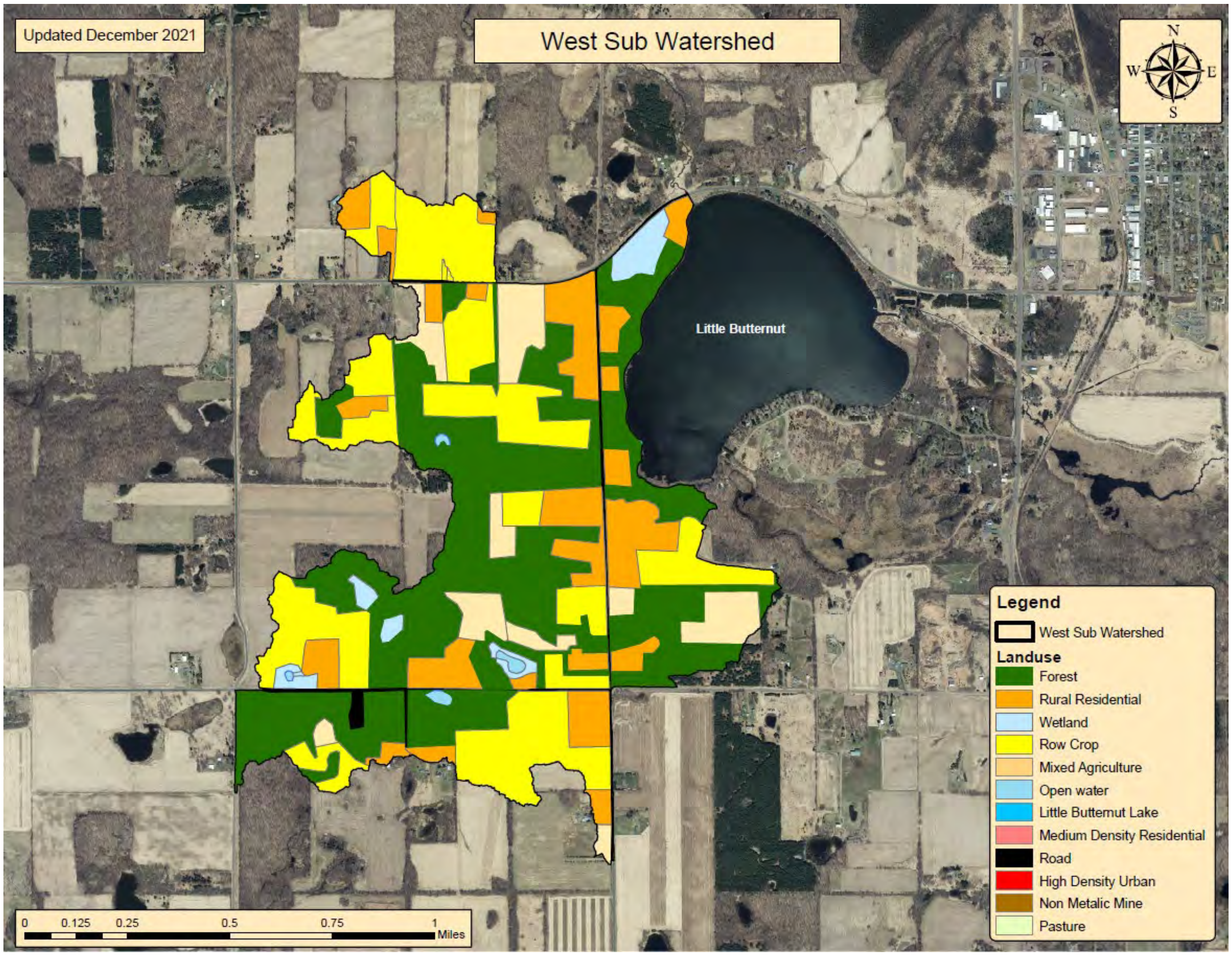
The Little Butternut North Sub Watershed is the smallest sub watershed at 583 acres and is primarily forest (35%), wetlands (17%), and medium density residential (13%). The annual phosphorus load from this sub watershed is 194 pounds per year. High density urban is responsible for 34% of the phosphorus load in this sub watershed, row crop for 26% of the load, and mid density urban for 17% of the load.



Little Butternut North Sub Watershed

Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Forest	205	35%	15	9%
Wetland	97	17%	9	5%
Mid density urban	75	13%	33	17%
Pasture/grassland	57	10%	15	8%
Row crop	57	10%	51	26%
High density urban	49	9%	66	34%
Rural residential	43	7%	4	2%

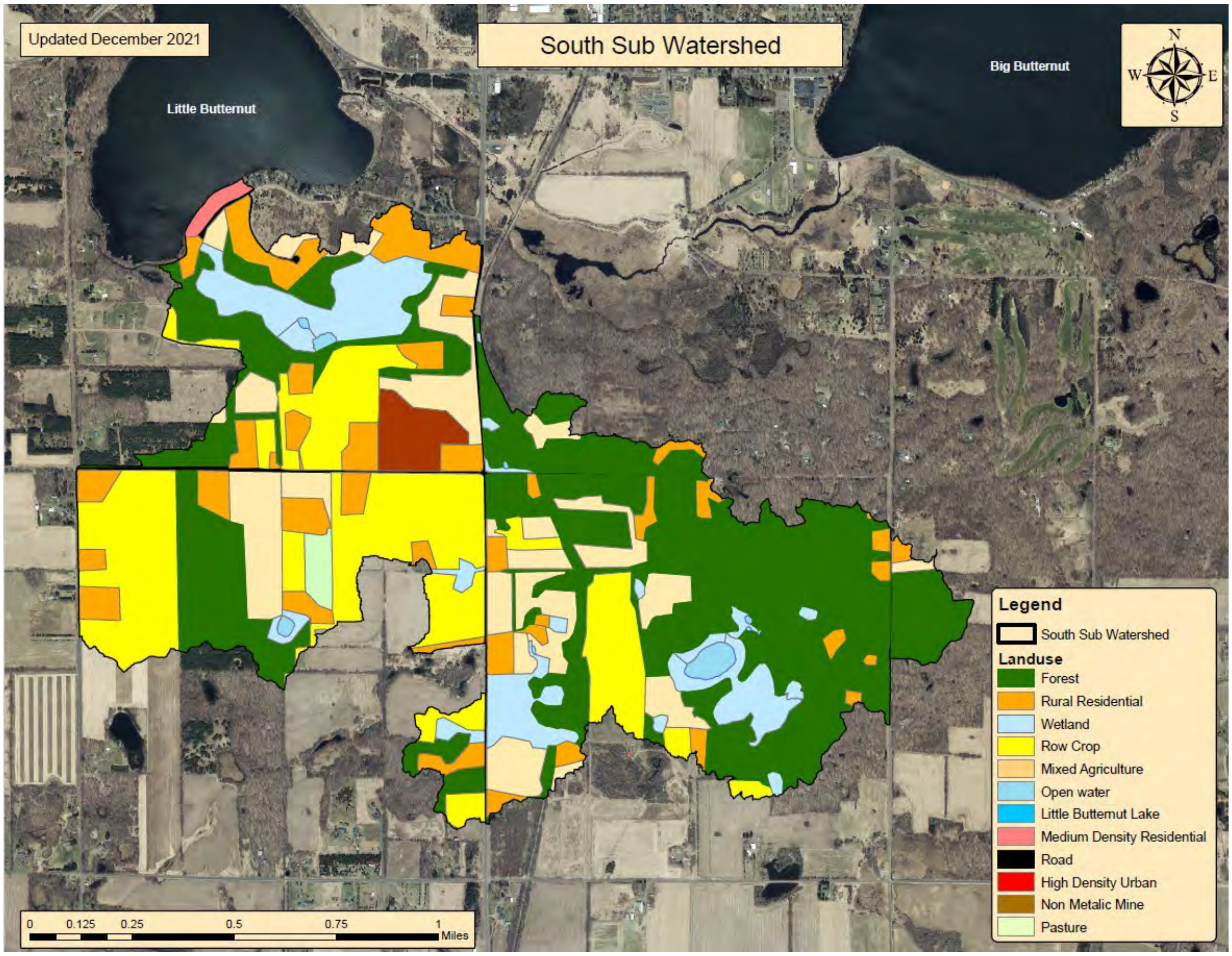
The Little Butternut West Sub Watershed is 698 acres and primarily forest (42%), row crops (29%), and rural residential (17%). The annual phosphorus load from this sub watershed is 235 pounds per year. Row crop is responsible for 76% of the phosphorus load in this sub watershed.



Little Butternut West Sub Watershed

Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Forest	290	42%	24	10%
Row crop	200	29%	179	76%
Rural residential	117	17%	11	4%
Pasture/grassland	57	8%	15	7%
Wetland/open water	21	3%	2	0.8%
Mid density urban	13	2%	7	3%

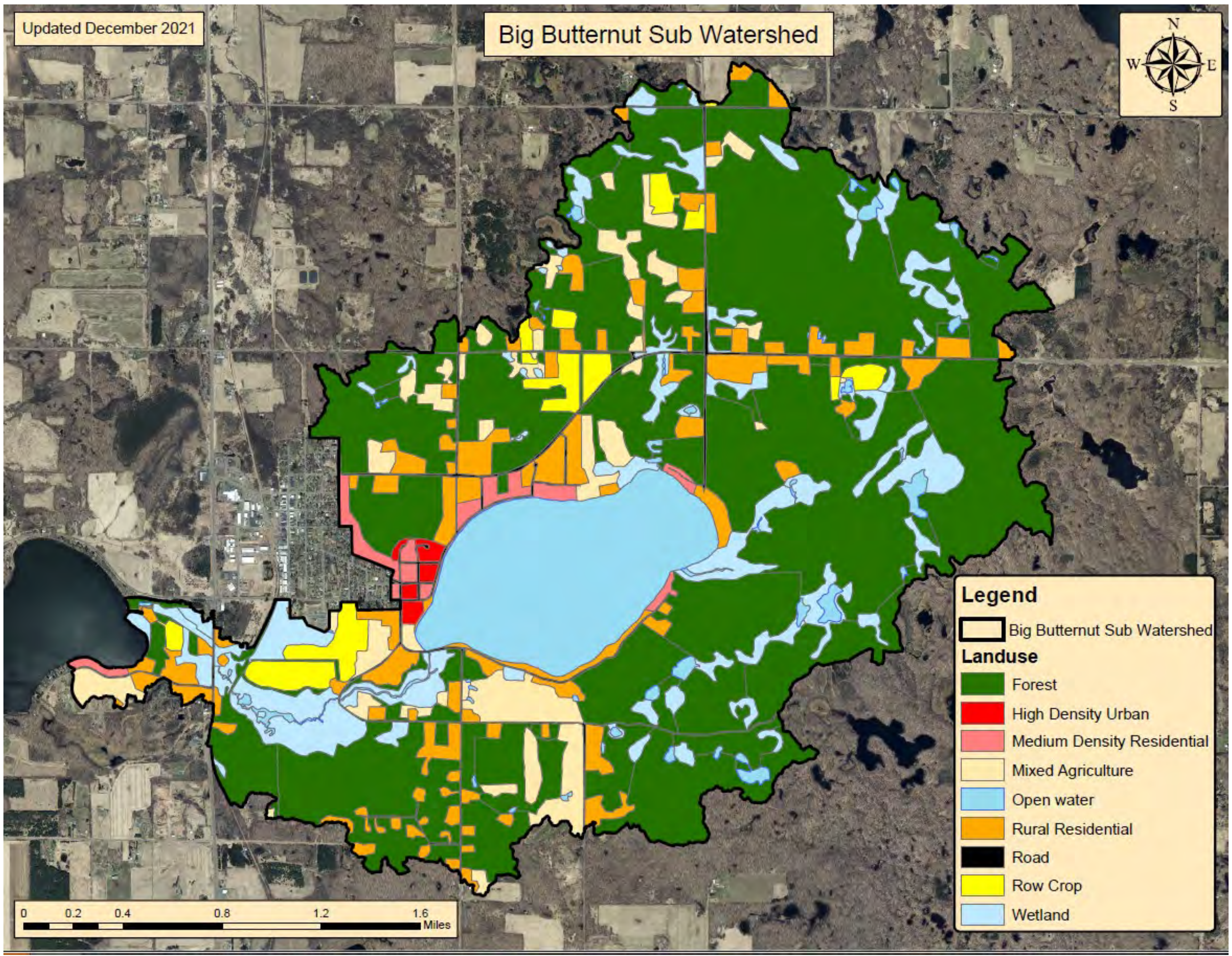
The Little Butternut South Sub Watershed is 1,051 acres in size and primarily forest (40%) and row crop (21%). The annual phosphorus load from this sub watershed is 306 pounds per year. Row crop is responsible for 64% of the phosphorus load in this sub watershed.



