Cedar Lake
Lake Management Plan and
Aquatic Plant Management Plan

Photo by Beth Wood

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Introduction

The Cedar Lake Management Plan was approved by the Wisconsin Department of Natural Resources January 30, 2015. Since that time, Eurasian water milfoil was discovered in the lake, and advances have been made in alum treatment strategies. The 2017 plan update incorporates the planning needed to address both of these important issues.

The Cedar Lake Protection and Rehabilitation District (the Lake District) initiated the project with guidance from the Wisconsin Department of Natural Resources (DNR) and an advisory committee of lake residents. The advisory committee reviewed existing plan activities and made recommendations for plan updates related to aquatic invasive species management. A WDNR Rapid Response grant funded updates related to aquatic plant management requirements, and a Lake Planning grant funded updates related to the alum treatment. The Lake District provided project match.

Eurasian water milfoil was discovered in Cedar Lake on June 26, 2015. It was found during an aquatic invasive species survey conducted by Lake District consultant Steve Schieffer. Follow-up monitoring indicated that EWM growth appeared to be limited to the south end of the lake, except one sprig was found and removed near the north landing. Herbicide treatment was used in July 2015 and May 2016 in an attempt to limit the growth of EWM in Cedar Lake. Poor visibility due to algae growth has limited the ability to see clearly for effective monitoring and hand pulling plants remaining after herbicide treatment.

Cedar Lake has been on the Wisconsin list of impaired waters since 1998 because of high total phosphorus levels. Phosphorus leads to heavy growth of algae in the lake. Impairment of recreation uses was added to the list of water quality impairments for Cedar Lake because of excess algae growth in 2012. This plan includes management actions to address lake impairments to the point where the lake can be removed from the impaired waters list. The most significant management action for water quality improvements is an alum treatment. Watershed practices alone would not improve water quality enough to be less than the phosphorus impairment threshold.

Chlorophyll a concentrations (a measure of algae growth) frequently exceeded the threshold associated with human health risk of potential exposure to blue green algae toxins during the project study period. Significantly reducing the internal phosphorus load from lake sediments is expected to reduce this risk from expected toxin production during 17 percent of the summer to about 1 percent.

Plan Scope

The plan presents information about Cedar Lake water quality, fisheries, aquatic plants, and lake management methods. The lake is part of the Wisconsin Department of Natural Resources Long Term Lake Trend Monitoring Program. As a result, the DNR gathered information about fisheries, aquatic plants, and water quality regularly over the past several years. Extensive new information gathered as part of the 2013/14 planning process included lake and tributary water

quality analysis, estimates of pollutant loading from the watershed and lake sediments, and lake water quality response modeling.

The plan is intended to meet EPA requirements for watershed planning for impaired waters. It is also written to meet WDNR requirements for lake management planning to establish eligibility for Wisconsin Lake Protection Grants. The planning period is from 2017 through 2026. Results of ongoing evaluation and monitoring and availability of new management information will likely lead to adaptations in plan actions as the plan is implemented.

The plan is also updated to meet aquatic plant management planning requirements of NR 198.43.

Cedar Lake 2020 Future Vision

Cedar Lake is a healthy lake that provides clear water, excellent aquatic and nearshore fish and wildlife habitat, and quality recreation.

The Cedar Lake Management Plan guides an active Protection and Rehabilitation District Board and a broad range of partners.

Lake and watershed residents and lake visitors practice good lake and watershed management.

Lake Management Goals

The following goals will guide management efforts for Cedar Lake.

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Goal 2. Achieve and maintain clear water throughout the summer.

Goal 3. Maintain a high quality sport fishery in Cedar Lake.

Goal 4. Protect and improve near shore habitat both in the water and on the land.

Goal 5. Balance recreational uses so that residents and lake users can enjoy the natural benefits Cedar Lake provides.

Goal 6. Carry out the Cedar Lake Management Plan effectively and efficiently with a cooperative spirit.

Goal 7. Encourage and engage lake residents and visitors to be active lake stewards.

Cedar Lake Protection and Rehabilitation District

The Cedar Lake Protection and Rehabilitation District is a special unit of government formed under Chapter 33 Wisconsin State Statutes. Property owners living within the district boundaries may be assessed fees as part of the property tax levy. The lake district addresses lake management issues. Lake districts can act together with other municipalities, agencies, and organizations to undertake lake protection and rehabilitation projects. This plan seeks partnerships between the lake district and other organizations for plan implementation.

Needs Assessment

Concerns of Lake Residents

Concerns of lake residents were gathered in a variety of ways in 2013. These included a public opinion survey, advisory committee meetings, the annual lake district meeting, and public draft plan review. In 2017 another advisory committee was formed and a draft was made available to the public.

Public Opinion Survey

A lake property owner survey was distributed in early March 2013. As of April 3, 2013, 159 out of 298 surveys were completed and returned, a return rate of 53 percent. The results of the survey are discussed below and are found in Appendix A of the 2014 plan. The degree of participation in lake activities is summarized in Figure 1 below. Relaxing and observing wildlife are the most frequent lake activities followed by motor boating, swimming, and socializing at the sand bar.

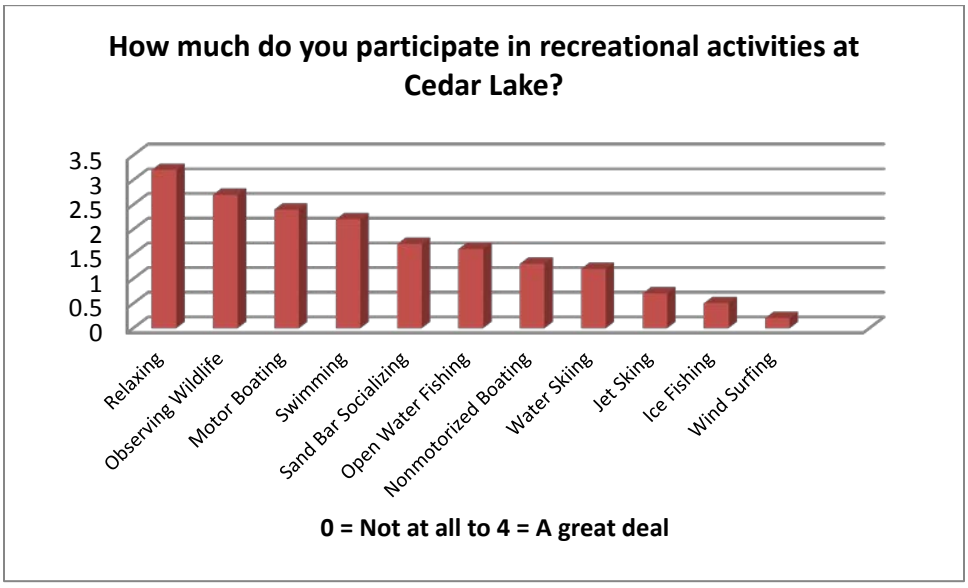


Figure 1. Survey Response: Recreational Activity Participation at Cedar Lake

Additional survey results indicated a range of concerns and priorities from lake residents. The top problems related to owning waterfront property identified in the survey were lack of water clarity in front of owner's property, potentially toxic algae blooms, protecting the lake environment, and maintaining the investment value of property. These all rated as having a medium to large impact as shown in Figure 2. Algae growth clearly ranked as having the highest negative impact on lake use (Figure 3).

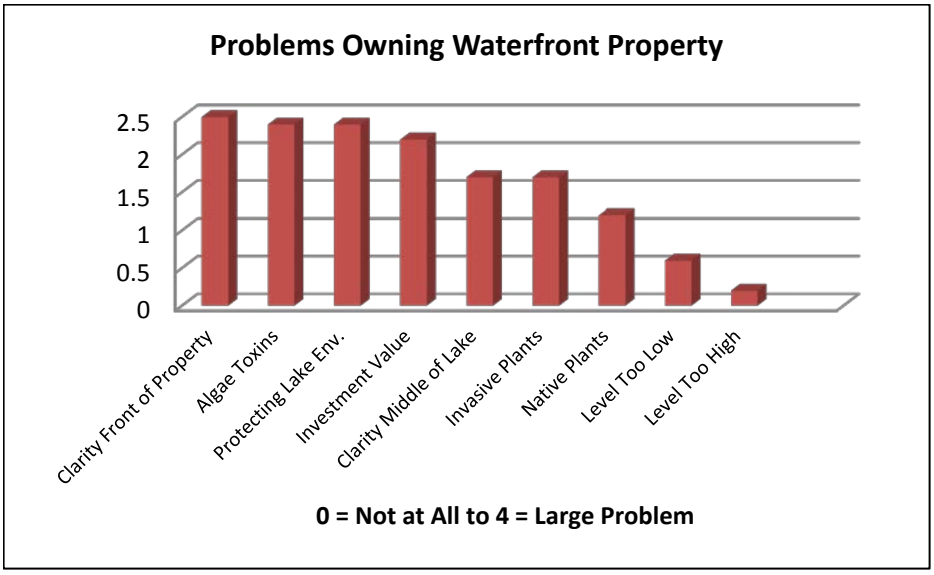


Figure 2. Survey Response: Problems Owning Waterfront on Cedar Lake

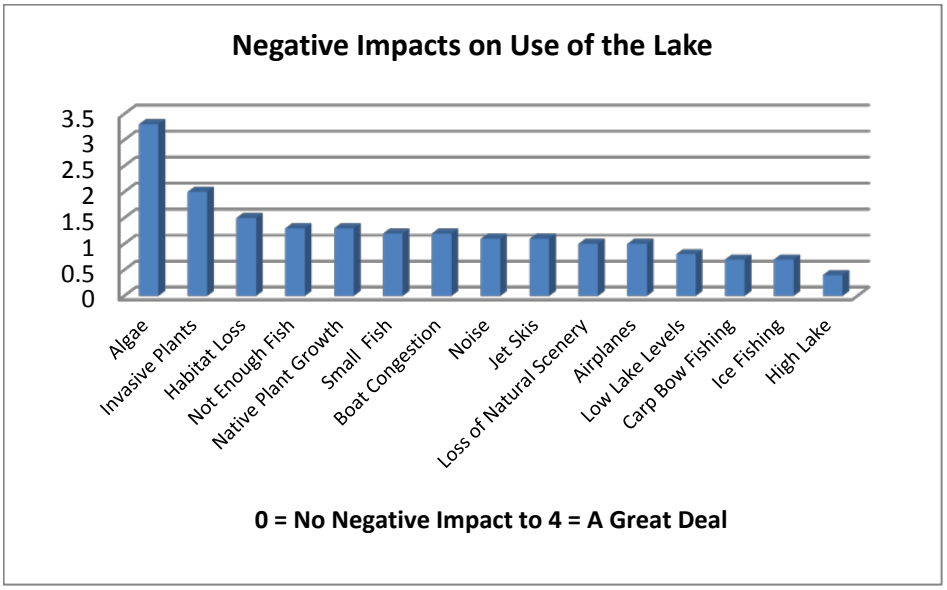


Figure 3. Survey Response: Negative Impacts on Use of the Lake

Lake Management Plan Advisory Committee 2017

The advisory committee met three times from March to May 2017 to review lake management goals, objectives, and actions and update the plan information and actions related to aquatic invasive species prevention and control.