Little Butternut South Sub Watershed

Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Forest	418	40%	33	11%
Row crop	221	21%	196	64%
Pasture/grassland	144	14%	37	13%
Rural residential	125	10%	11	4%
Wetland/open water	107	9%	9	3%
Mid density urban	36	3%	15	5%

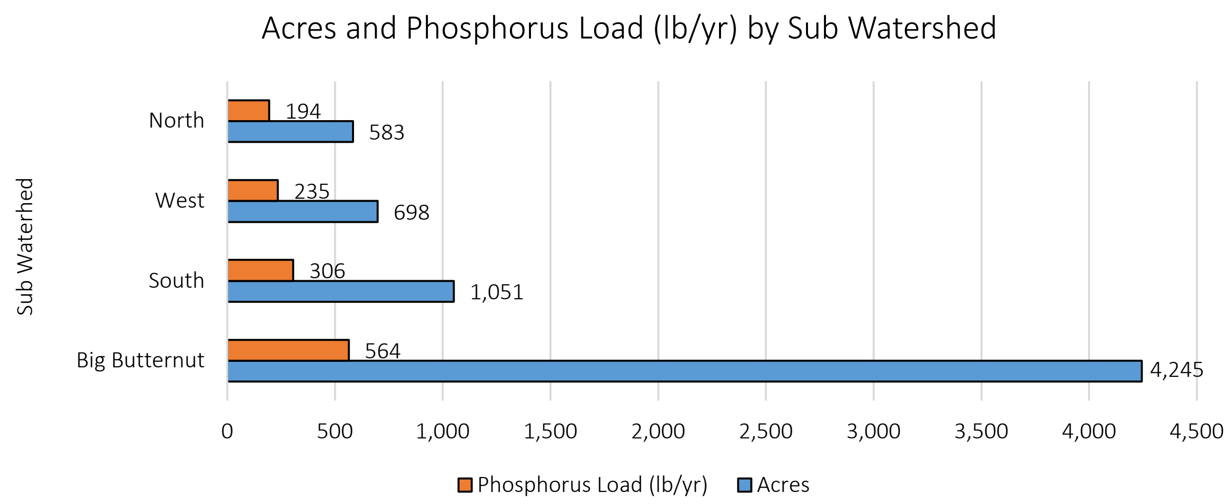
The Big Butternut Sub Watershed is the largest sub watershed at 4,245 acres and is primarily forest (59%), followed by wetland/open water (20%), and rural residential (9%). The annual phosphorus load from this sub watershed is 564 pounds per year. Forest is responsible for 36% of the phosphorus load in this sub watershed, row crop for 19%, and wetland/open water for 14%.



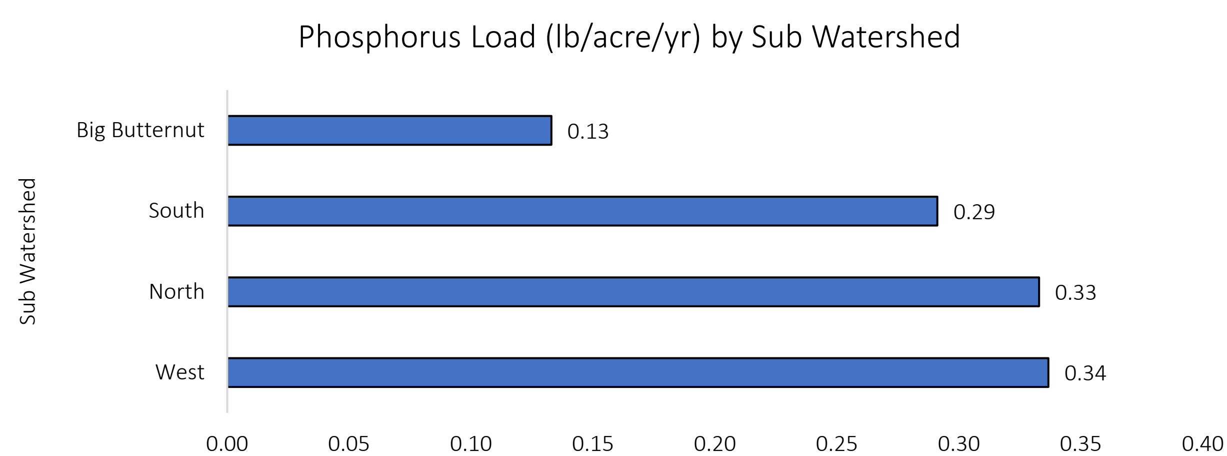
Big Butternut Sub Watershed

Land Use	Acres	Acres (%)	Phosphorus Load (lb/yr)	Phosphorus Load (%)
Forest	2,489	59%	201	36%
Wetland/open water	862	20%	77	14%
Rural residential	383	9%	35	6%
Pasture/grassland	251	6%	66	12%
Mid urban	122	3%	55	10%
Row crop	120	3%	108	19%
High density urban	18	0.4%	24	4%

The phosphorus load from each sub watershed is related to the size of the sub watershed. As the size of the watershed increases, the annual phosphorus load increases.



When the data is shown as the annual pounds of phosphorus loading to Little Butternut Lake as pounds per acre, the sub watersheds contributing the greatest amount of phosphorus to Little Butternut Lake are the west and north sub watersheds.



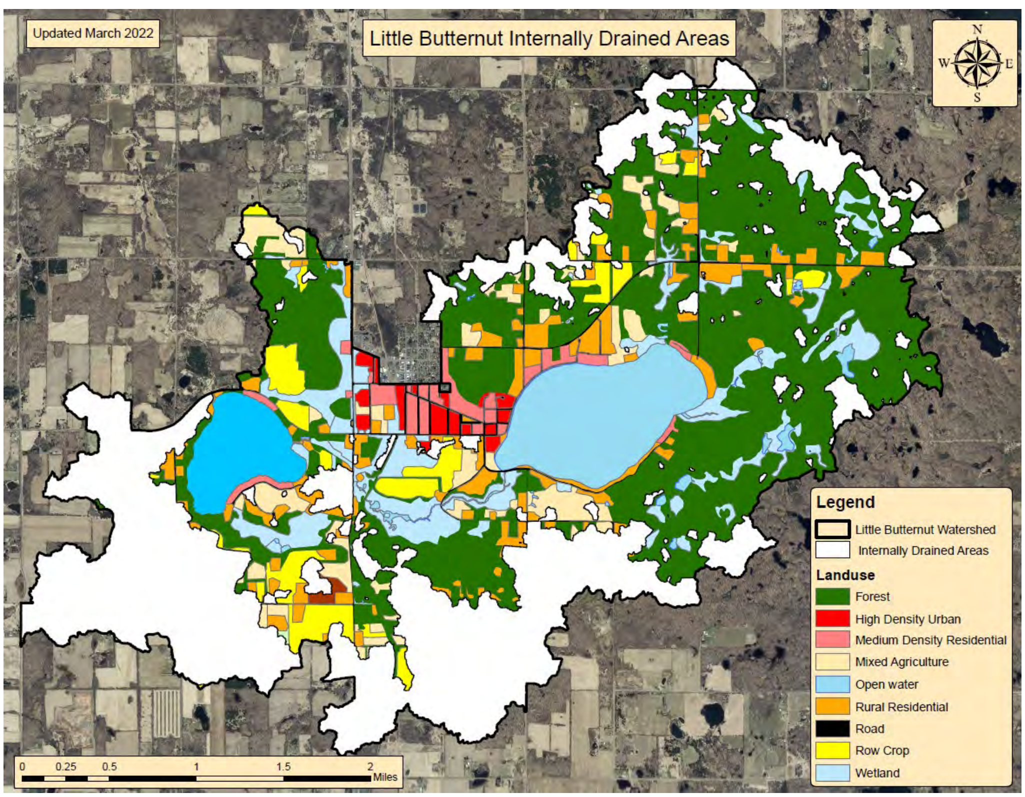
When considering the Big Butternut Sub Watershed, WiLMS estimated the annual phosphorus load as 564 pounds per year. WiLMS uses average evaporation and precipitation data along with runoff coefficients for various land uses to determine the annual nonpoint source load of phosphorus to a lake. FLUX estimated the load for the Big Butternut Sub Watershed as 430 pounds per year. FLUX uses grab samples for phosphorus concentrations and corresponding flow measurements and a complete flow record to estimate nutrient loading for tributaries over an annual timeframe.

Internally Drained Areas

The Little Butternut Lake Watershed is a unique landscape because a large part of the landscape in internally drained. Internally drained areas are depressions on the landscape that accumulate water during rainfall events and spring snowmelt. The depressions are deep enough that water is not able to exit the basin. Therefore, water that accumulates in internally drained areas infiltrates into the ground rather than contributing to overland runoff/flow to a lake or river.

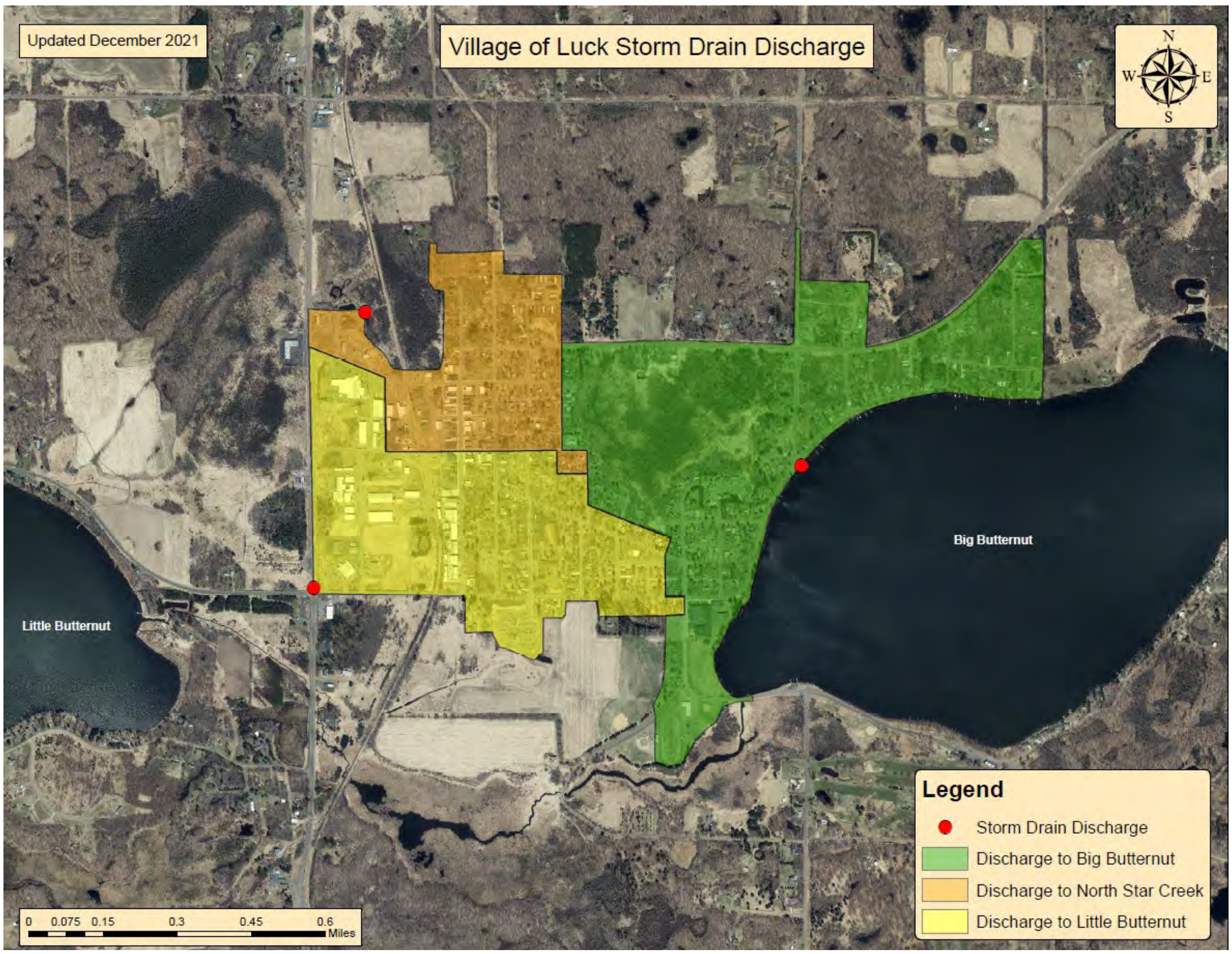
Internally drained areas are modeled based on storm intensity. For this project, a 10-year storm with a duration of 24 hours was used to model internally drained areas. This is equivalent to 4.2 inches of rain falling within a 24-hour period. This storm intensity is the commonly used standard for which conservation practices are designed to withstand. In total 2,254 acres (38%) of the Little Butternut Lake Watershed are internally drained. If 4.2 inches (or less) of rain falls on the watershed within a 24-hour timeframe these acres will not contribute runoff to Little Butternut Lake.

One way to prioritize project installation would be to focus more effort on the land within the watershed that contribute to the lake during lower intensity/duration events. It is important not to entirely discount the internally drained areas because under high storm intensity events runoff from these areas would contribute to Little Butternut Lake.



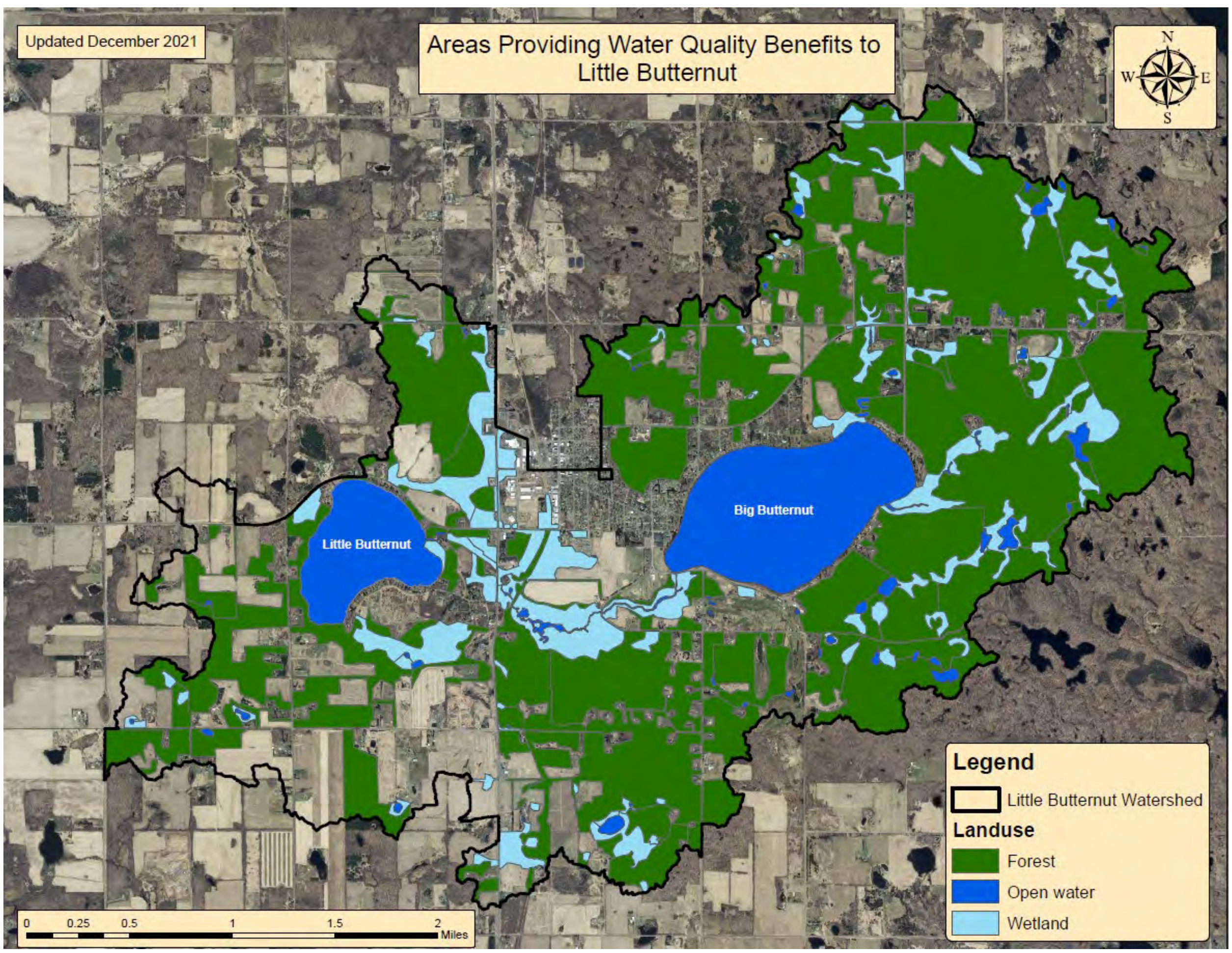
Village of Luck Storm Drain Discharge

The Village of Luck is primarily located within the Little Butternut Watershed. The Village has a network of storm drains that outlet at 3 different locations. Two storm drain systems are a part of the Little Butternut Lake Watershed, one entering directly into Big Butternut and the other discharging into a wetland/ditch before working its way to Little Butternut. The third storm drain discharges into North Star Creek which flows to Long Trade Lake.



Areas Providing Water Quality Benefits to Little Butternut Lake

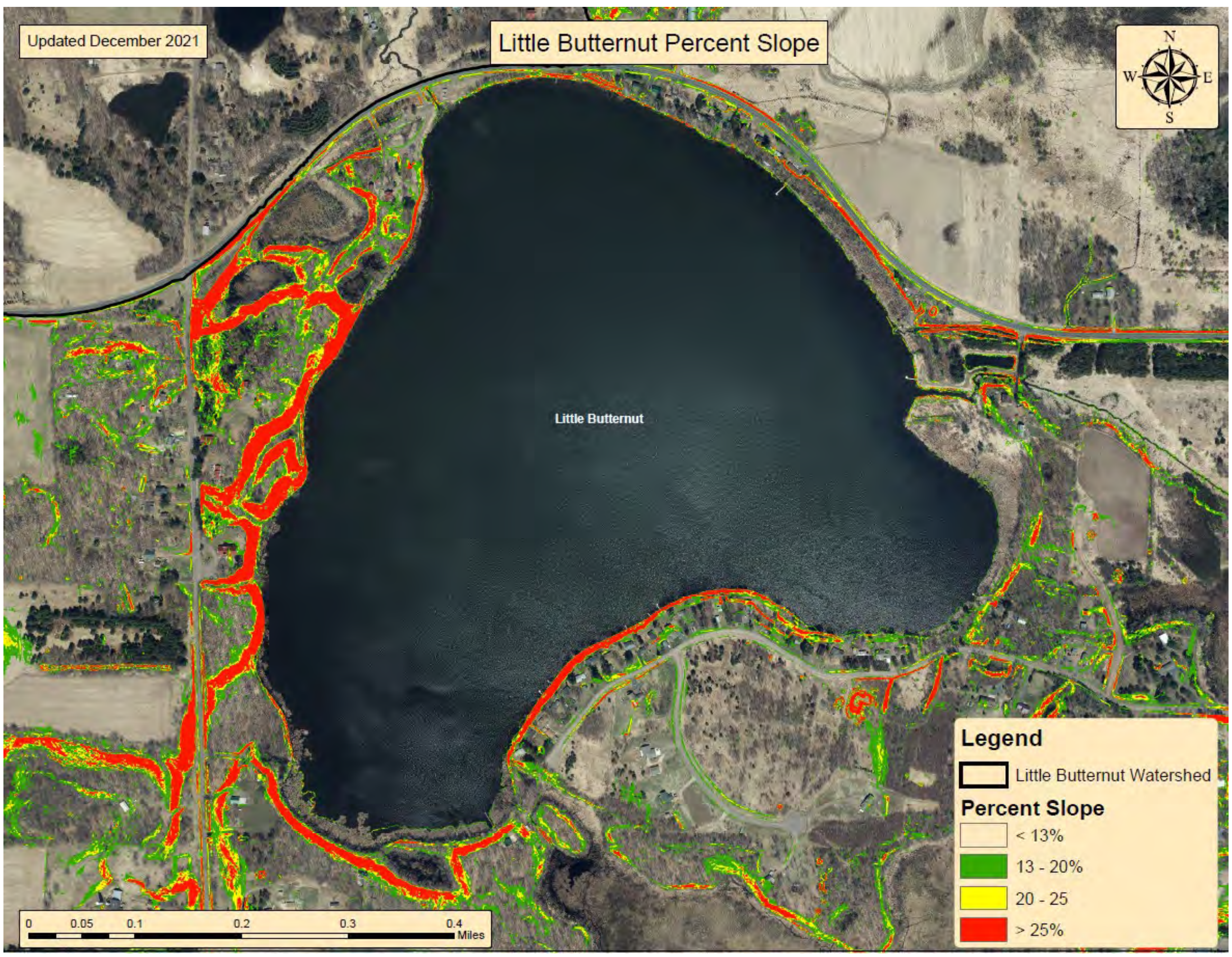
Natural areas such as forests and wetlands allow for more infiltration of precipitation when compared with conventionally tilled row cropped fields and developed residential sites containing lawns, rooftops, sidewalks, and driveways. Dense vegetation lessens the impact of raindrops on the soil surface, thereby reducing erosion and allowing for greater infiltration of water. Additionally, wetlands provide extensive benefits through their ability to filter nutrients and allow sediments to settle out before reaching lakes and rivers. In the Little Butternut Lake watershed 50% of the land use is forest and 9% is wetland.



Slope

Steep slopes occur in areas where the gradient of land is 13% or greater. Areas having steep slopes can be categorized into three levels: 13-20%, 21-25%, and greater than 25%. A slope map can be used to prioritize areas that are prone to erosion and would benefit from establishment of perennial vegetation. Areas of likely gully erosion can also be identified from a slope map. Establishment of perennial vegetation will require landowner participation and in the case of gully erosion, it is likely an engineer would need to be hired to address problem areas.

Much of the shoreline on the west side and southwest side of Little Butternut Lake has a slope greater than 25%.



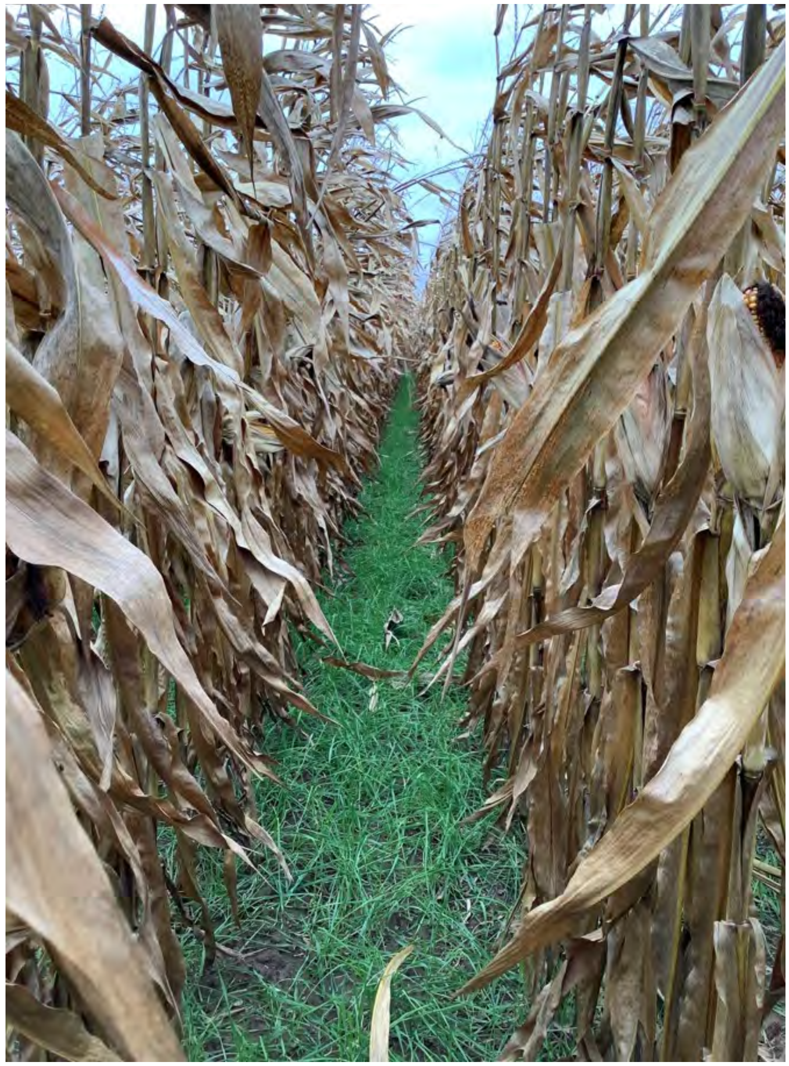
Agricultural Land Use Inventory

An agricultural land use inventory was conducted across the Little Butternut Lake Watershed to establish a baseline understanding of the types of agricultural practices currently being used in the watershed and to identify conservation practices that could be adopted that would have a positive impact on water quality. The inventory identified the type of crops being produced, tillage practices used in crop production, and the use of cover crops. The current use of conservation practices was identified and the potential to expand the use of conservation practices was determined.

Two windshield surveys were conducted to assess the utilization of two agricultural conservation practices (no-till and cover crops) in the watershed. An early summer inventory in 2020 documented the type of crops being grown and whether conventional or no-till practices were utilized. The second survey was conducted in the spring of 2021 to document the use of cover crops.