Public Review

The draft plan was made available for public comment on the web site: cedarlake-wi.org beginning June 15, 2017 with comments accepted through July 15, 2017. The 2017 plan was approved by the lake district board April 25, 2017 and no public comments were received during the subsequent public comment period.

The original lake management plan was discussed and approved unanimously at the Lake District annual meeting on August 3, 2013. Lake district members also approved the borrowing necessary for the plan implementation at the 2013 annual meeting. A revote at the 2016 annual meeting also supported the alum treatment included in plan implementation.

Lake Overview

Cedar Lake is located in the Lower Apple River Watershed within the St. Croix River Basin. The lake spans the town of Alden in Polk County (S34 and 35, T32N, R 18W) and the town of Star Prairie in St. Croix County, WI (S2 and 3, T31-32N, R18W). Its water body identification code is 2615100. It is a 1,118 acre lake with a maximum depth of 34 feet. Cedar Lake is a drainage lake with Horse Creek flowing into the lake at the north end and Cedar Creek flowing from the lake in the southeast corner. A map of the lake is included as Figure 5.

A dam on Cedar Creek maintains the lake within a required level through the use of four aluminum stop logs. The lake level is held at 96.62 feet (maximum 97.15 feet) by order of the Wisconsin Department of Natural Resources. The Cedar Lake dam is a small dam with a structural height of 6 feet and a hydraulic height of 1 foot. (DNR Surface Water Data Viewer, 2014)

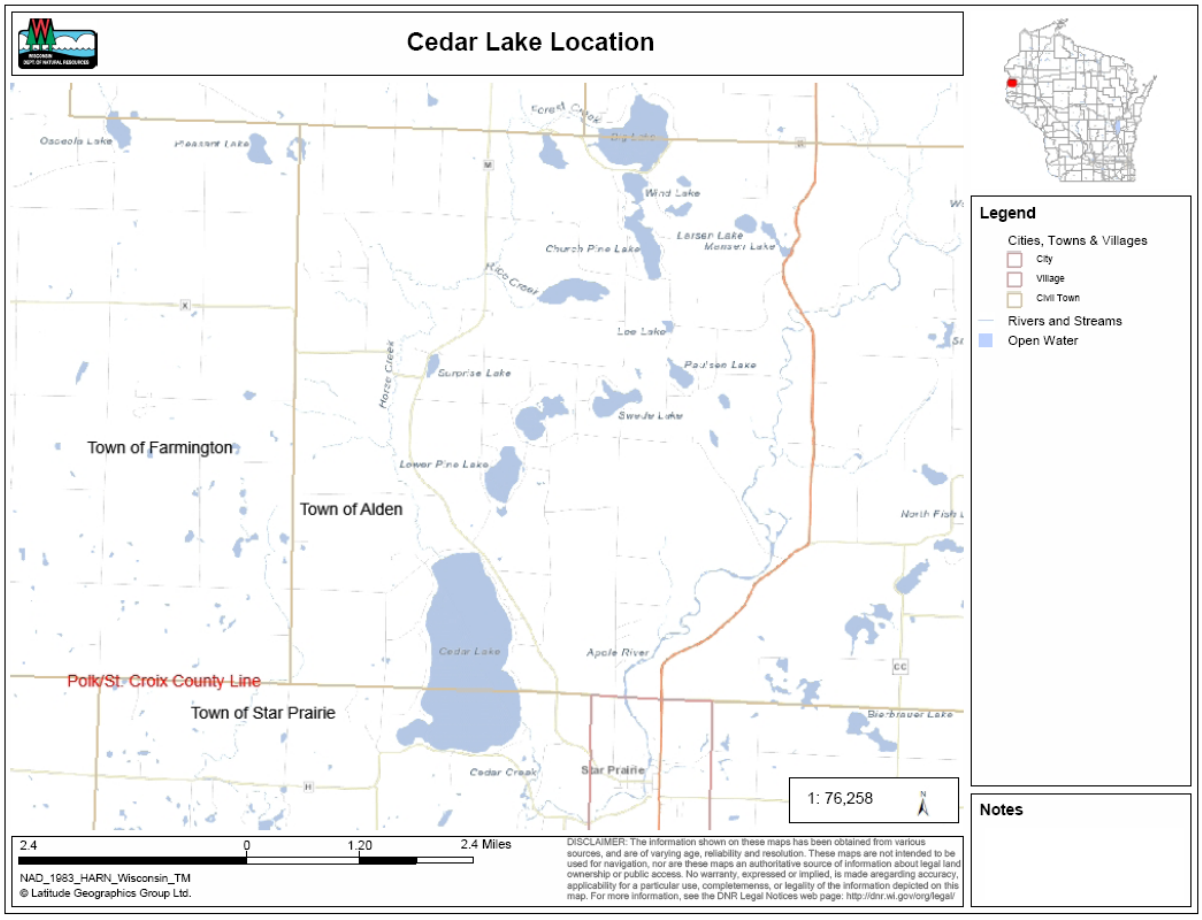


Figure 4. Cedar Lake Location

Table 1. Cedar Lake Characteristics

Surface Area	4,522, 767 m^2	1,118 acres
Volume	25,235,867 m^3	20,459 acre feet
Mean Depth	5.78 m	18.96 feet
Maximum Depth	10.4 m	34.12 feet
Maximum Fetch	3.5 km	2.17 miles

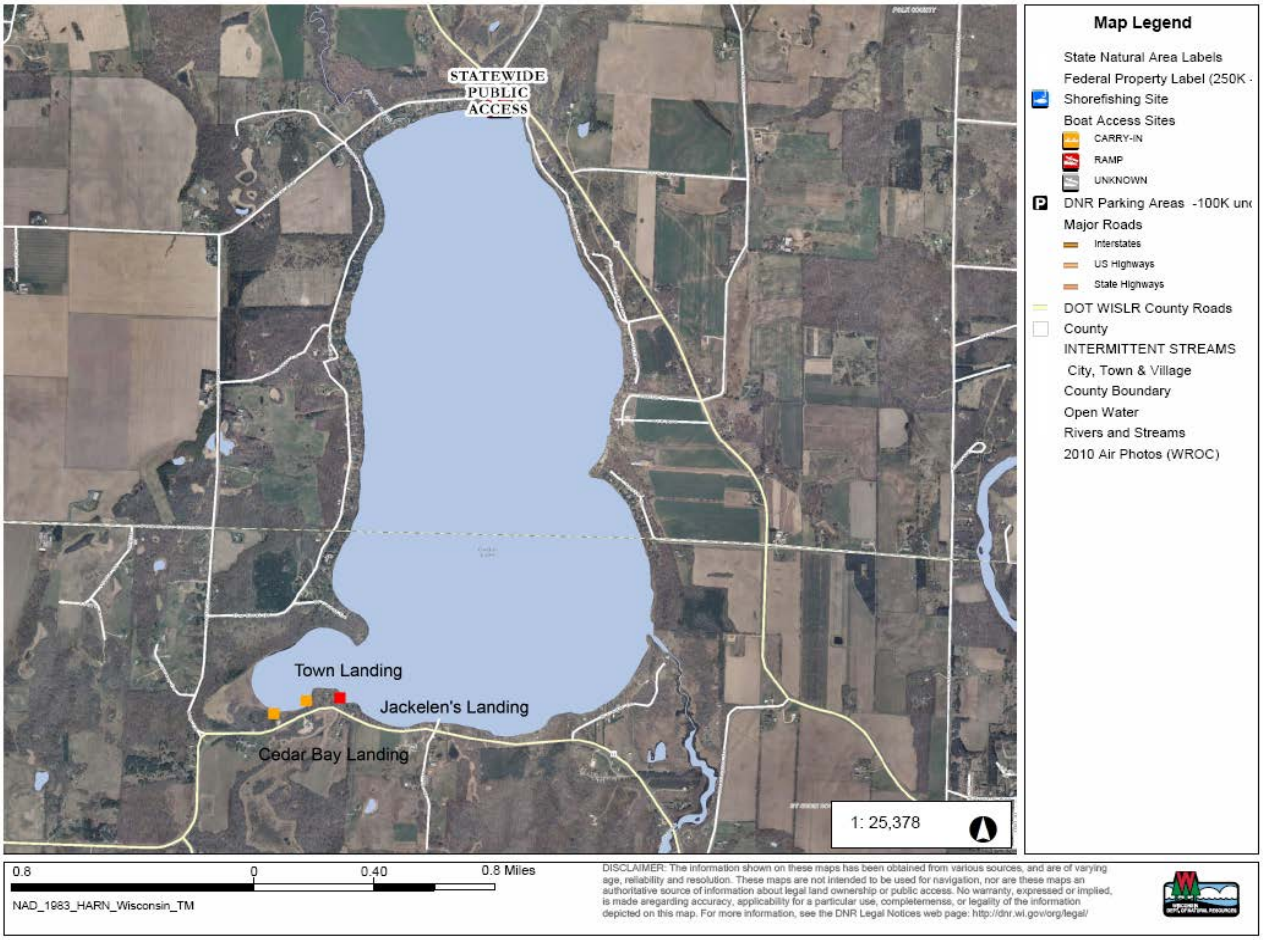


Figure 5. Cedar Lake Map

Historic and Current Lake Use

Lake sediment cores provide historical information about land use and impacts to the lake from these uses over many decades. A sediment core was collected from Cedar Lake in June 1997. The core was dated, and the sedimentation rate was analyzed. Sedimentation increased from less than 0.02 g/cm/year to about 0.06 g/cm/year as the area was plowed for agriculture in the late 1800s. After a subsequent decline, sedimentation rates again increased beginning around 1960 through 2000 when sedimentation rates reached almost 0.10 g/cm/year. From 1980-2000, potassium increased more than aluminum, indicating an increase in the use of commercial fertilizers. According to Garrison, increased phosphorus in sediments over the years was from increased loading from the watershed and resultant increased internal loading from the lake sediments (Garrison 2002).

Cedar Lake algae blooms have been documented since the 1930s. Copper sulfate was used on the lake since the 1940s to provide short term relief of nuisance algae blooms. (Sorge May 1989).

Changes in the lake environment have led to some changes in recreational use. One major change in the lake is the complete lack of emergent vegetation. Historically, there were small isolated patches of emergent vegetation found around the shoreline - particularly in the southwest corner of the lake. Previous attempts to plant emergent vegetation have been unsuccessful (Lepsch July 2015). Loss of aquatic plant beds, loss of bulrush stands, and removal of woody debris result in loss of fish habitat in Cedar Lake. Introduction of carp and white bass has also displaced native fish species (Engel 2009).

There are three public locations and one private location where the public has access to the lake. The north access parking lot is owned by the Department of Natural Resources, and the boat ramp itself is owned by the Town of Alden. The DNR purchased the Cedar Lake School and parking area in 2011. The Town of Alden formally agreed to operate and maintain the boat ramp and parking area through 2030.

The Star Prairie Land Preservation Trust owns the South Cedar Bay Landing where there is parking, but access is for non-motorized boats only. The Town of Star Prairie owns a winter access (just four lots west of the S Cedar Bay Access) with no parking available. Jackelen's is a private boat landing on the south end of the lake. No wake areas are established on the lake including in the south bay.

Fishing tournaments have been popular for many years on Cedar Lake. Meister's Bar and Restaurant sponsored ice fishing tournaments in the 1950s and 60s. The New Richmond Athletic Department sponsored tournaments in recent years. The Indianhead Bassers have an annual tournament on the lake. While heavy algae growth tends to limit lake use, pontoon boating, fishing, personal watercraft use (i.e., jet skis), kayaking, and water skiing are popular lake activities.

Water Quality Information

Cedar Lake is eutrophic to hypereutrophic with summer algae blooms that result in odors and unsightly build-up of algae along the shorelines. The lake is phosphorus limited: it is the concentration of phosphorus which controls the level of algae growth.

Lake sediments release phosphorus when oxygen levels decrease at the lake bottom. The lake is polymictic (with complete water column mixing several times a year). It periodically mixes during high summer winds and cool conditions, bringing phosphorus-rich water to the surface for algal uptake and growth. In addition to this internal loading of phosphorus, phosphorus input to the lake comes from the watershed and direct rainfall, along with minor inputs from groundwater.

Previous Lake Studies

The Department of Natural Resources completed a variety of water quality studies and management plans to increase understanding of the water quality of the lake. Summaries of previous studies are included in Appendix C of the 2014 plan.

Lake Self-Help Monitoring Results[1]

Secchi depths have been collected by citizen monitors on Cedar Lake since 1986, and July and August averages are reported in Figure 6 below. Secchi depths measure water clarity. The Secchi depth reported is the depth at which the eight inch black and white Secchi disk is no longer visible when it is lowered into the water. Greater Secchi depths occur with greater water clarity. Cedar Lake has had relatively poor summer water clarity ranging from an average of two to six feet for many years.

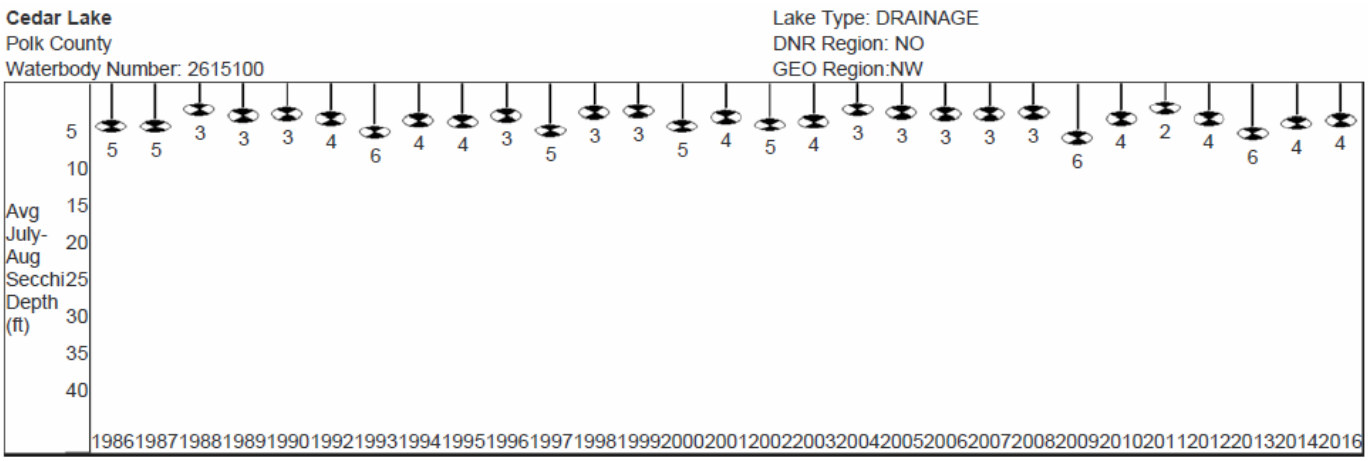


Figure 6. Cedar Lake July and August Secchi Depth 1986 - 2016

[1] Wisconsin Department of Natural Resources. Citizen Lake Monitoring Data. http://dnr.wi.og/lakes/CLMN/

Total phosphorus measured in DNR's Long Term Trend Monitoring Program illustrates a general upward trend in mean summer (July – September) epilimnion (uppermost lake layer) phosphorus concentration from 1986 through 2016.

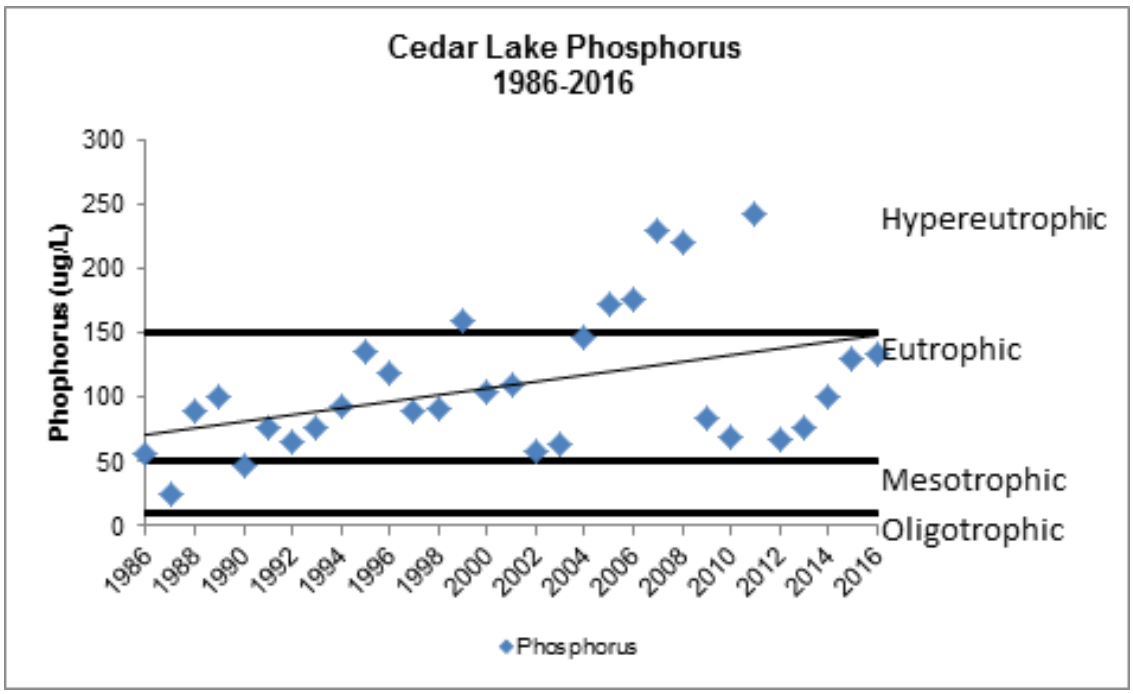


Figure 7. Cedar Lake Total Phosphorus (ug/L)

Blue Green Algae Toxins

Blue green algae (or cyanobacteria) are of concern because these blooms can produce neurotoxins and hepatotoxins that may be harmful to human and animal health. Cyanobacterial blooms can occur at any time during the growing season, but are most common in late summer and fall. Blooms can look like foam, scum, or mats that float on the surface of the water, but some blooms present are as a thick "pea-soup" without a scum layer. The scum layer can be blue, bright green, brown, or red. Human and animal exposure may result in breathing problems, ear and eye irritation, vomiting, or skin rashes. Pets, livestock, or wildlife such as birds and fish can also be sensitive to blue green algae toxin exposure. Individuals with suspected exposure should seek medical attention (http://dhs.wisconsin.gov/eh/bluegreenalgae 2009).

Cyanobacterial toxins are classified as neurotoxins and hepatotoxins. Neurotoxins are produced by *Anabaena* and *Oscillatoria* species. Symptoms of exposure include muscle cramps, twitching, paralysis, cardiac or respiratory failure, and death in animals. Hepatotoxins are produced by *Microcystis* and *Cylidrospermopsis* species (Cyanobacteria and Human Health June 2004). *Gloeotrichia* species produce toxins that can cause skin irritation and liver damage (King 2005).

Cyanobacteria overwhelmingly dominated algae abundance in Cedar Lake during the summers of 2009-11. They were most abundant during the fall turnover period in mid-August through October when potential toxin-producing species dominated.

Established World Health Organization guidelines for actions at various cell densities of cyanobacteria are reported in Table 2 below. The World Health Organization chlorophyll a concentration threshold for high risk associated with potential exposure to cyanotoxins is 50 ug/L. (WDNR 2013) Cedar Lake exceeded the 50 ug/L threshold about 17 percent of the summer during the water quality study period (2009-2010) (James 2013).

Table 2. Summary Table of WHO Guidelines for Cyanobacteria Levels in Water

Risk Category	Cell Density (cells/mL)	Chl a (ug/L	Action Recommended
Low	20,000 – 100,000	<10	None
Moderate	>100,000	10 - <50	Advisory and Possible Closure
High	Visible Scum Layer	>50	Closure

Watershed

The Horse Creek watershed is 140 km^2 (34,743 acres). It is illustrated in Figure 8. The watershed has gently rolling terrain. Upper reaches of the watershed contain numerous small lakes that are not connected by streams to Cedar Lake. This internally drained area makes up 42 percent of the watershed (59 km^2 or 14,569 acres). Internally drained areas are illustrated in Figure 8 with light green shading. Areas draining directly to Cedar Lake total 81 km^2 or 20,173 acres. Direct drainage areas are shown in darker green on the map below and subwatersheds are labeled in the legend. Discharge from the subwatershed draining out of Big Lake was minimal during the 2009-11 study period.