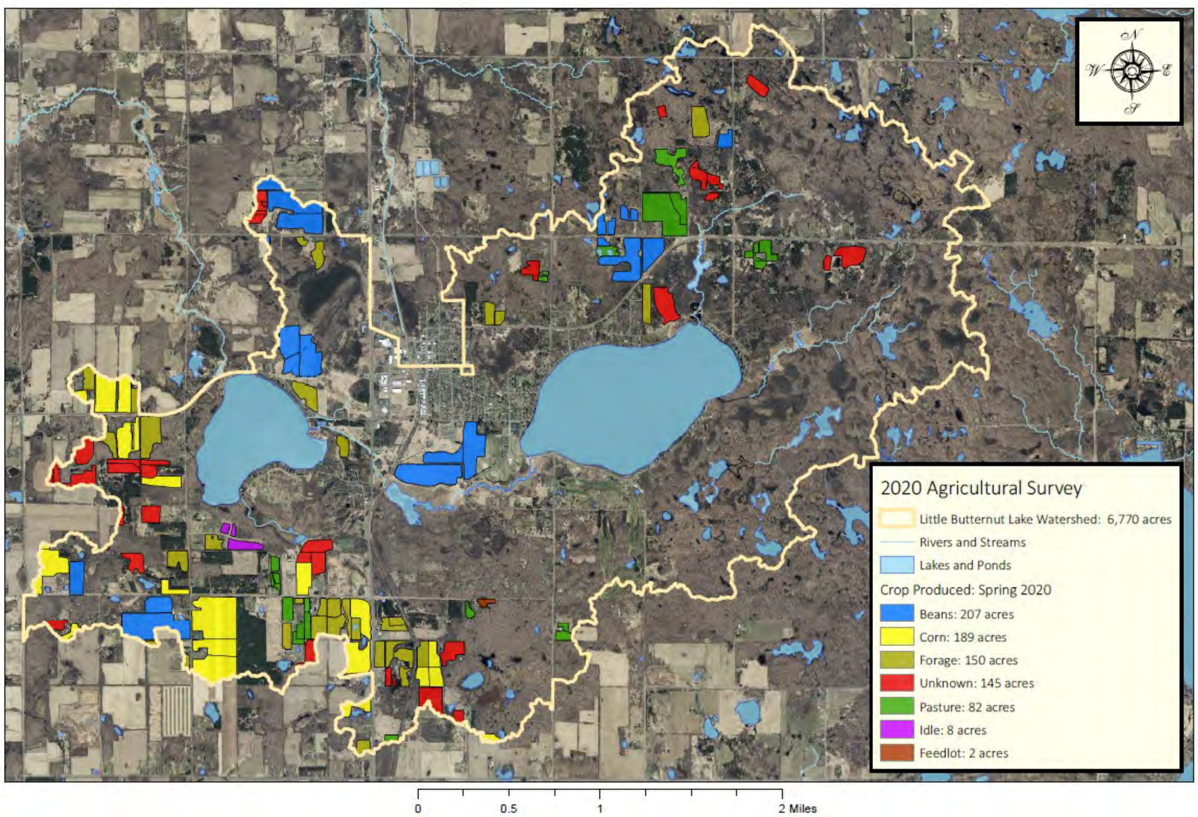
No-till planting is a conservation practice where crops are grown without the use of tillage. Soil tillage is a common agricultural practice used to loosen soil, incorporate crop residue and plant nutrients (fertilizer and manure), and prepare a suitable seed bed for planting the crop. Tillage also increases the potential of soil erosion and nutrient runoff. Tillage breaks soil structure, inhibits the process of soil aggregation, and reduces surface crop residue. Soil is left exposed and more susceptible to the erosive forces of wind and water. Soil erosion from agricultural landscapes can be a major source of sediment and nutrients in lakes and rivers causing decreased water quality. The adoption of no-till planting reduces the potential for soil erosion and nutrient loss, thus minimizing agriculture's impact on water quality.

Planting cover crops is another conservation practice that can reduce agriculture's impact on water quality. Cover crops are plants that are grown outside of the main production crop specifically for their benefits to the soil or main crop. The primary benefit of cover crops is the reduction of erosion. Cover crops reduce erosion because the vegetation and roots protect the soil from early spring and late fall rains when the primary crop is not growing. Cover crops can increase infiltration, capture unused nutrients, build soil structure, promote soil bacteria and fungi growth, break compaction layers, suppress weeds, and provide many other benefits to the soil and environment. These benefits can lead to reductions in soil erosion, runoff, and nutrient loss from agricultural fields.



The windshield surveys identified 12% of the land use in the Little Butternut Lake Watershed as agricultural (783 acres). The 2020 survey revealed a diversity of cropping practices throughout the watershed. Four crop categories were documented in the watershed: soybean (207 acres), corn (189 acres), forage (150 acres), and pasture (82 acres). The remaining agricultural land use consisted of unknown crop (145 acres), idle land (8 acres), and feedlot (2 acres).

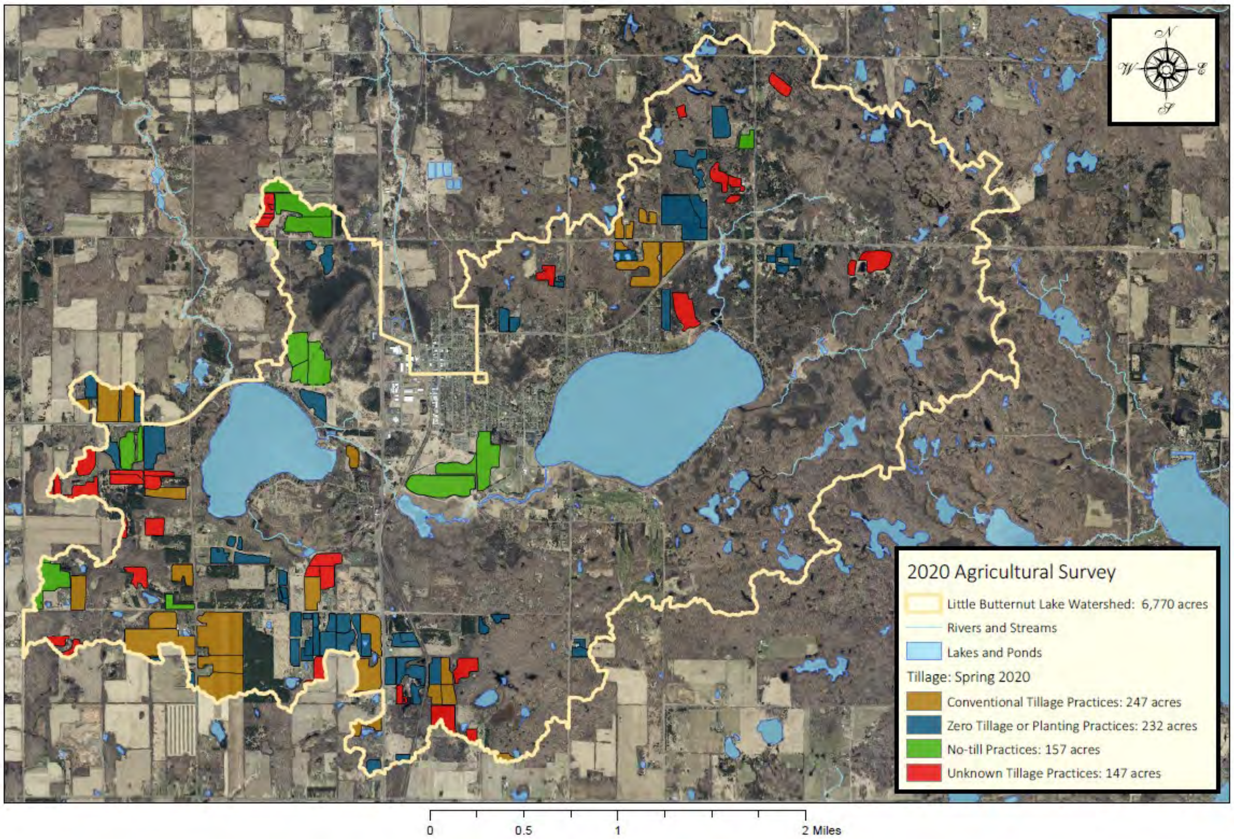
Little Butternut Lake Watershed: 2020 Crop Inventory



Crop grown in 2020	Acres	Acres (%)
Soybean	207	26%
Corn	189	24%
Forage (grass/forbs primarily harvested mechanically)	150	19%
Unknown (unable to determine tillage/crop, likely due to obstructed view from roadway)	145	19%
Pasture (grass/forbs primarily harvested by livestock)	82	10%
Feedlot (bare soil due to animal activity)	2	<1%
Idle land (zero tillage and crop not planted at time of survey)	8	1%
Total	**783**	**100%**

The tillage survey identified 247 acres of conventional tillage, 232 acres where zero tillage or planting activities had occurred, 157 acres of no-till, and 147 acres where tillage practices were unknown. Fields that could not be identified from the roadway were documented as unknown crop with unknown tillage. Fields that had not yet been planted were identified as idle land and any tillage was documented.

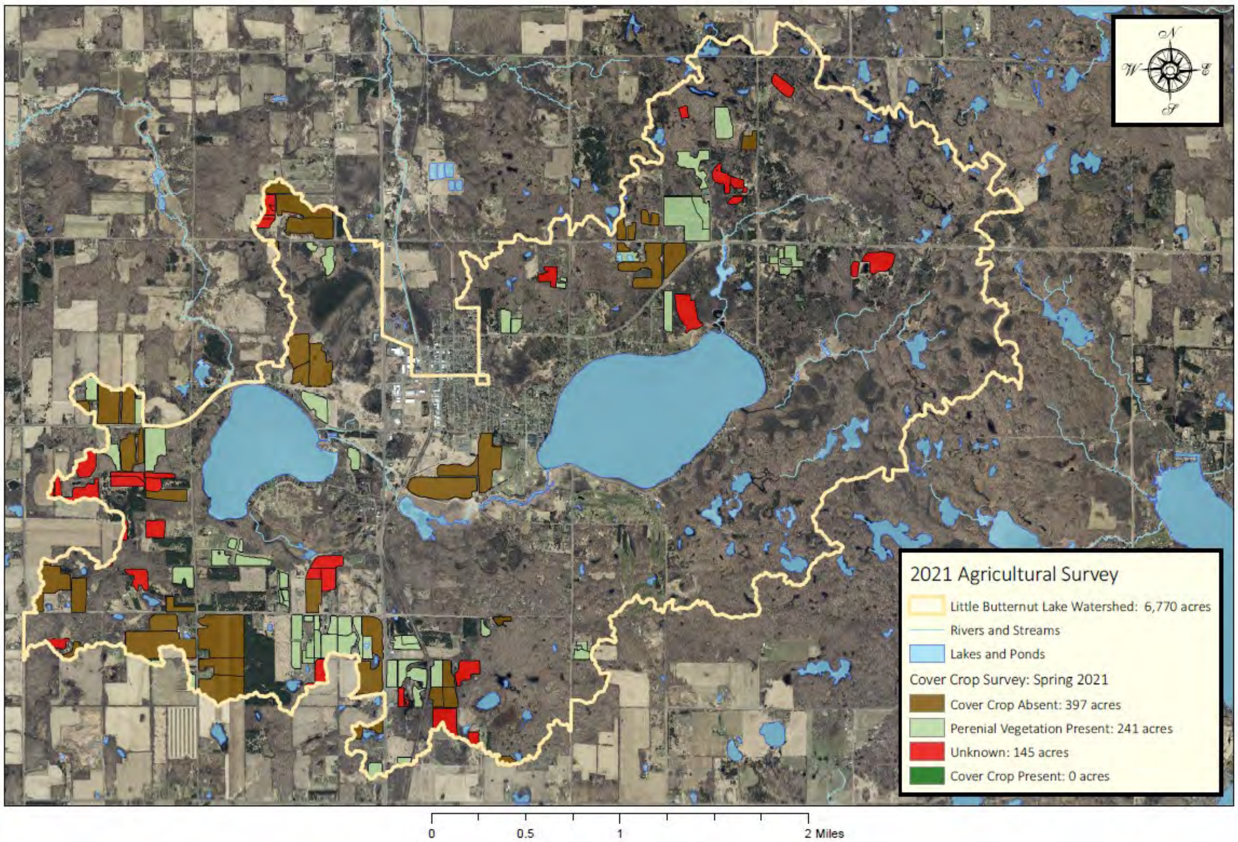
Little Butternut Lake Watershed: 2020 Tillage Inventory



Tillage practice in 2020	Acres	Acres (%)
Conventional	247	31%
Zero tillage (field not tilled due to perennial vegetation present or	232	30%
No-till	157	20%
Unknown (unable to determine tillage, likely due to obstructed	147	19%
Total	**783**	**100%**

The 2021 cover crop survey identified zero acres of cover crops in the Little Butternut Lake Watershed.

Little Butternut Lake Watershed: 2021 Cover Crop Inventory



Cover crop in 2021	Acres	Acres (%)
Cover crop absent	397	51%
Perennial vegetation present (forage or pastureland)	241	31%
Unknown	145	18%
Cover crop present	0	0%
Total	**783**	**100%**

This inventory is a single year representation of the crops and practices being used in the Little Butternut Lake Watershed. The crops producers choose to grow, and the practices used to grow them can change from year to year due to numerous factors such as commodity prices, feed demand, livestock type, equipment, and weather.

The crops grown in a watershed often reflect the type of livestock present in the surrounding area. Farmers who raise livestock primarily grow crops to provide a food source for their animals. Different livestock species require different food sources. Dairy animals are often fed a forage-based diet consisting of corn silage and alfalfa haylage. Beef animals are often fed a diet consisting of corn (grain or silage) and dry hay (grass/alfalfa) and/or haylage. Horses are fed a diet consisting of dry hay (grass/alfalfa). Farmers that don't raise livestock often grow row crops (corn and soybean) and sell the grain. The Little Butternut Watershed has very few livestock, with only horses and beef being observed during the agricultural land use inventory. Due to this observation, it can be deducted that most crops grown in the Little Butternut Watershed are grown to provide feed for horses and beef, or for grain.

A single field is typically managed using a crop rotation, where a series of different crops are grown over a period of years. The inventory completed in 2020 would represent a single year of a crop rotation. To determine the types of crop rotations being used in the Little Butternut Lake Watershed, an inventory would need to span multiple years. Crop rotations common in Wisconsin include row crop rotations and livestock rotations. A typical row crop rotation might involve planting corn in odd numbered years and soybeans in even numbered years. A livestock rotation generally includes corn harvested for grain or silage, perennial vegetation such as alfalfa/grass that is harvested as a forage and soybeans or small grain (wheat, rye). Over a seven-year period, a field in a livestock rotation might be planted in alfalfa for the first four years, followed by two years of corn, and one year of soybeans. On the eighth year the rotation would begin again, with four years of alfalfa. Fields used to produce hay for horses are often left in grass/alfalfa for many years and may never be planted to a row crop.