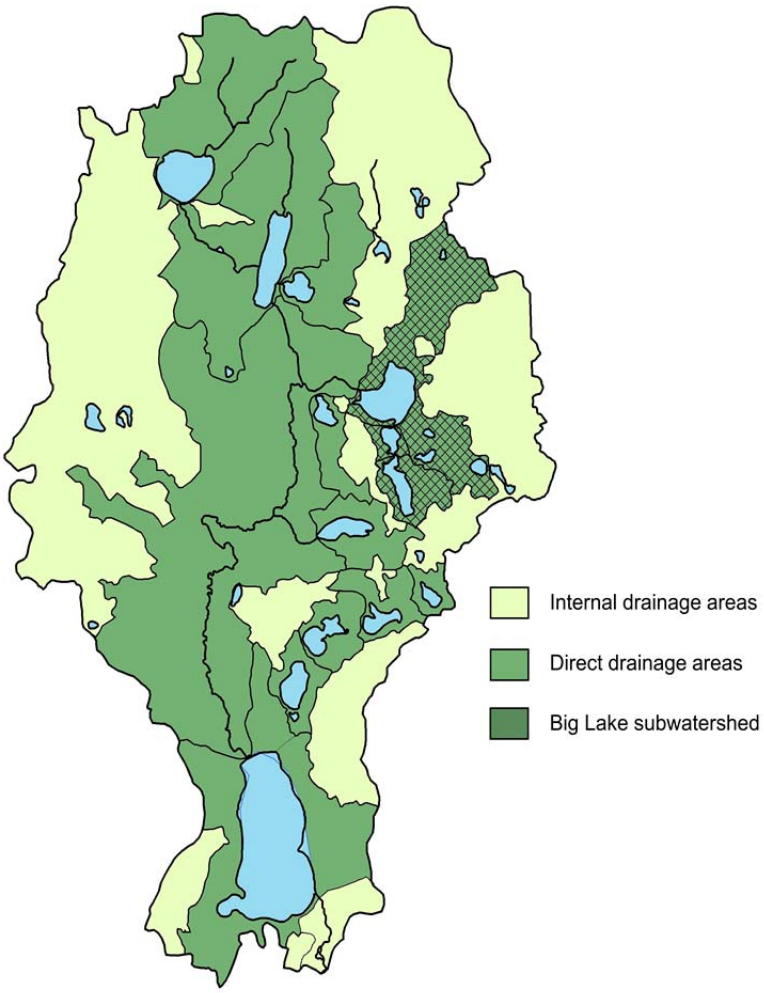


Figure 8. Horse Creek Watershed (James 2013)

Within the Horse Creek Watershed direct drainage areas, land cover is mostly woodland, grassland, open water, and wetlands (58%). These land covers generally deliver low levels of pollutants in runoff to lakes and streams. Row crop and forage (hay) fields account for 34% of the land cover (Horse Creek Priority Watershed Nonpoint Source Pollution Management Plan 2001). Farmstead, lakeshore, and rural residential land covers make up 8% of the watershed. Because of soil disturbance and fertilization, these land covers tend to generate higher levels of pollutants to lakes and streams than undeveloped land.

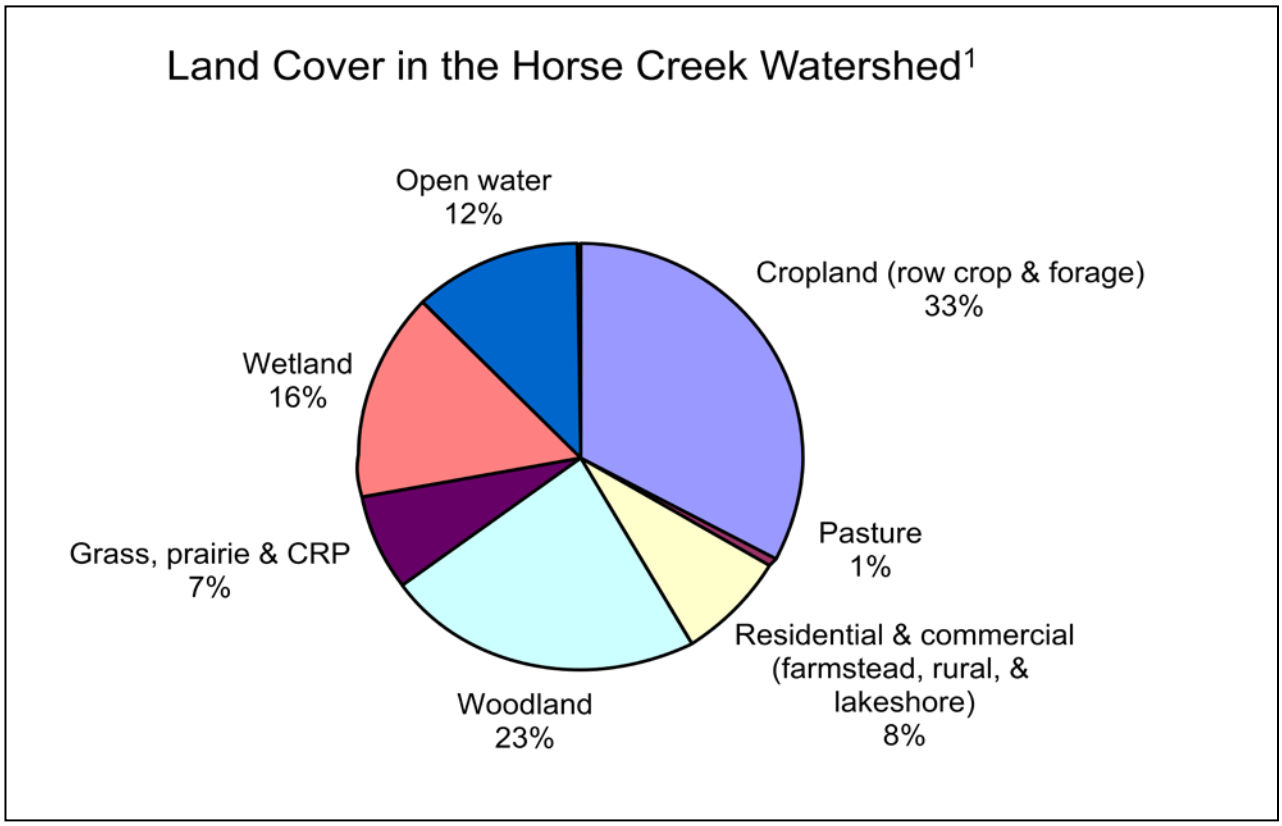


Figure 9. Horse Creek Watershed Land Cover

There are six known active dairy farms within the watershed and a few additional small operations. Small hobby beef and horse operations are also present. (Wojchik 2013)

Horse Creek Priority Watershed Appraisal

The amount of phosphorus that is contained in runoff as estimated for the Horse Creek Priority Watershed Appraisal is included in Table 3 below. Calculated cropland phosphorus export rates varied with manure applications, length and steepness of slope, and distance to channelized flow. The water quality appraisal estimated a total phosphorus load to Cedar Lake of 3,200 kg (7,040 lbs.). The historic load prior to development was estimated to be 957 kg (2,106 lbs.).

Table 3. Phosphorus Export Rates by Land Use (Cahow 1999)

Land Use Type/Source	**Phosphorus Export Rate (kg/ha/year)**	**Phosphorus Export Rate (lb/ac/year)**
Cropland	0.5 – 2.10	0.45 – 1.9
Pasture/grassland	0.3	0.3
Farmstead	0.8	0.7
Rural Residential	0.4	0.4
Lakeshore Residential	0.5	0.45
Wetland	0.05	0.04
Woodland	0.1	0.09
Construction	4.0	3.7
Commercial	1.0	0.9
Atmospheric Deposition	0.3	0.3

Horse Creek Priority Watershed Plan

The Horse Creek Priority Watershed Plan identified phosphorus sources to Cedar Lake as 80% agriculturally-related, 8% from disturbed lands, 6% from open space, and the remainder from miscellaneous land covers. The plan called for a 15% reduction in watershed phosphorus. (Horse Creek Priority Watershed Nonpoint Source Pollution Management Plan 2001) This project ended in 2009. The watershed final report lists best management practices installed as part of the project. They included many agricultural practices such as nutrient management (over 5,000 acres), high residue management (over 1,300 acres), pesticide management (over 3,700 acres), gully stabilization in a farm field, and animal waste storage system abandonment (2). Unfortunately, measured soil erosion rates from crop fields (in tons/acre) increased over the course of the project. This was attributed to increased row cropping and decreases in acres planted to hay for dairy cattle. (Horse Creek Priority Watershed Final Report)

Phosphorus Export Rates

Following implementation of the Horse Creek Watershed Plan, phosphorus export rates recently measured are very low for an agricultural watershed. The calculated total phosphorus for the entire area draining to Cedar Lake via Horse Creek at 10th Avenue is only 0.30 lbs/acre/year (0.27 kg/ha/year). When the phosphorus that comes from Horse Lake from carp and sediment resuspension is removed from this calculation, the phosphorus export rate is even lower at 0.24 lbs/acre/year (0.22 kg/ha/year) (James 2013). These estimates fell well below the “most likely” range for watersheds with greater than 50% agricultural land use in Wisconsin of 0.63

lbs./acre/year (0.56 kg/ha/y) and is very close to the "low" rate of 0.18 lbs./acre/year (0.16 kg/ha/year) (Panuska and Lillie 1995). The total watershed phosphorus load to Cedar Lake is estimated to be 1,478 kg (3,252 lbs.) (James 2013).

Soil Fertility and Phosphorus Index Assessment

The Polk County Land and Water Resources Department conducted an assessment of soil fertility and phosphorus delivery from cropland to Horse Creek and Cedar Lake as part of plan development in 2012 and 2013 (Wojchik 2013). The objectives of this work were to gather field soil test data, model phosphorus delivery from fields, identify areas of concern, and identify strategies to reduce nutrient runoff. The main drainage to Horse Creek (the direct drainage area between Horse Lake and Cedar Lake) was the priority area of study.

Soil test data were collected from all subwatersheds to calculate average soil phosphorus levels. Fields adjacent to Horse Creek had the highest average soil test phosphorus levels at 52.4 ppm. However, because of field management practices and field characteristics, the phosphorus index in the Horse Creek main drainage was estimated to be quite low at 1 lb. per acre per year. In the report, the phosphorus index is defined as an estimation of a field's potential to deliver nutrients to surface waters. This value represents pounds of phosphorus delivered per acre of cropland per year. Many of these fields have conservation or no till cropping practices which minimize the potential of phosphorus and sediment delivery to water resources. (Wojchik 2013)

Water Quality Study

Study Purpose

The Department of Natural Resources and the Cedar Lake Protection and Rehabilitation District commissioned a comprehensive water quality study to estimate phosphorus loading from Horse Creek and Cedar Lake sediments. A water quality model was used to predict in-lake effects of management efforts. Bill James, University of Wisconsin Stout, conducted the water quality study with data gathered from 2009 through 2011 and data analyzed and results reported in 2012 and 2013 (James 2013). Information in text boxes is added to help understand the study results.

<u>The study included:</u>

- Weekly to bi-weekly grab samples in specific tributary locations below Horse Lake (County K) and above Cedar Lake (10th Avenue). (2009 – 2011). (See map in Figure 10) Nutrients (nitrogen and phosphorus) were analyzed from these samples.
- Flow measurements of Horse Creek.
- Lake samples at 1 meter intervals between the lake surface and 0.2 meter above the lake bottom: analyzed nutrients, algal pigments (chlorophyll), and iron.
- Temperature and oxygen profiles assessed stratification and oxygen levels. Included years when the aerator was off (2009 and 2010) and on (2011).
- Secchi depths measured lake water clarity.
- Two models predicted in-lake effects from reducing watershed (external) and sediment (internal) phosphorus loads. This information helped to establish feasible water quality targets based on proposed management efforts.

- Laboratory lake sediment studies assessed sediment characteristics, calculated alum dosage, provided treatment area options, and estimated costs.
- Identification of algae assemblage in lake surface waters (0-3 meters) monthly.

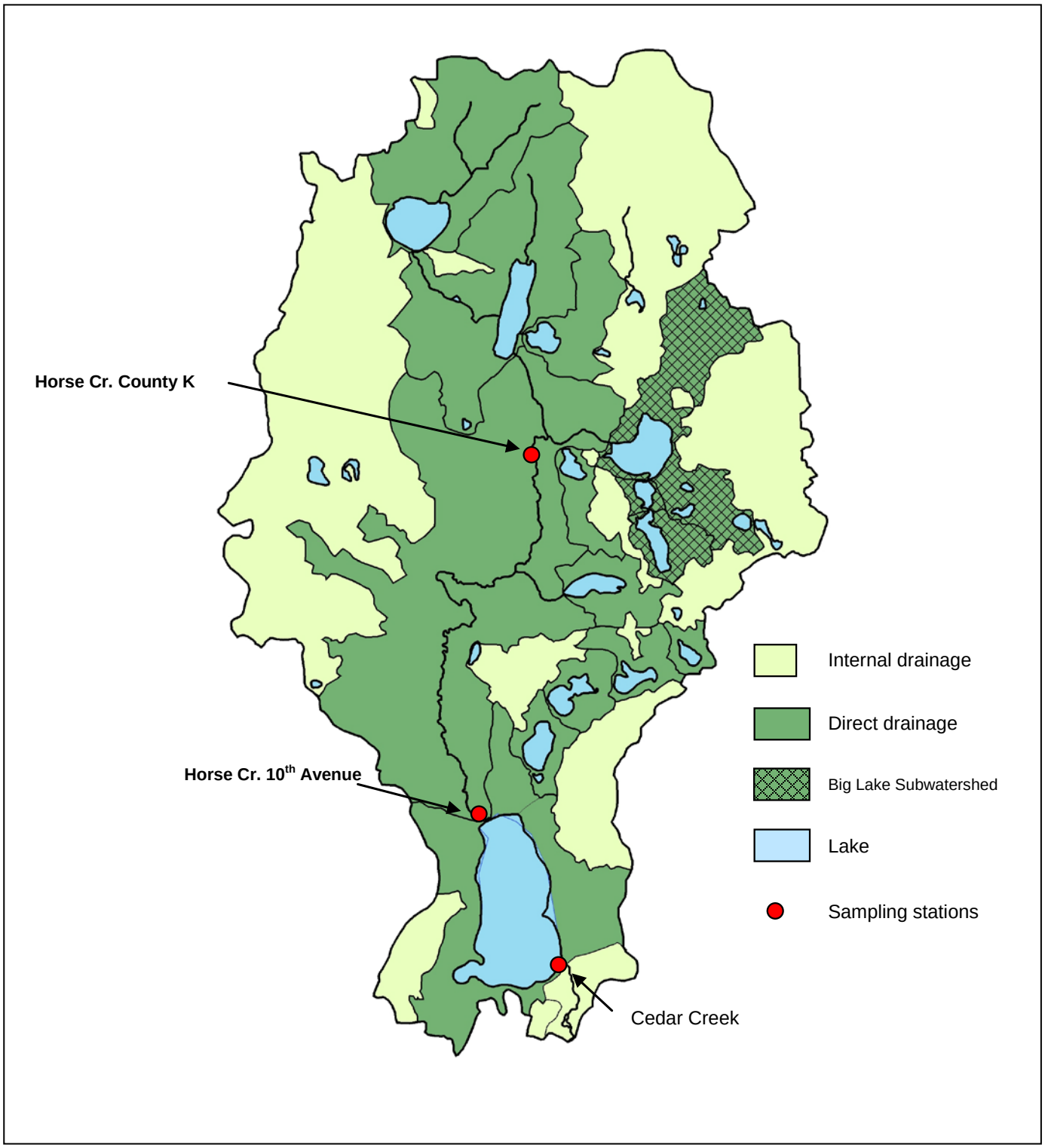


Figure 10. Tributary Sampling Locations

Nutrient Loading from Tributaries – External Phosphorus Load

Phosphorus was the focus of the water quality study because phosphorus leads to algae growth in Cedar Lake and most lakes in the region. Analysis of other nutrients helps to identify the source of pollutants to the lake. Total phosphorus includes both dissolved (or soluble reactive phosphorus) and phosphorus attached to sediment particles and contained in algae. SRP or dissolved phosphorus is found in fertilizers and manures.

Analysis of phosphorus in Horse Creek tells us what is coming from the watershed. We call this an external source of phosphorus because it comes from outside the lake.

Total phosphorus (TP) (0.089 mg/L) and Soluble Reactive Phosphorus (SRP) (0.031 mg/L)[2] concentrations were moderate in Horse Creek directly above Cedar Lake (10th Avenue). In this location, SRP made up about 35 percent of the phosphorus load. Phosphorus concentrations were highest during snowmelt and spring and fall storms.

Much further upstream at County K below Horse Lake, the TP concentration was similar, but SRP was much lower at 0.010 mg/L. Increases in SRP from County K to 10th Avenue suggest that TP may transform to SRP, phosphorus attached to particles may settle in the creek, and a net loading of SRP likely occurs from this area of the watershed. The source of high nitrate-nitrogen in runoff to 10th Avenue is likely from agricultural sources such as crop fertilization in the watershed. Best management practices should therefore target these sources in the watershed below County K.

Cedar Creek, the outflow from Cedar Lake, generally had lower concentrations of total phosphorus than the inflow. This means that phosphorus is captured in Cedar Lake. The exception occurred in mid-August to September when lake phosphorus was especially high due to phosphorus release from lake sediments. (James 2013)

[2] Annual flow-weighted.

Nutrient Loading from Lake Sediments – Internal Phosphorus Load

Cedar Lake's sediments have accumulated for thousands of years. In the past 200 years, agricultural use has increased the nutrient levels of these sediments. Sediment increased as the area was plowed for agriculture in the late 1800s. After a subsequent decline, sedimentation rates again increased beginning around 1960 through 2000. From 1980-2000, an increase in the use of commercial fertilizers is evident. Increased phosphorus in sediments over the years is probably from both increased loading from the agricultural watershed and increased internal loading from the lake sediments (Garrison 2002).

When anoxia (low oxygen) occurs near the lake bottom, phosphorus is released from the lake sediment. If the lake water stratifies (forms layers of water based on temperature) this phosphorus is held in colder bottom layers. Mixing of a lake generally occurs in the spring and fall when lake temperatures equalize. During mixing, phosphorus held in bottom waters is brought to the surface. The lake can also mix due to aeration or high winds. Cedar Lake is a polymyctic lake, mixing periodically during the summer. Mixing was enhanced in recent years in Cedar Lake, because stratification was weakened when the aerator was turned on. When mixing occurs, phosphorus is brought to the surface and algae growth increases.

Algae growth (as measured by chlorophyll a) is highest in late August through October because mixing brings phosphorus-rich waters to the surface. Phosphorus then fuels algae growth.

Water at the bottom of Cedar Lake lacked oxygen at 6 meters (20 feet) and deeper in 2009 and 2010 when the aerator was off. This anoxia lasted about 47 days. In 2011, when the aerator was on, the bottom lacked oxygen beginning at 7 meters (23 feet) and lasted 36 days. Low iron to phosphorus ratios in lake sediments limited the ability of iron to bind with phosphorus in lake sediments increasing the release of phosphorus.

Even without the aerator, Cedar Lake is susceptible to mixing because it is long and narrow and relatively shallow. The aerator made lake mixing even more likely. Stratification, which prevents mixing, was strongest during 2010 when it was warm. In 2009 the lake mixed more frequently with the passage of summer cold fronts. Lake stratification was very weak in 2011 when the aerator was on. The lake mixed frequently, bringing phosphorus to the surface in 2011. Therefore, when combined with the limited ability of iron in lake sediments to bind with phosphorus, the aerator actually increased phosphorus loading from lake sediments.

Potentially toxin forming algae were highest in number during the fall turnover periods in mid-August through September.

Internal loading from lake sediments dominated phosphorus loading to Cedar Lake in all study years. (James 2013)

Phosphorus Contributions to Cedar Lake

Contributions from the external and internal load varied each year with changes in temperature, precipitation, and wind. Estimates for overall loading to the lake in 2009 and 2010 when the aerator was not turned on are shown in Figure 11 below. Internal sources of phosphorus made up 85 percent of the phosphorus loading during the summer growing season and 64 percent over the course of the year.

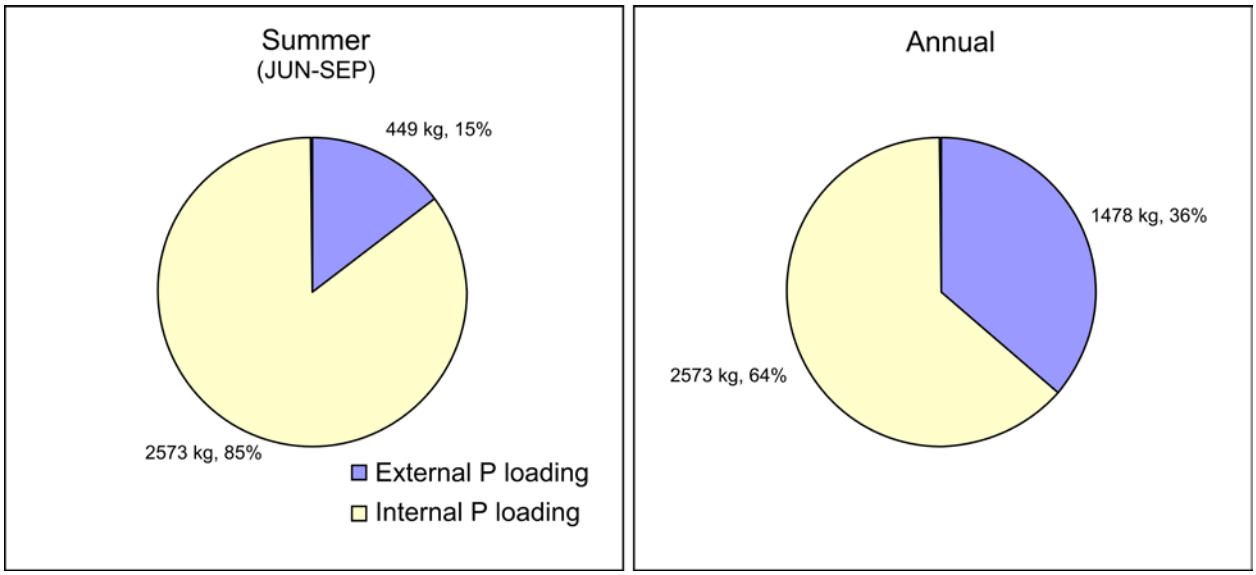


Figure 11. Cedar Lake Summer (period of stratification) and Annual Phosphorus Load Showing External and Internal Source (James 2013)

Predicting Management Results

Water quality models are used to predict changes to in-lake water quality that result from management methods which reduce the internal and external phosphorus load to the lake. The study used Bathtub (1996) and Nurenburg (1998) models to make water quality predictions. The values shown below are an average of the results of the two models used.