Different rotations have varying impacts on water quality based on the crops being grown and the practices used. A rotation that incorporates perennial vegetation over several years of the rotation would have a lower potential to negatively impact water quality as compared to an excessively tilled field where only row crops are produced. The years of perennial vegetation production offer water quality benefits by eliminating several years of tillage and providing year-round vegetative cover that protects the soil from erosion.

Row crops (corn and soybeans) were the dominant agricultural commodity grown in the Little Butternut Watershed in 2020 (50%), with at least 31% of all fields being planted using conventional tillage. These fields may be part of a row crop or livestock rotation. In 2020, a portion of the agricultural land in the watershed (29%) was in perennial (long term) vegetation (forage or pasture) where soil was not disturbed through tillage. The fields documented as forage are likely in a livestock rotation, where perennial vegetation is grown and harvested in a rotation with row crops, or they may be in long term perennial vegetation. The fields documented as pasture are likely never or vary rarely tilled and planted into row crops. These fields would provide water quality benefits during the years when perennial vegetation is present.

No fields in the Little Butternut Watershed had cover crops present during the 2021 survey. Based on the 2020 crop survey, cover crops could have been planted on 548 acres in the watershed. However, the absence of cover crops in the watershed is not entirely surprising. Cover crops are an emerging conservation practice that have many benefits, but also many barriers to adoption. Cover crops can be a difficult practice to incorporate into rotations with row crops harvested for grain due to a short planting window and limited growing season remaining. Adoption of cover crops in the Little Butternut Watershed may be limited due to these barriers.

Agriculture's overall impact on water quality in the watershed can change on a yearly basis. These changes can be influenced by the types of rotations grown, how those rotations are managed, as well as environmental conditions. This land use survey represents a one-year snapshot of agricultural practices being used in the Little Butternut Lake Watershed. The acres of no-till or cover crops may fluctuate yearly based on multiple factors. Other barriers (equipment, agronomic, environmental, financial, social) may inhibit or prevent producers from implementing conservation practices. Future inventories could be used to gauge long term implementation and trends in practice adoption. Agricultural producers may also be using other practices to reduce erosion or nutrient loss that were not inventoried with this survey. Outreach to producers about how conservation practices can be implemented into their operation is one way to obtain the nutrient and sediment reduction goals of this lake management plan.

The data collected for this agricultural survey was incorporated into the Spreadsheet Tool for Estimating Pollutant Load (STEPL) to determine nitrogen, phosphorous, and sediment load reductions in the Little Butternut Lake Watershed based on the use of no-till and cover crops. The agricultural survey documented 157 acres of no-till in the watershed in

2020 which resulted in a 7% reduction in nitrogen, 12% reduction in phosphorus, and 15% reduction in sediment loading. No cover crops were identified in the watershed.

Based on the land use and data from the agricultural survey, it can be assumed that 548 acres were potentially suitable for no-till and/or cover crop practices in 2020. STEPL was used to predict pollutant load reduction percentages assuming the use of no-till and/or cover crops were implemented on these acres.

If no-till was adopted on all suitable acres in 2020, it would have resulted in a 24% reduction in nitrogen, 45% reduction in phosphorous, and 53% reduction in sediment load to the lake. If cover crops were planted on all suitable acres and current use of no-till (157 acres) was maintained, it would have resulted in pollutant load reductions of 12% nitrogen, 17% phosphorous, and 20% sediment load to the lake. If all suitable acres were no-till planted and planted with a cover crop this would have reduced nitrogen loading by 27%, phosphorous by 46%, and sediment by 55%.

Based on STEPL modeling, the implementation of additional acres of no-till and/or cover crops, especially in fields near the main flow paths of the watershed, could be enough to achieve the 3% phosphorous load reduction necessary to meet the phosphorous standard (40 µg/L) in Little Butternut Lake.

Agriculture Conservation Planning Framework

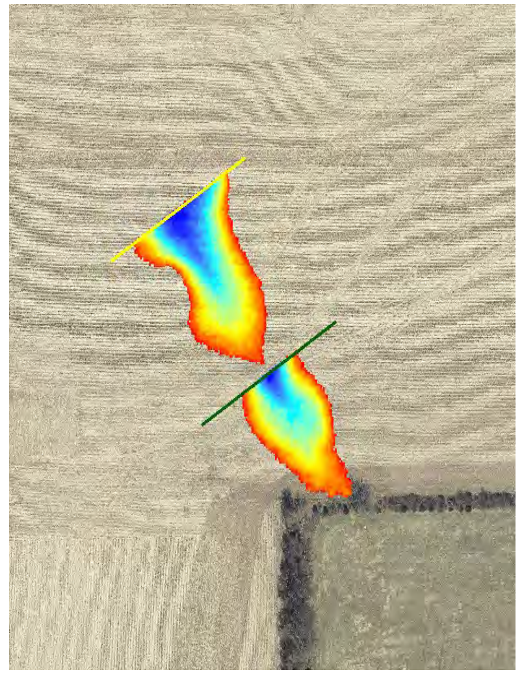
The Agriculture Conservation Planning Framework (ACPF) is a toolbox in ArcMap used to identify and prioritize conservation practices on the landscape at a watershed scale. ACPF uses high resolution LiDAR elevation data and a user supplied culvert inventory to determine flow paths on the landscape. Once the flow paths are created, the program prescribes conservation practices on the landscape based on slope, soils, field boundaries, and relevance to flow paths. This program is agriculture based so the practices suggested are designed for and located within agricultural fields.

ACPF was used to identify and prioritize agricultural conservation practices within the Little Butternut Lake Watershed. The program recommended a variety of conservation practices for implementation including water and sediment control basins, contour buffer strips, grass waterways, and farm ponds. The following summary of each practice will include how each conservation practice works, in-field examples, and the number of potential practices identified within the Little Butternut Lake Watershed. ACPF ranks practices based on priority, with adjustable criteria. The practices displayed will be color coordinated based on priority, with green being lowest concern, yellow being moderate concern, and red being high concern. Distance to stream and field runoff risk are used to rank the priority level of conservation practices. ACPF also produces a map showing height above channel, or meters above the surface water elevation.

The outputs of ACPF allow for the prioritization of conservation practices that reduce runoff, erosion, and nutrient/sediment loading to surface waters. It is important to consider all the outputs of ACPF because the implementation of agricultural best management practices requires landowner participation and can directly impact the yields and economics for an agricultural system. Implementation of best management practices may not be possible on the highest priority areas, so it is important not to overlook lower ranked areas which will still result in a positive impact.

Exact locations of potential practices will not be included in this report to ensure the anonymity of landowners. Information regarding site locations and landowner information will be kept for internal use with Polk County Land and Water Resources Department. Any practices suggested with this tool should be field verified.

Water and sediment control basin



A water and sediment control basin (WASCOB) is a 3 foot or higher embankment built perpendicular to a drainage way in an agricultural field. During a rainfall event, WASCOBs collect water in a pooling area and then allow the water to slowly flow through a pipe to an area where it can infiltrate. WASCOBs can slow down peak discharge (runoff) and reduce phosphorus loading, sediment erosion, and gully formation.

Locations for 13 WASCOBs were identified in the Little Butternut Lake Watershed. The image shows the location of two potential WASCOBs in a single field. The lines indicate the location of the WASCOB embankment, while the rainbow colors indicate the pooling area behind the embankment. The blue color indicates the deepest part of the pooling area, while the red indicates the outer edge of the pooling area.

WASCOBs are ranked by the number of contributing acres, or area of land that drains to each WASCOB. The upper WASCOBs in the image is ranked as moderate concern (yellow line), meaning it has a decent sized contributing area of 8.4 acres, while the lower WASCOB (green line) has a small contributing area of 4.4 acres.

Contour buffer strips

Contour buffer strips are strips of perennial vegetation planted parallel to the contour line that intercept the flow of surface runoff. Contour buffer strips are often alternated throughout a field to allow for farming practices to continue between the buffer strips. This practice uses permanent vegetation to reduce the overall length of farmed land on a slope which reduces the accumulation and speed of runoff. This practice reduces erosion and overall runoff volume, improves water quality, and prevents the formation of gullies.

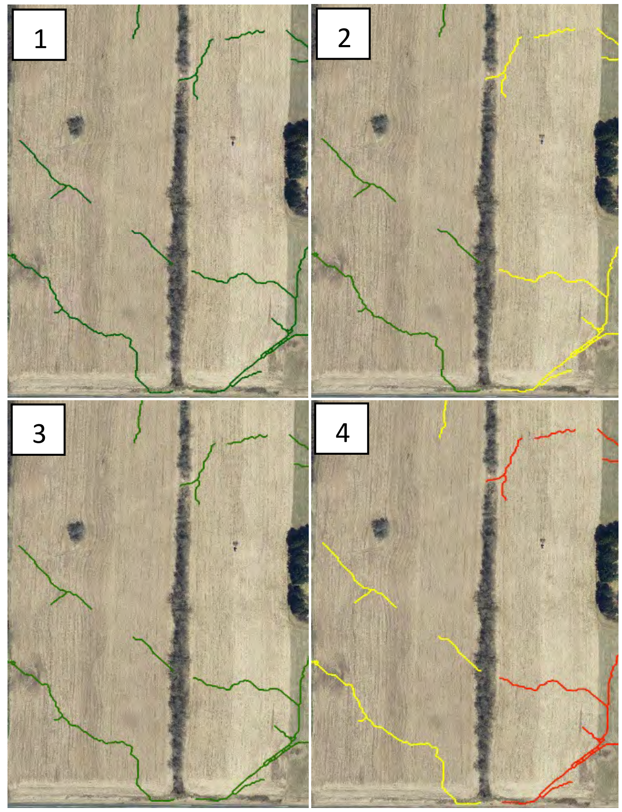
In the Little Butternut Lake Watershed 38 contour buffer strips were identified and categorized based on runoff risk potential: 3 high priority (red), 8 moderate priority (yellow), and 27 low priority (green). In the examples below, some fields have multiple contour buffer strip locations identified. Although each buffer might be identified as low priority, if all the buffers were installed, runoff would be greatly reduced in a single field.

Grass waterways

Grass waterways are installed within a concentrated flow path in an agricultural field where there is a high probability of concentrated runoff. Grass waterways are planted with perennial grasses and are maintained in permanent vegetation. Installing grass waterways in areas where concentrated water flows through a field ensures that water is moving within a vegetated flow path (rather than over bare soil) which reduced the velocity of water and the risk of erosion and gully formation. The deep roots of the grasses keep the soil in place and reduce the amount of soil being transported by water in a runoff event. Grass waterways do not trap and store water or sediment; rather, they are reducing sediment loss where erosion and runoff has a high probability of occurring.

ACPF identified 45 locations within the Little Butternut Lake Watershed where grass waterways could be implemented. This tool considers many different possibilities when prioritizing the locations of grass waterways.

The image on the right shows four different methods of prioritizing the location of a single grass waterway. In image 1 grass waterways are prioritized by runoff risk potential (which considers slope and stream proximity), in image 2 by slope of where the waterway would be implemented, in image 3 by distance to stream, and in image 4 by mean slope of 75% of the field.



The grass waterways are displaying as higher priority in image 4 because of the steep slope of the field. However, because the field is not located near a main tributary to Little Butternut Lake, the waterway is displaying as a lower priority in image 3.

Since ACPF ranks grass waterways based on four different criteria, a site visit to higher priority locations would be recommended to determine implementation potential.

Farm ponds

Farm ponds are depressions that are created in areas of higher slopes where other practices are not suitable. They are designed to catch runoff, reduce erosion, and allow for sediment and nutrients to settle out before entering surface waters. These ponds can have five to one hundred acres of contributing area, or the area of land that drains to the pond.

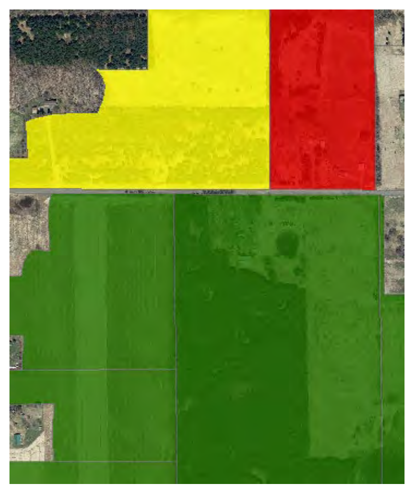
There were three areas in the Little Butternut Lake Watershed that ACPF identified as suitable for a farm pond. In the image, the blue area is the farm pond and the green area is the drainage area for the pond. This is a desirable location because the drainage area is an ag field next to a wetland. Implementing a farm pond in this location would keep nutrients from entering the wetland and eventually Little Butternut Lake.

Riparian attribute polygons

The riparian attribute polygons tool splits the three main tributaries in the Little Butternut Lake Watershed into 200-meter stream corridor segments and creates a 15 meter buffer area on each side of the stream. Three factors are determined for each 200 x 15 meter stream segment: preferred buffer type, desired buffer width, and runoff risk.

The preferred buffer type is determined using slope, land use, and soils. The three main buffer types include: deep rooted vegetation, multiple species vegetation, and stiff stemmed grasses. In areas where the three buffer types are inadequate, the tool classifies areas as either critical zones or those requiring additional bank stabilization.