Lake water quality is measured in a variety of ways. This report focuses on the following:
TP - Total phosphorus concentration during the growing season;
Chl a - Chlorophyll a concentration is a measure of the algae contained in the water column; and
Secchi depth – A measure of water clarity indicated by when the 8 inch black and white disc is no longer visible when lowered into the water.

Measured Cedar Lake Conditions (2009-2010)
Annual TP 0.062 mg/L
Summer Chl a – 33.1 ug/L
Nuisance Algae Bloom Frequency[3]: 69% of the summer
Cyanotoxin Production Risk: 17% of the summer
Secchi Depth (mean summer[4]): 2 meters (6 feet)

Following 30% Reduction in Watershed P loading only
Annual TP – 0.054 mg/L
Summer Chl a – 28 ug/L
Nuisance Algae Bloom Frequency: 61% of the summer
Cyanotoxin Production Risk: 12% of the summer
Summer Secchi Depth (summer) 2.2 meters (7 feet)

Following an Alum Treatment only
Annual TP – 0.033 mg/L
Summer Chl a – 13.4 ug/L
Nuisance Algae Bloom Frequency: 20% of the summer
Cyanotoxin Production Risk: 1% of the summer
Summer Secchi Depth (summer): 3.9 meters (13 feet)

Following an Alum Treatment and 30% Reduction in Watershed P loading
Annual TP - <0.025 mg/L
Chl a - <10 ug/L
Nuisance Algae Bloom Frequency: 8% of the summer
Cyanotoxin Production Risk: 0% of the summer
Summer Secchi Depth (summer): 5.1 meters (17 feet)

[3] Nuisance algae blooms occur when Chl a is >20 ug/L according to WisCALM 2013.
[4] June through October

Recommendations

Controlling Internal Loading

Alum or aluminum sulfate can be used to effectively control the internal phosphorus load from lake sediments. More information is available in the DNR fact sheet (Alum Treatments to Control Phosphorus in Lakes 2003) *and Cedar Lake Alum Questions and Answers handout. Both are found in Appendix G of the 2014 plan.*

An alum treatment is recommended to control internal phosphorus load from anoxic lake sediments. This is the top priority recommendation. External watershed P loads have already been reduced to low levels.

Figure 12. The Barge used for the Cedar Lake Alum Treatment

Alum will be applied at total amounts of from 100 to 130 g Al/m^2 based on the alum dosage studies. The maximum concentration of alum will be applied at the 25 foot contour and deeper. Approximately 60 percent of the sediment area is greater than 25 feet. A lower dosage (100 g Al/m^2) will be applied between the 20 and 25 foot contours. This treatment scenario is illustrated in Figure 13 and summarized in Table 4. The 20 foot depth represents the average depth of anoxia in the lake. Alum dosages are calculated based on the need to treat the mobile phosphorus in the upper 6-8 cm of sediment. The recommended treatment rate is based upon the best available alum dosage assays and recent alum application case studies. Lakes that receive at least 100 g Al/m^2 are expected to have a higher likelihood of success with long term reductions in phosphorus levels and resulting improvements in water clarity. (James 2013)

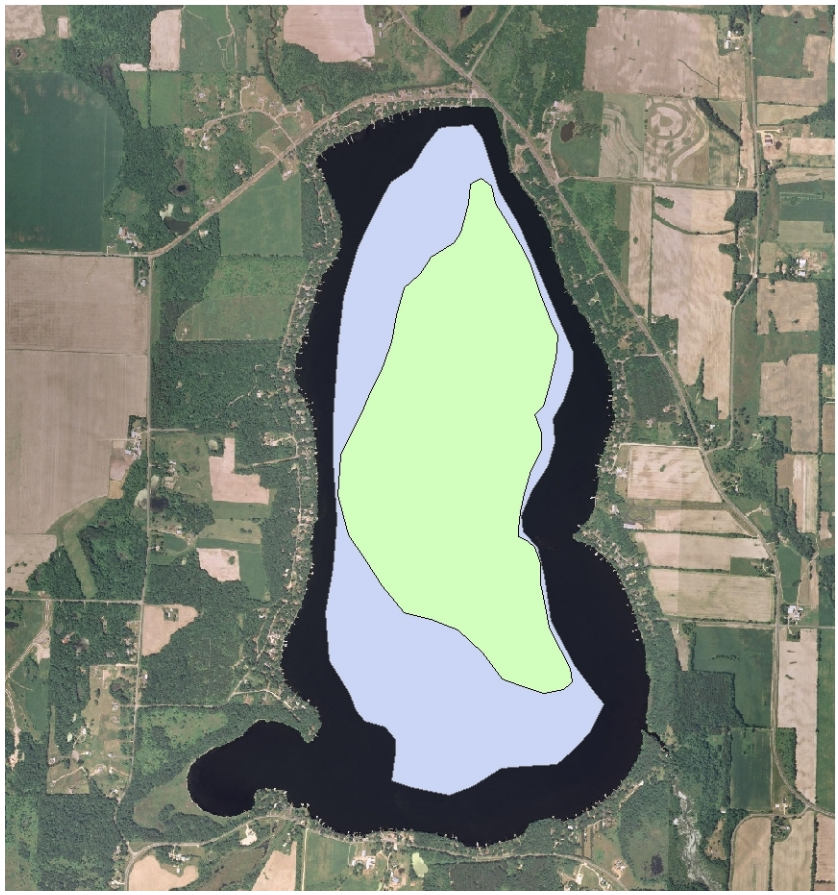


Figure 13. Recommended Alum Treatment: 130 g Al/m^2 to 25 feet and 100g Al/m^2 to 20 feet

Table 4. Alum Dosage Areas

	Area (acres)	**Total Alum Dosage (g/m^2)**
20-25 ft. Contour	306	100
>25 ft. Contour	370	130

It is important to maintain pH above 6 during an alum application. Because of this concern, pH and alkalinity (the ability to buffer low pH) must be measured prior to and at the time of treatment. If pH is likely to be too low with the recommended alum application, buffered alum can be used. However, this option is significantly more expensive. Another way to alleviate pH concerns is to treat the lake using multiple alum applications at 2-3 year intervals. This approach is proposed for Cedar Lake.

Alum Application Strategy 2017-2029

Split treatments, as described in Table 5, are planned to enhance the binding capability of alum. Researchers have suggested that multiple lower dose applications may be more effective than a single higher dose treatment in stabilizing Al crystallization and enhancing phosphorus binding efficiency (Lewandoski et al. 2003, de Vicente et al. 2008a, Huser 2012, Jensen et al. 2015). In addition, relatively rapid aging and polymerization of the Alum floc in the absence of phosphorus can greatly reduce future binding efficiency for mobile phosphorus (Berkowitz et al. 2005, 2006, de Vicente et al. 2008b) and reduce Al treatment longevity (James 2017).

A mid to late June alum application is planned for Cedar Lake so that phosphorus will be available in the hypolimnion (low in the water column) to bind with alum as it settles. This will not only remove phosphorus from the water column, but also increase the binding efficiency of the alum floc. Smaller, more frequent applications will also provide better binding of sediment phosphorus as it diffuses to the alum floc. Each application can be targeted based on interim monitoring results. Another significant benefit of split treatments is that the District can use a pay-as-you go approach rather than borrowing money up front. This will avoid interest charges and allow full use of grant funds as they become available.

The total amount of alum recommended in each area remains the same. Treatment dates and dosages may change depending upon in-lake and sediment monitoring results following the alum treatment.

Table 5. Alum Application Strategy (2017-2029)

	Treatment	Cumulative Al dose (g/m^2)	
Year	(mid-June)	20-25 ft	> 25 ft
2017		20	26
2018			
2019			
2020		40	52
2021			
2022			
2023		60	78
2024			
2025			
2026		80	104
2027			
2028			
2029		**100**	**130**

Monitoring Strategy

The WDNR recently awarded the Lake District two lake planning grants to partially fund comprehensive monitoring of tributary nutrient and sediment loading, in-lake conditions, and lake sediment response to the alum treatment. This extensive monitoring will allow an adaptive management approach. Monitoring results will be used to assess effectiveness of the alum application and to target future alum treatments over a 12 year period. For example, subsequent applications may be delayed or modified on a spatial basis to achieve the desired sediment aluminum concentration. Results will also help to plan alum treatments on other lakes in Wisconsin and even world-wide.

Special Assessment for Alum Treatment

A Special Assessment for an alum treatment was approved by Resolution 2016A by eligible voters at the Cedar Lake Protection and Rehabilitation District Meeting August 6, 2016.

Resolution 2016A

To proceed with implementing an Alum Treatment according to the Revised Alum Application Strategy presented at the 2016 Annual Meeting; and to fund the alum treatment strategy through a Special Assessment until the treatments are completed (anticipated in 2029). Total cost of treatment is currently estimated to be $2.5 million.

A special assessment is used to provide local funds for the alum treatment. The Cedar Lake P&R District board appointed a citizen committee of lake residents to develop a parcel classification system for the special assessment. The committee met twice in January and February of 2016. The committee used guidance from Wis. Stat 33.32 and 66 to develop the classification recommendation for the board. The board adopted the committee recommendations at a regular board meeting and followed the required legal process to establish the special assessment.

The commissioners shall apportion the special assessment within the district on a reasonable basis. Each parcel shall be examined and benefits to each parcel will be determined considering such factors as:

- **Size**
- **Proximity to the lake**
- Potential use of the parcel

The Cedar Lake P&R District established the special assessment for the alum treatment through the required process in August – October 2016. The established assessments are in place for ten years (through 2026) and are based on best estimates of cost. Assessments may need to be adjusted late in their implementation depending upon the results of the first four alum applications and the amount of additional grant funding secured.

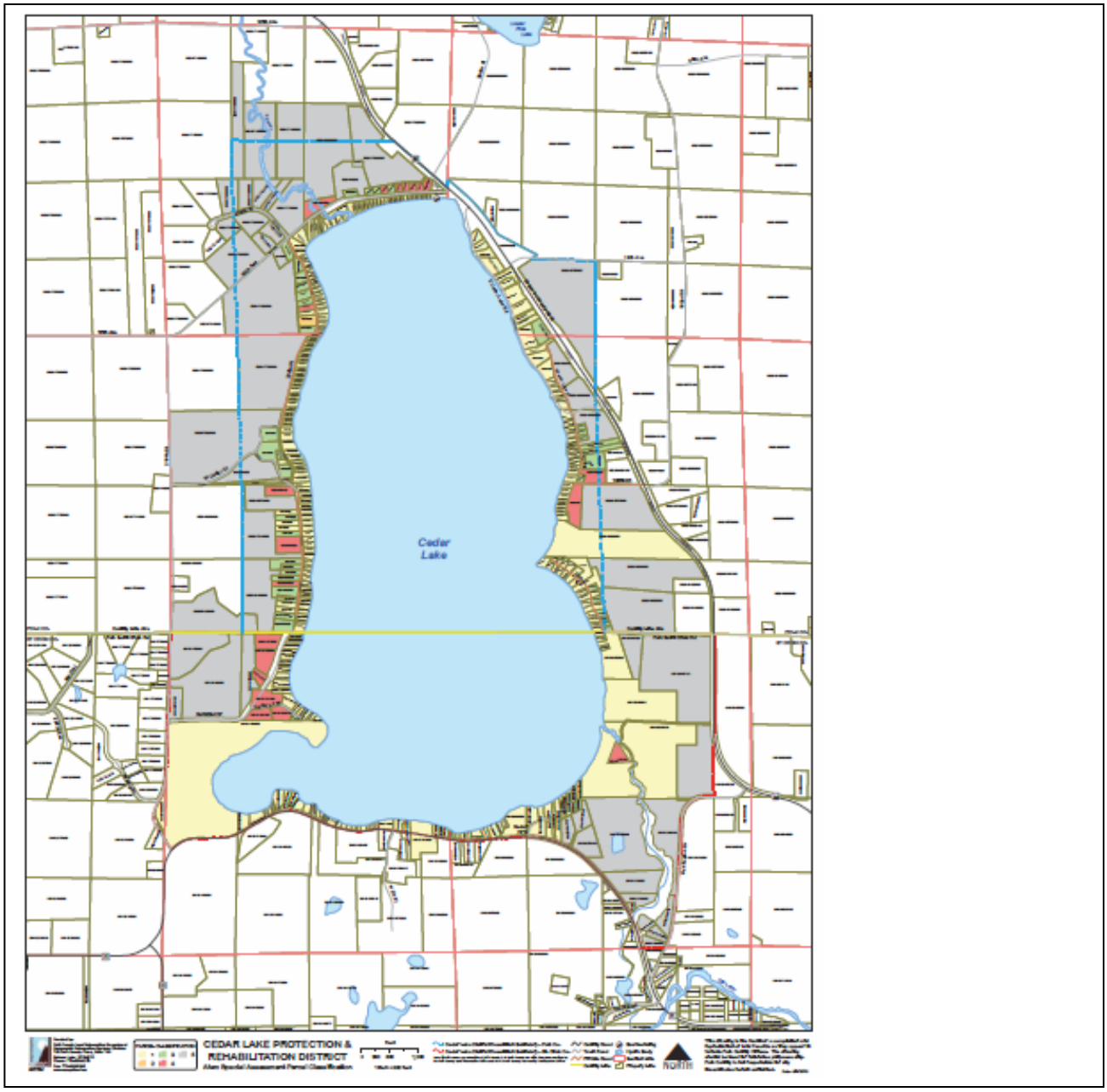


Figure 14. Special Assessment Parcel Classifications

Parcel Classification

1	Lake Lot/1st tier
2	Back lot/2nd tier with deeded access
3	Back lot/2nd tier with adjacent lake lot in same ownership
4	Back lot/2nd tier, no access, adjacent lake lots not same owner
5	"Other lot", no access, 2nd tier lot greater than 5 acres or 3rd tier lot

Definitions
Lake lot or 1st tier lot touches lake
2nd tier lot, common boundary with 1st tier lot
3rd tier lot, common boundary is adjacent to 2nd tier lot
Back lot is 2nd tier = or <5 acres

Special Assessment Rates
Class 1/2/3: 100% Assessment
Class 4: 50% Assessment
Class 5: 0% Assessment

Controlling External Loading

While current watershed or external loading rates of phosphorus are low, further reductions are recommended. Watershed best management practices should target reducing runoff of soluble phosphorus from areas that have a high runoff potential. These include areas with steep slopes, low soil infiltration rates, inadequate crop cover, and tillage practices that result in bare soil. These characteristics are especially important to target in areas with high soil phosphorus closest to stream flow which is connected to Horse Creek.

A cooperative WDNR/St. Croix Tribe carp control project was tried from 2013 – 2016. One motivation for the project was to control upstream sources of phosphorus from Lotus Lake. The project involved an attempt to commercially harvest carp to remove them from the lake. Gill nets and seining was used. The project was unsuccessful in that it removed vary few carp from the lake. There are no plans to continue the project. If successful, project expansion to Horse Lake was a possibility.[5] Reductions in Horse Lake carp populations were expected to lead to further reductions in Horse Creek watershed external phosphorus load (James 2013).

Soil Fertility and Phosphorus Index Assessment

The Polk County Land and Water Resources Department assessment of soil fertility and phosphorus delivery from cropland to Horse Creek and Cedar Lake as part of this project resulted in several recommendations for further study and agricultural management in the watershed.

Assessment Recommendations

1. Continue data collection. More data is needed over a longer period of time.

2. Compare modeled data with edge-of-field monitoring data to verify model estimates.

3. Emphasize more complete nutrient management plans and planning. Implement plans!

4. Inform agricultural community of elevated soil test levels in the main drainage and work to lower them slightly to optimum levels (18-35 ppm).

5. Use conservation practices to reduce watershed loading by up to 30 percent. These practices include conservation and no tillage, edge of field filter strips, strip cropping, cover crops, and farming on the contour. **Polk County Land and Water Resources Department projected best management practices for the Implementation Plan for the Lake St. Croix TMDL** (St. Croix Basin Implementation 2014) **are included in the implementation chart for Goal 2.**

6. Support and encourage the implementation of the Horse Creek Farmer-Led Watershed Council.

[5] Aaron Cole, WDNR Fisheries Biologist. Email communication January 2017.

Horse Creek Farmer-Led Watershed Council

The Horse Creek Watershed is home to one of the most progressive farmer-led watershed projects across the state. Farmers in the watershed are using information from an inventory conducted by the Polk County Land and Water Resources Department to develop incentives for on-farm measures for water quality improvements. The inventory results show that phosphorus levels leaving farm fields and draining directly to Horse Creek average only about 1/6 of the allowed state standard of 6 lbs./ac/yr.

The primary goal of the project is to allow members of the agricultural community to become actively engaged in the process of developing strategies to improve water quality through implementing conservation practices they see as most effective. The council has been meeting regularly with support from Polk County Land and Water Resources staff since 2013.

Local leaders have been selected, and incentives for farmer participation have been evolving. The current list is being re-evaluated for 2017. These incentives will target soil testing, cover crops, educational opportunities, and other practices related to soil health. The council has successfully gained additional producer participation each year. They expect more incentive participant and practice installation in 2017.

Funding for the farmer led council comes from a McKnight Foundation grant and Department of Agriculture, Trade and Consumer Protection grants. These grants provide funding for staff support, monitoring, and farm incentives.

A summary of Farmer-Led Watershed Council activities is included as Appendix H.

Cedar Lake Fishery

There are a variety of game fish in Cedar Lake. Walleye are abundant; musky and northern pike are common. Largemouth bass, smallmouth bass, and pan fish are also present.

Walleye are the predominant game fish in Cedar Lake. They were originally stocked in the lake. Walleye tend to do well in algae-dominated lakes because algae shields walleye fry from predation. The population is self-sustaining, but subject to annual variation. Because of concerns related to over-harvest, a 14-18 inch protected slot limit was instituted in 2008. Initial indications showed this slot limit has resulted in greater numbers of adult walleye per acre. It takes 10 years after instituting slot limits to fully assess effectiveness (Engel 2009).

The WDNR stocked large fingerling muskellunge every other year in Cedar Lake beginning in 1999 (WDNR Lakes pages).

Table 6. Game Fish Sampled by Netting and Electrofishing May 2009

Species	Size Range	Average Size	Population Estimate/Notes
Walleye	10.7 to 27.2 inches	15.1 inches	5,838
Musky	16.0 to 43.7 inches	34.2 inches	stable, stocked alternate years
Northern Pike	9.3 to 36.9 inches	20.1 inches	low levels
LM Bass	12.5 to 17.9 inches	14.1 inches	small population
SM Bass	6.5 to 17.9 inches	12.5 inches	small population
Yellow Perch	3.4 to 10.8 inches	4.1 inches	stable
Bluegill	to 8.8 inches	5.3 inches	slowly increasing since 2004

Historical Fisheries Information*

- 1938 - Poor water quality reported with pea soup conditions
- 1941 - First fish survey - cisco common, white bass present, no smallmouth or musky, otherwise the same species as today
- 1946 - Musky first planted
- 1947 - Cisco disappear, carp present
- 1950's - Water level manipulation
- 1953 - Walleye stocking ended
- 1960 - Carp a problem, commercial fishing followed
- 1981 - Complaints of aquatic vegetation disappearing, copper sulfate treatments blamed
- 1990 - Native Americans begin spearing
- 2002 - Spring viremia results in large carp kill
- 2004 - Smallmouth bass present
- 2009 - Bulrush beds gone
- 2013 - Rusty crayfish present
- 2013 Excellent game and pan fishing, carp population low!

* Summarized by Marty Engel, DNR Fisheries Biologist

Loss of aquatic plant beds, loss of bulrush stands, and removal of woody debris resulted in loss of fish habitat in Cedar Lake. Introduction of carp and white bass has also displaced native species. There are few options for habitat improvement on Cedar Lake. Cost effective carp control measures are not available. However, recent outbreak of disease caused the collapse of the carp and white bass populations. Woody debris, such as fallen trees in the water, is important for fish and wildlife habitat structure. Fish cribs were installed to compensate for the loss of woody debris in the lake. The 224 cribs placed in colonies throughout the lake created new habitat. Improvements in pan fishing can be attributed to these cribs.

Tree drops or fish sticks can also be installed to improve fish habitat. Fish sticks are essentially a complex of approximately 16 to 60 whole trees that are acquired from an upland source, cabled

together, and secured to the shoreline. The intent of these projects is to replicate wood that was historically present in the near shore littoral zone before lakeshore development and logging activities at the turn of the century "cleaned up" much of the shorelines. [6]

Fish Habitat Recommendations

Re-establishment of bulrush stands is desired but may require lowering lake levels (Engel 2009).

Carp Management

Carp have been implicated for poor water quality (Sorge May 1989) and removal of aquatic vegetation (Konkel 2003) (McComas 1998) on Cedar Lake for many years. Carp are bottom feeders, and bottom feeding releases significant amounts of nutrients to the water column as these fish feed and digest plant material. Harvesting carp has increased water clarity in some lakes (Managing Lakes and Reservoirs 2001). Numerous commercial carp fishing operations in Cedar Lake from 1959 – 1998 proved unsuccessful at carp control. It is difficult to quantify carp populations and subsequently reduce their density. Quantifying carp requires a mark and recapture population estimate.