Due to the large amount of wetland complexes that the tributaries flow through before they enter the lake, there are limited areas where buffers can be implemented. Of the few sites that potentially could have a buffer implemented, site visits need to be conducted to address suitability of site



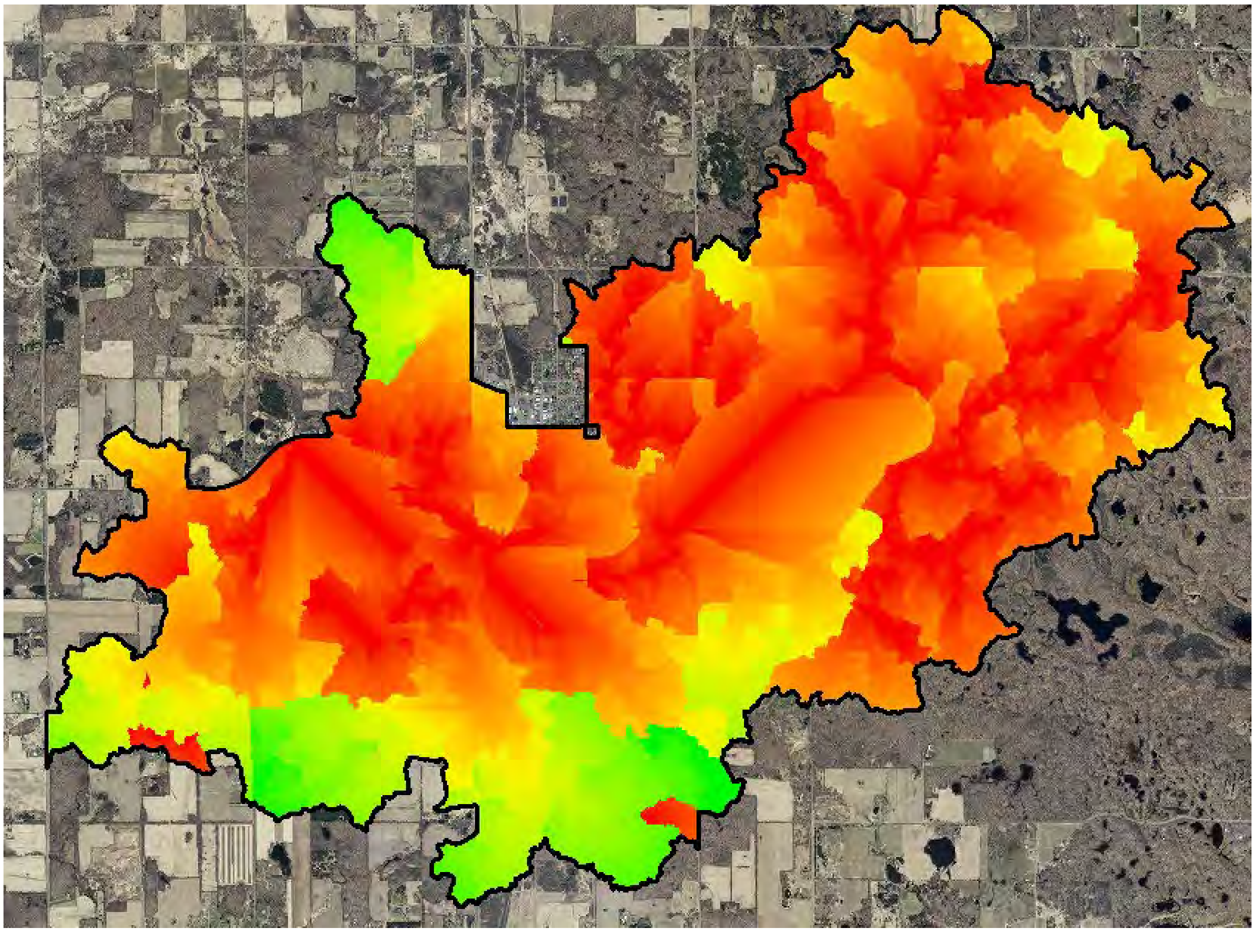
Field runoff risk

This tool is used to identify areas of concern by ranking agricultural fields based on their runoff risk. This tool takes into consideration slope, soil type, and land use classification (row crop or pasture). Based on field runoff risk, 1 field was considered very high risk, 3 were considered high risk (red), 13 were considered moderate risk (yellow), and 1 was considered low risk (green).

Distance to stream

The distance to stream output uses flow direction, stream reach, and slope to determine relative risk of sediment delivery to Little Butternut Lake. The tool ranks the land in the watershed according to the distance from the main streams in meters. The darkest red areas represent the main flow path (or tributaries) entering Little Butternut Lake. The distance to stream is displayed on a scale from red to green, with red areas being closest to the streams entering Little Butternut Lake and green areas being furthest from the streams entering Little Butternut Lake.

The distance to stream map is used to prioritize where to implement conservation practices, with areas in red being the most critical for implementation. Even though the green areas are the farthest from the stream and likely have the lowest impact, they should not be overlooked. Implementation in the green areas could still be very important and beneficial in watershed management.



Pontoon Classroom

A pontoon classroom opportunity was offered to members of the Little Butternut Lake Association on September 11th, 2021. Several Association members attended to learn more about the study completed on Little Butternut Lake. The tour included plant identification, sampling procedures, equipment used, and general information about lakes.

Polk County Ordinances

One way the Polk County Board establishes policy is by adopting ordinances. Ordinances are local laws prescribing rules of conduct and are enforced by county officials. Ordinances become a permanent part of the governmental code and may be amended from time to time. Once policy has been approved by the county board of supervisors through plans, budgets, ordinances, and resolutions, it is the responsibility of county staff to implement the decisions of the board. Ordinances relevant to the Little Butternut Lake Management Plan are administered by the Land and Water Resources Department and the Department of Land Information Zoning and are briefly summarized below.

Land and Water Resources Department

Manure and Water Quality Management Ordinance

The purpose of this ordinance is to enhance public health, prosperity, and welfare by protecting ground and surface water resources by promoting the proper storage and management of animal waste, including the prohibitions found in NR151.08.

Storm Water Management and Erosion Control Ordinance

The general purpose of this ordinance is to establish regulatory requirements for land development and land disturbing activities aimed to minimize the threats to public health, safety, welfare, and the natural resources in Polk County from construction site erosion and post-construction storm water runoff.

Nonmetallic Mining Reclamation Ordinance

The purpose and goal of this ordinance is to ensure the effective reclamation of nonmetallic mining sites after mining operations have ceased. This ordinance adopts and implements the uniform statewide standards for nonmetallic mining reclamation required by Section 295 of Wisconsin Statute and contained in Wisconsin Administrative Code NR 135. The ordinance in effect means that any proposed nonmetallic mining site (sand, gravel, or other nonmetallic minerals) is required to receive an approved reclamation permit to begin nonmetallic mining operations in Polk County. The permit also requires the development of an approved site-specific reclamation plan and for the operator to post financial assurance to guarantee the completion of reclamation.

Illegal Transport of Aquatic Plants and Invasive Animals Ordinance

The purpose of this ordinance is to prevent the spread of aquatic invasive species in Polk County and surrounding waterbodies to protect property values and the property tax base and ensure quality recreational opportunities. It requires all plants and invasive animals be removed from a boat and trailer prior to entering a public roadway. In 2021 this ordinance was amended to include decontamination. The ordinance now requires decontamination of watercraft if a decontamination station is present at the boat landing. In the fall of 2021, a decontamination station was installed at the Little Butternut Lake boat landing.

Land Information-Zoning

Comprehensive Land Use Ordinance

The purpose of this ordinance is to promote and protect public health, safety, and other aspects of the general welfare. Further purposes of this ordinance are to: aid in the implementation of provisions of the county comprehensive plan; promote planned and orderly land use development; protect property values and the property tax base; fix reasonable dimensional requirements to which buildings, structures, and lots shall conform; prevent overcrowding of the land; advance uses of land in accordance with its character and suitability; provide property with access to adequate sunlight and clean air; aid in protection of groundwater and surface water; preserve water quality, shorelands, and wetlands; protect the beauty of landscapes; conserve flora and fauna habitats; preserve and enhance the county's rural characteristics; protect vegetative shore cover; promote safety and efficiency in the county's road transportation system; define the duties and powers of certain county officers and administrative bodies relative to the application, administration, and enforcement of the ordinance; and prescribe penalties in the form of civic forfeitures for violations of this ordinance and to facilitate enforcement of the provisions of this ordinance by injunctive relief.

Shoreland Protection Ordinance

The purpose of these shoreland regulations is to ensure the proper management and development of the shoreland of all navigable lakes, ponds, flowages, rivers, and streams in the unincorporated areas of Polk County. The intent of these regulations is to further the maintenance of safe and healthful conditions; prevent and control water pollution; protect spawning ground for fish and aquatic life; control building sites, placement of structures, and land uses; and preserve shore cover and natural beauty.

Private Sewage System Ordinance

The underlying principles of this ordinance are basic goals in environment, health, and safety accomplished by proper siting, design, installation, inspection, maintenance, and management of private on-site waste treatment systems and non-plumbing sanitary systems.

Subdivision Ordinance

The purpose of this ordinance is to regulate and control subdivision development within Polk County to promote public health, safety, general welfare, water quality, and aesthetics. This purpose can be accomplished by requiring an orderly layout and use of land, providing safe access to highways, roads and streets, facilitating adequate provision of water, sewer, transportation and surface drainage systems and parks, playgrounds, and other public facilities.

Lower St. Croix Riverway Ordinance

The purpose of this ordinance is to promote the public health, safety, and general welfare of the public by: reducing the adverse effects of overcrowding and poorly planned shoreline and bluff area development; preventing soil erosion and pollution and contamination of surface water and groundwater; providing sufficient space on lots for sanitary facilities; minimizing flood damage; maintaining property values; and preserving and maintaining the exceptional scenic, cultural, and natural characteristics of the water and related land of the Lower St. Croix Riverway in a manner consistent with the National Wild and Scenic Rivers Act, the Federal Lower St. Croix River Act of 1972, and the Wisconsin Lower St. Croix River Act.

Floodplain Ordinance

This ordinance is intended to regulate floodplain development to minimize the potential for damage, the expenditure of public funds for flood control projects, and interruptions to businesses or other land uses.

Related Plans

The Little Butternut Lake Management Plan is meant to direct the activities of the Little Butternut Lake Association through the development of goals, objectives, and activities for a five-year timeframe.

However, the planning process is not unique to Little Butternut Lake and many organizations have plans with goals, objectives, and activities which are related to or align with those of the Little Butternut Lake Management Plan.

Lake St. Croix Total Maximum Daily Load (TMDL) Implementation Plan, 2013

The St. Croix Lake TMDL plan calls for a 38% reduction in the human-caused phosphorus carried to the rivers and streams of the basin, and eventually entering the St. Croix River and Lake St. Croix. The TMDL sets goals for each watershed in the basin, based on land cover and land uses practices. It also sets a cap on the amount of phosphorus that can be discharged each year by wastewater treatment plants serving communities and industries in the St. Croix Basin. Polk County's phosphorus load is 160,976 pounds of phosphorus per year, which is the largest of any county in the basin.

Sub watershed	Acres in Basin	Loading (lbs/year)	TMDL Load Reduction
Apple	303,298	84,087	28,493
Clam	74,533	14,393	3,733
Trade	60,563	11,607	3,098
Trout	46,172	14,599	5,099
Willow	26,821	9,055	3,350
Wolf	69,725	21,339	7,310
Wood	24,301	5,897	1,676

The Squaw Lake, Lake Mallalieu, and Cedar Lake TMDL also exist within the boundary of the Lake St. Croix TMDL. The Squaw Lake and Cedar Lake TMDL boundary includes land in Polk and St. Croix County and the Lake Mallalieu TMDL includes land in St. Croix, Polk, and Barron County.

Agriculture and Farmland Preservation Plan, 2014

Under Chapter 91, a county must have a certified farmland preservation plan. The Polk County Agricultural and Farmland Preservation Plan identifies the county's goals and policies related to farmland preservation and agricultural development and identifies farmland preservation areas, agricultural enterprise areas, and areas for development within the next 15 years.

Polk County Aquatic Invasive Species Strategic Plan, 2021-2025

This plan provides an overview of aquatic invasive species in Polk County and includes an implementation plan to direct aquatic invasive species work.

Goal 1. Prevent the introduction, establishment, and spread of AIS in Polk County waterbodies
Goal 2. Control populations of aquatic invasive species
Goal 3. Monitor Polk County waterbodies for AIS and document results

Goal 4. Provide AIS information and education in Polk County and surrounding areas
Goal 5. Sustain the implementation of the plan

Polk County Comprehensive Plan, 2009-2029

The Polk County Comprehensive Plan presents a vision for the future of Polk County, with long-range goals, objectives, and policies for housing, transportation, utilities and community facilities, economic development, intergovernmental cooperation, land use, energy and sustainability, and agricultural, natural, and cultural resources.

St. Croix-Red Cedar Cooperative Weed Management Area Strategic Management Plan, 2017

The St. Croix Red Cedar (SCRC) Cooperative Weed Management Area (CWMA) is a partnership of local, state, tribal, and federal agencies, businesses, nonprofits, community organizations, and individuals. Formed in 2013, the group combats invasive species in Washburn, Barron, Burnett, Polk, and St. Croix Counties in northwestern Wisconsin. The SCRC CWMA fosters multi-generational awareness of invasive species and works to prevent and limit their intrusive impacts through partnerships.

Goal 1. Raise public awareness about invasive species through education and outreach efforts
Goal 2. Develop an early detection and management framework
Goal 3. Maintain and build organizational capacity

Polk County Outdoor Recreation Plan, 2020-2024

This plan assesses the existing recreation system in Polk County, identifies recreation needs based upon public input and recreation standards, sets forth goals and objectives to be used as guidelines in formulating recreation plans, and establishes recommendations for improving the recreation system over the next four years.

Polk County Forest Comprehensive Land Use Plan, 2021-2035

The County Forest Comprehensive Land Use Plan seeks to use sustainable forest management practices to protect forestry resources for present and future ecological and socioeconomic needs.

State of the St. Croix Basin, 2002

The Wisconsin Department of Natural Resources prepared the State of the St. Croix Basin in March 2002. The report describes the status of land and water resources in the Wisconsin portion of the basin. Goals for the St. Croix Basin include maintaining and improving water and air quality; maintaining diverse, rich shoreland habitat; preserving large contiguous blocks of forestland; working with the agricultural community to minimize non-point runoff; and working with cities, villages, towns, and counties to help stem urban sprawl.

St. Croix National Scenic Riverway Management Plans

A Cooperative Management Plan was completed for the Lower St. Croix National Scenic Riverway in 2002 and a General Management Plan for the Upper St. Croix and Namekagon Rivers was completed in 1998. The plans describe the direction the National Park Service intends to follow to manage the upper and lower riverways for the next 20 - 25 years.

Polk County Land and Water Resource Management Plan, 2020-2029

In 1997, a County Land and Water Resource Management Planning Program was created through amendments to Chapter 92.10 of the Wisconsin Statutes in Wisconsin Act 27. Act 27 directed the Wisconsin Department of Natural Resources (WDNR) to prescribe performance standards and prohibitions that farms in Wisconsin need to meet to reduce non-point source pollution and improve water quality. Act 27 also directed the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) in conjunction with the WDNR to promulgate rules that prescribe technical standards and best management practices agriculture producers must follow to meet the performance standards. In October 2002, the rules were promulgated into law. WDNR administrative code NR 151 identifies the agricultural and urban performance standards for Wisconsin and WDATCP administrative code ATCP 50 sets the technical standards that agriculture producers will need to follow to implement the performance standards. County Land and Water Resource Management Plans are the local mechanism to implement NR 151.

Goal 1. Protect and improve the water quality of lakes, rivers, and streams
Goal 2. Protect and improve groundwater quality and quantity
Goal 3. Sustain and enhance land resources
Goal 4. Support and develop community stewardship and partnerships to improve our natural resources

Lake Management Plans

Lake studies identify challenges and threats to a lake’s health along with opportunities for improvement. These studies identify practices already being implemented by watershed residents to improve water quality and areas providing benefits to a lake’s ecosystem.

Additionally, these studies quantify practices or areas on the landscape, or within the lake, which have the potential to negatively impact the health of a lake and identify best management practices for improvement.

The product of most lake studies is a lake management plan which identifies goals, objectives, and action items to either maintain or improve the health of a lake. These goals should be realistic based on inherent lake and watershed characteristics (lake size, depth, land use, etc.) and should align with the goals of watershed stakeholders. Lake management plans are designed to be working documents that are used to guide the actions that take place to manage a specific lake. Additionally, having an approved lake management plan allows lake organizations to apply for WDNR funding to implement improvement projects. WDNR approved Comprehensive Lake Management Plans are usually written for a ten-year timeframe and exist for many Polk County lakes.

Aquatic Plant Management Plans

In many cases an Aquatic Plant Management plan is required to apply for a permit to remove, add, or control aquatic plants. Generally, Aquatic Plant Management Plans describe the lake, present the aquatic plant management circumstances for a lake, and propose a set of goals and actions for managing aquatic plants in the lake. WDNR approved Comprehensive Aquatic Plant Management Plans are usually written for a five-year timeframe and exist for many Polk County lakes.

Priority Watershed Plans

Priority watershed plans have been completed for the Balsam Branch Watershed, Horse Creek Watershed, and the Osceola Creek Watershed. Priority watershed planning provided a funding mechanism in the 1980s to begin implementing water quality and habitat improvement activities in these watersheds. Through the Priority Watershed Planning program, the WDNR ranked watersheds for nonpoint source problems to identify high priority areas under the state's Nonpoint Source Pollution Abatement Program. Today the WDNR uses these watershed and waterbody rankings to direct funding decisions in the Targeted Runoff Management Grant Program and identify specific work tasks needed in the watershed.

Implementation Plan Development

Lake management plans help protect natural resource systems by encouraging partnerships between concerned citizens, lakeshore residents, watershed residents, agency staff, and diverse organizations. They identify concerns of importance and set realistic goals, objectives, and action items to address each concern. Additionally, lake management plans identify roles and responsibilities for meeting each goal and provide a timeline for implementation.

Lake management plans are living documents which are under constant review and adjustment depending on the condition of a lake, available funding, level of volunteer commitments, and the needs of lake stakeholders.

The vision statement, guiding principles, and lake management plan goals presented below were created through collaborative efforts using current and past water quality data and a series of four meetings by the Little Butternut Association Plan Committee held in 2022. Key study details were presented to the Little Butternut Lake Association over the course of the project. Additionally, the draft vision statement, guiding principles, and lake management plan goals were presented at the 2022 Little Butternut Lake Association Annual Meeting.

The draft plan was posted on the Polk County Land and Water Resources Department website and opened for a 30-day public comment period ending on July 18th, 2022. A notice of public comment was published in the Leader on June 8th and June 15th. There were zero public comments received. The plan was approved by the Little Butternut Lake Association in August 2022 and by the Wisconsin Department of Natural Resources on XXX.

Implementation Plan

Vision An overall statement for what you want Little Butternut Lake to look like

Little Butternut Lake is a healthy lake that is removed from the Impaired Waters List and is a peaceful place to enjoy wildlife, natural beauty, and a sustainable fishery

Goal 1. Improve water quality on Little Butternut Lake

Goal 2. Increase natural beauty and habitat for fish and wildlife on Little Butternut Lake

Goal 3. Use multiple strategies to ensure the goals of the plan are met

Goal 1. Improve water quality on Little Butternut Lake

Little Butternut Lake is listed on the Impaired Waters List for total phosphorus and chlorophyll a. This goal will be met when Little Butternut Lake is removed from the Impaired Waters List: average total phosphorus is less than 40 µg/l and chlorophyll a is less than 20 µg/l for 70% of the days during the sampling season.

The inlet to Little Butternut Lake exceeded the State Standard for total phosphorus in 2021 but not in 2020. The West, North, and Southern Subwatershed are contributing the highest load per acre of phosphorus to Little Butternut Lake.

A. Install best management practices that will reduce phosphorus entering Little Butternut Lake from shoreline residential properties
    1. Provide information on shoreline best management practices: shoreline native plantings, rain gardens, diversions, and rock infiltration
    2. Use the annual meeting and other communications as opportunities to encourage landowners to install best management practices
    3. Identify landowners interested in installing best management practices
    4. Offer site visits to landowners interested in installing best management practices
       Encourage all landowners to install best management practices; however, use a targeted approach for landowners with mowed vegetation at the shore (shoreline survey results) and those with steep slopes (slope map).
    5. Explore funding for best management practice implementation through the Healthy Lakes Grant program
    6. Offer tours of properties where practices have been installed to generate interest in the program
    7. Recognize landowners who have installed best management practices
    8. Install WDNR signs at Healthy Lakes project sites
    9. Fertilizer use is not encouraged. However, encourage property owners to conduct a soil test to determine current soil nutrient conditions and if fertilizer application is necessary for lawns, flower gardens, and vegetable gardens
       In Wisconsin, the use of fertilizers containing phosphorus are prohibited for closely mowed managed grass with limited exceptions (establishment of new lawn or a soil test showing phosphorus deficiency). WI State Statute 94.643

10. Determine the schedule for clearing brush along power lines and ensure property owners are given advance notice and opportunity to opt out of herbicide applications

B. Install best management practices that will reduce phosphorus entering Little Butternut Lake from developed sites in the watershed
    1. Partner with local businesses to install practices that reduce stormwater runoff and increase infiltration
    2. Partner with the Village of Luck to explore options to reduce stormwater inputs to the lake
    3. Partner with Polk County to address runoff at the boat landing

C. Partner with agricultural landowners to install best management practices that will reduce phosphorus reaching Little Butternut Lake
   Priority will be given to landowners in the West, North, and Southern Subwatersheds
    1. Meet once a year with the Polk County Land and Water Resources Department to identify best management practices identified by ACPF
    2. Initiate meetings with landowners to discuss options for technical assistance and funding for the installation of best management practices identified by ACPF
    3. Invite agricultural landowners in the watershed to Association meetings
    4. Recognize agricultural landowners who have taken steps to reduce phosphorus from reaching Little Butternut Lake

D. Partner with the Big Butternut Lake District to install best management practices that will reduce phosphorus reaching Little Butternut Lake from the Big Butternut Subwatershed
   Water from Big Butternut Lake enters Little Butternut Lake through the inlet on the southeast side of the lake.
    1. Invite members of the Big Butternut Lake District Board to the Little Butternut Lake Association Annual Meeting
    2. Have a representative of the Little Butternut Lake Association attend the Big Butternut Lake District Annual Meeting

3. Determine areas where the goals of the Big and Little Butternut Lake Management Plans overlap as potential areas for partnership and joint implementation

E. Reduce sediment disturbance on Little Butternut Lake
    1. Ensure residents and visitors are aware of the slow-no-wake requirements within 100 feet of the shoreline
    2. Partner with the Polk County Public Works Division to install signage at the landing related to power loading

F. Upgrade non-compliant septic systems near Little Butternut Lake and promote best practices for septics
A 2022 septic system inventory determined that 27% of the systems near the lake were out of compliance.
    1. Develop and deliver an educational message regarding the relationship between septic systems and water quality which includes information about proper maintenance and best practices for systems
    2. Identify shoreline property owners with non-compliant systems that are willing to upgrade their septic systems
    3. Explore a lake protection grant to upgrade non-compliant systems and determine a match for the grant (Association or individual property owners)

G. Engage stakeholders in improving water quality by increasing their understanding of the importance of installing best management practices to reduce phosphorus
Messages to convey
- *Phosphorus is the nutrient responsible for excessive plant and algae growth in Little Butternut Lake.*
- *Major sources of phosphorus to a lake include lawn and agricultural fertilizers, soil erosion, human and animals waste, and runoff from the landscape.*
- *Natural shorelines and vegetated surfaces limit the amount of runoff, soil erosion, and amount of phosphorus that reaches Little Butternut Lake.*
- *Erosion control practices associated with new development reduce runoff, erosion, and phosphorus.*
- *Cover crops, ground cover, and reduced tillage limit runoff, erosion, and phosphorus from agricultural landscapes.*

- *Wetlands filter sediment and nutrients (including phosphorus) from runoff.*
- *Best management practices exist to reduce the harmful effects of runoff and soil erosion: shoreline restoration, rain gardens, infiltration, diversions, sediment ponds, grassed waterways/buffers, etc.*
- *Grant funding is available to install best management practices.*
- *Large wakes can contribute to phosphorus release from the sediments into the water column where it is available for algae growth.*
- *Non-compliant septic systems can negatively impact the water quality of Little Butternut Lake*
- *Follow best practices and routine maintenance schedules for septic systems*

Goal 2. Increase natural beauty and habitat for fish and wildlife on Little Butternut Lake

A. Expand habitat for fish and wildlife
    1. Increase native plants on the shoreline of Little Butternut Lake, see goal 1A
    2. Work with DNR fisheries biologist to identify ideal locations for habitat additions
       The shoreline inventory shows current woody habitat in Little Butternut Lake. A meeting with the fisheries biologist could determine locations for fish sticks and other best management practices. Fish sticks are a cost-effective method of providing additional fish habitat, as well as expanding fishing opportunities and providing protection to shorelines. Fish sticks are a grant eligible project through the Healthy Lakes Program.
    3. Maintain the winter aeration system on Little Butternut Lake.
    4. Partner with DNR fisheries biologist to monitor dissolved oxygen concentrations each winter (January – February) to determine aerator effectiveness and risk of severe winter fish die offs
    5. Partner with DNR to explore options to reinitiate a walleye stocking program in Little Butternut Lake.
    6. As undeveloped, highly erodible, and/or ecologically sensitive land in the Little Butternut Lake Watershed comes up for sale work with partner groups to consider the costs and benefits of its purchase
       WDNR Land Acquisition Grants are available to purchase land. Purchased land could be restored to a more natural state to reduce human impacts and/or have designated public recreational areas including trails, wildlife viewing, etc.

B. If aquatic plants impede navigation, set up a site assessment with WDNR to explore options for management

C. Control existing aquatic invasive species
    1. Monitor for new locations of purple loosestrife on the lake and engage property owners in its removal
       Purple loosestrife has been found and removed on the lake in the past but is still present in Luck/upstream areas. Purple loosestrife flowers should be cut, bagged, and disposed of to prevent the spread of seed. Plants can be dug or killed with herbicide (follow regulations).

2. Engage individual property owners in yellow iris removal for single plants and small stands
   Yellow iris flowers/seed pods should be cut, bagged, and disposed of to prevent the spread of seed. Plants can be dug or killed with herbicide (follow regulations). The sap of the plant can cause skin irritation.
3. Consider hiring a contractor to spray large stands of yellow iris while considering the environmental impacts of herbicide application
4. Conduct a plant survey every five years to determine if curly leaf pondweed is expanding

D. Prevent the establishment of aquatic invasive species
   1. If a new AIS is found on the lake, research and determine control options
   2. Partner with Polk County to ensure that the local AIS ordinance sign, state prevention AIS sign, and decontamination station installed at the boat landing and maintained in good condition
   3. Explore opportunities to participate in statewide AIS education initiatives such as the Drain Campaign and Landing Blitz
      Contact Polk County Land and Water Resources Department and/or Polk County Public Works Division if concerns arise.

E. Monitor for new and existing aquatic invasive species
   1. Find at least one volunteer to participate in the AIS Citizen Lake Monitoring Network Program
      Polk County Land and Water Resources Department provides training and materials from WDNR for this statewide program.
   2. Ensure that lake residents and visitors know how to identify common AIS and where to report new findings
      New findings can be reported to Polk County Land and Water Resources Department, or a lake contact can be designated.

F. Engage property owners in increasing natural beauty and habitat by increasing their understanding of the importance of native vegetation and coarse woody habitat and the negative impacts of aquatic invasive species
   Messages to convey

- *Ninety percent of a lake ecosystem depends on what happens in the littoral zone, or the area of a lake close to shore.*
- *Leaving fallen trees in the lake provides habitat for fish and aquatic animals.*
- *Natural shorelines reduce nutrients entering the lake and provide critical habitat for fish, wildlife, and pollinators.*
- *Currently Little Butternut Lake has populations of three aquatic invasive species: curly-leaf pondweed, purple loosestrife, and yellow iris.*
- *It is important that lake residents know how to identify AIS and who to contact if they locate suspected AIS.*
- *Polk County and the State of Wisconsin have regulations that make it illegal to transport aquatic species on public roads.*
- *Prevention of AIS establishment is easier and more likely to be successful than AIS management.*
- *Wisconsin law requires the following prevention strategies: INSPECT your boat, trailer, and equipment, REMOVE any attached aquatic plants or animals (before launching, after loading and before transporting on a public highway), DRAIN all water from boats, motors and all equipment, NEVER MOVE live fish away from a waterbody, DISPOSE of unwanted bait in the trash, and BUY minnows from a Wisconsin bait dealer and use leftover minnows only on the same water or on other waters if no lake or river water or fish were added to their container.*
- *Early identification of a small population of AIS increases the likelihood that the AIS can be successfully managed.*

Goal 3. Use multiple strategies to ensure the goals of the plan are met

Strategies to ensure the goals of the plan are met include communicating with lake stakeholders, forming committees to implement the plan, exploring funding and fundraising opportunities, and evaluating the progress of lake management efforts.

A. Engage stakeholders in meeting the goals of the Little Butternut Lake Management Plan

Messages to convey

- *Lake Management Plans identify goals, objectives, and activities to maintain and improve the health of a lake.*
- *Lake Management Plans are designed to be working documents that adapt as new issues and conditions arise.*
- *Lake Management Plan implementation success relies on participation by landowners in the Little Butternut Lake Watershed.*
- *Grant funding is available from WDNR to cost share up to 75% of the costs of eligible projects in the Little Butternut Lake Management Plan, fundraising may be necessary to provide the 25% match.*

B. Evaluate the progress of lake management efforts through data collection efforts

1. Ensure that a volunteer is in place to collect phosphorus, chlorophyll a, and secchi disk data each year (WDNR Citizen Lake Monitoring Network Program)
2. Repeat the 2020-2021 water quality study in ten years

C. Review and summarize the progress of plan implementation

1. Form committees to develop an action plan for each goal
2. Identify current and future barriers to implementing each goal
3. Seek funding through WDNR or other sources to implement the action plan for each goal
4. Report actions completed, in progress, or not completed to the Lake Association Board
5. Report progress to Lake Association members
6. Adapt the plan as new issues arise

D. Use the information and education strategy to communicate with lake stakeholders
The information and education strategy includes target audience, messages to convey, and methods used to reach the target audience. Messages to convey are included under each goal.

The Association will determine a key issue to focus on each year. Information and education efforts will begin at the annual meeting and continue throughout the year using additional methods (newsletter, etc.).

Target audience

- *Shoreline property owners*
- *Property owners in the Little Butternut Lake Watershed*
- *Lake visitors*
- *Local government: Town, Village, County, Lake District partners*

Methods to reach the target audience

- *Presentations, workshops, and trainings at Lake Association Board and Annual Meetings, schools and youth events, and community events,*
- *Pontour of Little Butternut Lake*
- *Attendance at meetings (Town of Laketown, Village of Luck, Polk County, Big Butternut Lake District) and events*
- *Public displays and posters*
- *Articles in the Laker or other newspaper publications*
- *Signs/information at the boat landing*
- *Brochures (existing and newly designed)*
- *One-on-one site visits, technical assistance, and offer of financial assistance to lakeshore and watershed property owners interested in implementing practices to improve Little Butternut Lake*
- *Recognition of landowners implementing practices to improve Little Butternut Lake*
- *Tours and demonstration sites highlighting best management practices*
- *Posting information at the Little Butternut Lake boat landing*

Acronyms used for partners in the following implementation table

WDNR = Wisconsin Department of Natural Resources
LWRD = Polk County Land and Water Resources Department
PCPW = Polk County Public Works Division
LBA = Little Butternut Lake Association
BBLD = Big Butternut Lake District
CON = Consultant

Acronyms used for funding sources in the following implementation table

LPL = WDNR Lake Planning Grant Program, funds 67% of eligible projects costs
LPR = WDNR Lake Protection Grant Program, funds 75% of eligible project costs
LPR-HL = WDNR Healthy Lakes Grant Program, funds 75% of eligible project costs
AEPP = WDNR Aquatic Invasive Species Grant Program, funds 75% of eligible project costs
EDR = WDNR Early Detection and Response Grant Program, funds 75% of eligible project costs

Goal 1. Improve water quality on Little Butternut Lake	Priority	$ Estimate	Volunteer hours	Partners with LBA	Funding sources
A. Install best management practices that will reduce phosphorus entering Little Butternut Lake from shoreline residential properties	High	$ - $$$		LWRD, CON	LPR, LPR-H
1. Provide information on shoreline best management practices: shoreline native plantings, rain gardens, diversions, and rock infiltration		Free material from WDNR			
2. Use the annual meeting and other communications as opportunities to encourage landowners to install best management practices		No cost			
3. Identify landowners interested in installing best management practices		No cost		LWRD	
4. Offer site visits to landowners interested in installing best management practices		No cost - $		LWRD, CON	
5. Explore funding for best management practice implementation through the Healthy Lakes Grant program		Grant $1000/ project			
6. Offer tours of properties where practices have been installed to generate interest in the program		No cost			
7. Recognize landowners who have installed best management practices		No cost - $			
8. Install WDNR signs at Healthy Lakes project sites		Signs no cost		WDNR	
9. Fertilizer use is not encouraged. However, encourage property owners to conduct a soil test to determine current soil nutrient conditions and if fertilizer application is necessary for lawns, flower gardens, and vegetable gardens		Soil test at UW Soil and Forage Lab $15			

10. Determine the schedule for clearing brush along power lines and ensure property owners are given advance notice and opportunity to opt out of herbicide applications		No cost	1 hr/yr		
B. Install best management practices that will reduce phosphorus entering Little Butternut Lake from developed sites in the watershed	High	$ - $$$		LWRD, CON	LPR
1. Partner with local businesses to install practices that reduce stormwater runoff and increase infiltration		$ - $$$			
2. Partner with the Village of Luck to explore options to reduce stormwater inputs to the lake		$ - $$$			
3. Partner with Polk County to address runoff at the boat landing		$ - $$$			
C. Partner with agricultural landowners to install best management practices that will reduce phosphorus reaching Little Butternut Lake	High	High	$ - $$$		LWRD, CON
1. Meet once a year with the Polk County Land and Water Resources Department to identify best management practices identified by ACPF		No cost			
2. Initiate meetings with landowners to discuss options for technical assistance and funding for the installation of best management practices identified by ACPF		No cost			
3. Invite agricultural landowners in the watershed to Association meetings		No cost			
4. Recognize agricultural landowners who have taken steps to reduce phosphorus from reaching Little Butternut Lake		No cost - $			
D. Partner with the Big Butternut Lake District to install best management practices that will reduce phosphorus reaching Little Butternut Lake from the Big Butternut Subwatershed	High	$ - $$$			BBLD

1. Invite members of the Big Butternut Lake District Board to the Little Butternut Lake Association Annual Meeting		No cost	1 hour		
2. Have a representative of the Little Butternut Lake Association attend the Big Butternut Lake District Annual Meeting		No cost	3 hours		
3. Determine areas where the goals of the Big and Little Butternut Lake Management Plans overlap as potential areas for partnership and joint implementation		No cost - $$$	3 hours		
E. Reduce sediment disturbance on Little Butternut Lake		$			
1. Ensure residents and visitors are aware of the slow-no-wake requirements within 100 feet of the shoreline		No cost			
2. Partner with the Polk County Public Works Division to install signage at the landing related to power loading		No cost		PCPW	
F. Upgrade non-compliant septic systems near Little Butternut Lake and promote best practices for septics		$ - $$$			LPR
1. Develop and deliver an educational message regarding the relationship between septic systems and water quality which includes information about proper maintenance and best practices for systems		No cost - $			
2. Identify shoreline property owners with non-compliant systems that are willing to upgrade their septic systems		No cost		LWRD	
3. Explore a lake protection grant to upgrade non-compliant systems and determine a match for the grant (Association or individual property owners)		No cost - $$$			LPR
G. Engage stakeholders in improving water quality by increasing their understanding of the importance of installing best management practices to reduce phosphorus		No cost			

Goal 2. Increase natural beauty and habitat for fish and wildlife on Little Butternut Lake	Priority	$ Estimate	Volunteer hours	Partners with LBA	Funding sources
A. Expand habitat for fish and wildlife	High				
1. Increase native plants on the shoreline of Little Butternut Lake, see goal 1A		No cost - $$$			LPR-H
2. Work with DNR fisheries biologist to identify ideal locations for habitat additions		Grant (75%): $1000/fish sticks	3 hours	WDNR	LPR-H
3. Maintain the winter aeration system on Little Butternut Lake				WDNR	
4. Partner with DNR fisheries biologist to monitor dissolved oxygen concentrations each winter (January – February) to determine aerator effectiveness and risk of severe winter fish die offs		No cost		WDNR	
5. Partner with DNR to explore options to reinitiate a walleye stocking program in Little Butternut Lake		10 fish/acre, ~$2/head		WDNR	
6. As undeveloped, highly erodible, and/or ecologically sensitive land in the Little Butternut Lake Watershed comes up for sale work with partner groups to consider the costs and benefits of its purchase		$$$			
B. If aquatic plants impede navigation, set up a site assessment with WDNR to explore options for management		No cost		WDNR	
C. Control existing aquatic invasive species	High	$ - $$$			
1. Monitor for new locations of purple loosestrife on the lake and engage property owners in its removal		No cost	10 hr/yr	LWRD, CON	
2. Engage individual property owners in yellow iris removal for single plants and small stands		No cost - $	1 hr/yr		
3. Consider hiring a contractor to spray large stands of yellow iris while considering the environmental impacts of herbicide application		$1,500 per application		CON	

4. Conduct a plant survey every five years to determine if curly leaf pondweed is expanding		$1,500		LWRD, CON	
D. Prevent the establishment of aquatic invasive species	High				
1. If a new AIS is found on the lake, research and determine control options		No cost			RR
2. Partner with Polk County to ensure that the local AIS ordinance sign, state prevention AIS sign, and decontamination station installed at the boat landing and maintained in good condition		No cost - $	10 hr/yr	LWRD	
3. Explore opportunities to participate in statewide AIS education initiatives such as the Drain Campaign and Landing Blitz		No cost	10 hr/yr	LWRD	
E. Monitor for new and existing aquatic invasive species					
1. Find at least one volunteer to participate in the AIS Citizen Lake Monitoring Network Program		No cost	10 hr/yr	LWRD	
2. Ensure that lake residents and visitors know how to identify common AIS and where to report new findings		No cost	5 hr/yr	LWRD	
F. Engage property owners in increasing natural beauty and habitat by increasing their understanding of the importance of native vegetation and coarse woody habitat and the negative impacts of aquatic invasive species		No cost - $			

Goal 3. Use multiple strategies to ensure the goals of the plan are met	Priority	$ Estimate	Volunteer hours	Partners with LBA	Funding sources
A. Engage stakeholders in meeting the goals of the Little Butternut Lake Management Plan		No cost			
B. Evaluate the progress of lake management efforts through data collection efforts		No cost			
1. Ensure that a volunteer is in place to collect phosphorus, chlorophyll a, and secchi disk data each year (WDNR Citizen Lake Monitoring Network Program)		No cost	10 hr/yr	WDNR	
2. Repeat the 2020-2021 water quality study in ten years		$$		LWRD, CON	LPL
C. Review and summarize the progress of plan implementation					
1. Form committees to develop an action plan for each goal		No cost			
2. Identify current and future barriers to implementing each goal		No cost			
3. Seek funding through WDNR or other sources to implement the action plan for each goal		No cost			
4. Report actions completed, in progress, or not completed to the Lake Association Board		No cost			
5. Report progress to Lake Association members		No cost			
6. Adapt the plan as new issues arise		No cost			
D. Use the information and education strategy to communicate with lake stakeholders		No cost - $			