The Cedar Lake P&R District (Jim Brockpahler) installed a carp barrier at the dam (the lake outlet) around 1997.[7] A new lake map was developed in 1998. Potential snags that might interfere with carp fishing were recorded on the map. Carp fishing was encouraged. A carp round up to attempt population estimates was unsuccessful. Lack of success was due to low capture rates and the presence of snags.

Frustrations with carp management efforts were minimized when a natural die off of carp occurred in 2002. An estimated 1,500 carp died in Cedar Lake over a 6 week period from late April through the first week in June. This was the first report of spring viremia of carp virus in wild carp in North America. (Dekkeboom 2004) The population of carp in Cedar Lake remains low through 2013 (Engel 2013).

[6] Information provided by Aaron Cole, DNR Fisheries Biologist. April 2015.
[7] Stuart Nelson. Personal Communication March 15, 2013.

Aquatic Plants

The aquatic plant community of a lake is full of complex interactions that contribute to the overall health of a lake. Every level of the aquatic food chain from bacteria and invertebrates to fish and waterfowl are dependent upon aquatic plants, to some degree, for their survival. Aquatic plants stabilize sediments and absorb wave action which in turn prevents turbidity caused by suspended sediments. (Lepsch July 2015)

The WDNR conducts aquatic plant surveys on Cedar Lake every 3-5 years. The most recent survey was conducted in July 2015 according to WDNR guidelines for the point intercept method. Methods and results are reported in *Aquatic Plant Community of Cedar Lake St. Croix County, Wisconsin 2012-2015.* Cedar Lake has an average to below-average plant community, but still a good diversity of plants. The community is not overly dominated by a single species. Summary statistics from this report are shown in Table 6 below.

Table 7. Plant Community Comparisons

	1988	1991	1994	1997	2000	2004	2012	2015
Number of Species	17	22	23	23	17	18	17	24
Maximum Rooting Depth (feet)	12.0	11.5	13.0	13.0	11.0	7.0	10	13
Simpson's Diversity Index	0.87	0.88	0.87	0.90	0.88	0.86	0.84	0.85
FQI	20.5	23.2	24.1	23.6	19.7	19.3	21.5	20
Average Coefficient of Conservatism	4.8	5.0	5.1	4.9	4.8	4.6	5.7	5.25
AMCI	46	49	45	45	43	38	46	49

Simpson's Diversity Index (SDI)[8] was used to measure the diversity of the plant communities in each survey. The formula measures the probability that two individuals from the same community will be the same species. Values for SDI range from 0-1 where a value of 0 indicates 2 individuals will always be the same species and a value of 1 indicates 2 individuals will always be different species.

The Floristic Quality Index (FQI)[9] is used to assess each community's resemblance to an undisturbed condition. Coefficients of conservatism are values assigned to plant species based on their ties to a pre-settlement condition. Plants are given a value on a scale of 1 to 10 based on the probability that a species will occur in a disturbed habitat with higher values given to plants that

[8] SDI = 1 - (Sum (frequency of occurrence of one species/sum frequency of all species))
[9] FQI = Average Coefficient of conservatism * √Number of species.

are less likely to occur in a disturbed habitat (Nichols, 1999). Coefficient of conservatism values are assigned only to native species that would normally be found in a lake environment.

The Aquatic Macrophyte Community Index (AMCI) was used to define the quality of the aquatic plant community based on seven parameters: the maximum rooting depth, the percentage of the littoral zone vegetated, the relative frequencies of submerged species, sensitive species and exotic species, Simpson's Diversity Index and the total number of taxa. Each parameter was scaled from 1 - 10 with 10 representing the most desirable condition. The scaled values were then summed to obtain the AMCI (Nichols et al., 2000). The AMCI and FQI of Cedar Lake were compared to those of all Wisconsin Lakes and lakes in the North Central Hardwood region in the report.

One invasive species, curly leaf pondweed (*Potamogeton crispus),* was present at low levels when measured in July 2012. It was present at 3% of sites over the entire lake and at 11% of sites in the littoral zone (the area where plants grow). (Lepsch July 2015)

One change in the lake that is particularly troublesome is the complete lack of emergent vegetation. Historically there were small isolated patches of emergent vegetation found around the shoreline, particularly in the southwest corner of the lake. Previous attempts to plant emergent vegetation have been unsuccessful. (J. Lepsch 2013)

Plants grew to about 13 feet deep in Cedar Lake in 2015. Increases in water clarity will increase light penetration and open a large portion of the lake to vegetation. For example, an increase from an average 5 foot to 10 foot Secchi depth, is predicted to increase to plant growth about 15 feet deep.[10] There will likely be an increase in the number of species and the percent of the lake with vegetation. A more robust plant community will lead to a healthier aquatic ecosystem. (J. Lepsch 2013)

Eurasian water milfoil was first discovered in Cedar Lake in June 26, 2015. It was found during an aquatic invasive species survey by the District's consultant. The Department of Natural Resources followed up with a full lake plant survey and lake perimeter aquatic invasive species survey on Monday, June 30th. Eurasian water milfoil is not reported in the 2015 WDNR survey results above because it was not found at any of the point intercept sample points. See the aquatic plant management section for more information.

[10] Predicted rooting depth (ft.) = (Secchi Disc (ft.) * 1.22) + 2.73. (from Dunst, 1982)

Sensitive Habitats and Species

A sensitive area survey was conducted on Cedar Lake in 2002 (Designation of Sensitive Areas in Cedar Lake, St. Croix County 2003).

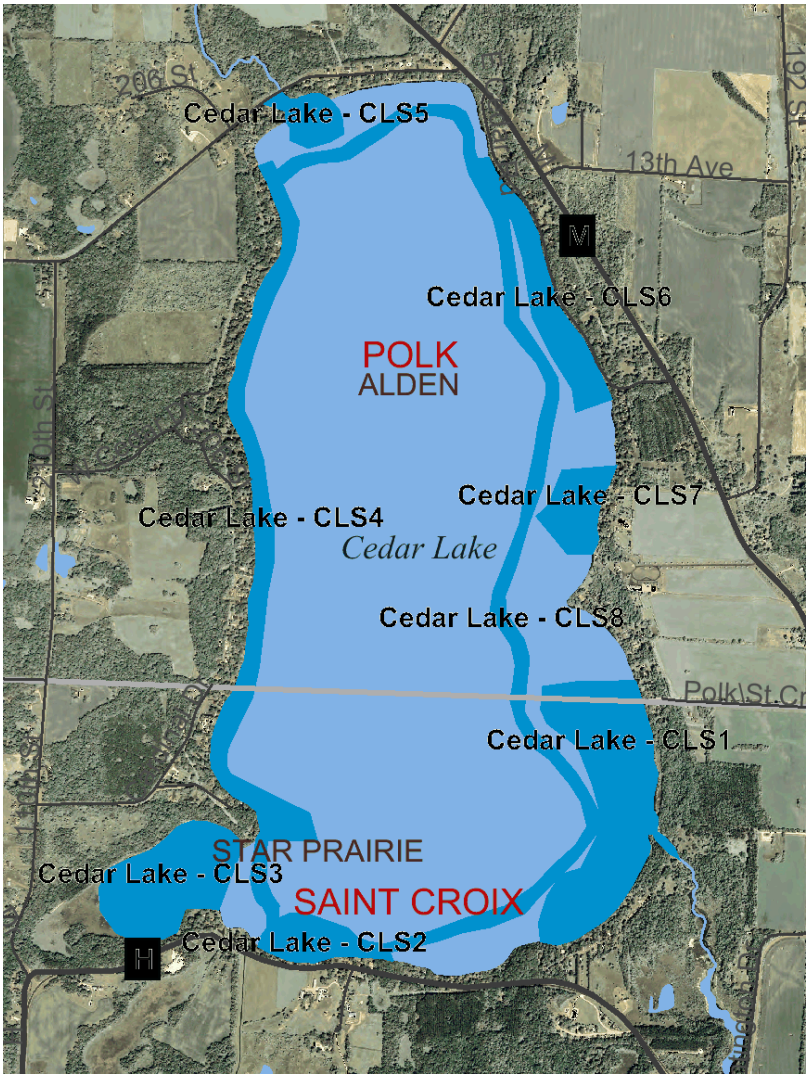


Figure 15. Cedar Lake Sensitive Areas

Table 8. Sensitive Area Descriptions

Sensitive Area	Location/description	Importance
CLS1	Historic Bulrush Site – 2,000 feet	Includes emergent vegetation and scattered submergent vegetation. Mostly undeveloped shoreline.
CLS2	South Shore Site – 500 feet	Submergent vegetation. Walleye spawning area.
CLS3	Southwest Bay	11-acre bay supports fish and wildlife. Area of natural beauty.
CLS4	West Shore Spawning Beds – 4,500 feet	Premier walleye spawning site on the lake.
CLS5	Horse Creek Inlet – 600 feet along shoreline and 300 feet up creek	Fish spawning and nursery area.
CLS6	East Shore Gravel Beds – 2,000 feet	Wooded steep shoreline, fish spawning and nursery area.
CLS7	Deep Hole Site – 300 feet	Extensive tamarack bog and woodland with fallen woody cover.
CLS8	Break Zone – 8 to 12 foot depth contour around the lake	Aquatic plant community provides valuable fish habitat.

Cedar Lake sensitive area descriptions from 2002 are included in Table 8. Sensitive areas are the sensitive and fragile areas that support wildlife, fish and aquatic habitat, protect water quality, and preserve aesthetic beauty. Management restrictions in sensitive areas may include limits on grading, dredging, and boat ramp placement.

Recommendations for sensitive areas generally involve limiting the impact of human use and development by restoring and maintaining in-lake and shoreline vegetation, leaving fallen trees in the lake, limiting the installation of piers, protecting undeveloped areas, and not allowing permits for dredging or bank grading.

Since the sensitive area report was completed, the Menke family donated 63 acres with over 1,000 feet of shoreline along CLS1 to the Star Prairie Land Preservation Trust with support from the Cedar Lake P&R District, Star Prairie Fish and Game, and the Department of Natural Resources. The Land Trust also received support from the Town of Star Prairie, Star Prairie Fish and Game, St. Croix County, and the DNR to purchase and develop a nonmotorized access and wildlife observation point adjacent to CLS3.

Invasive Species[11]

When non-native plants, animals, or pathogens rapidly take over a new location and alter the ecosystem, they are considered invasive species**.** Invasive species can sometimes take over and spread rapidly and widely causing major harm to the native ecosystem or humans. One of the reasons that invasive species are able to succeed is that they lack natural predators and competitors. Without these checks and balances, they are able to reproduce rapidly and out-compete native species.

Invasive species can alter ecological relationships among native species and can affect ecosystem function, economic value of ecosystems, and human health. Humans have created conditions where plants and animals can aggressively invade and dominate natural areas and water bodies in three ways:

- introducing exotic species (from other regions or countries);
- disrupting the delicate balance of native ecosystems by changing environmental conditions -- e.g., stream sedimentation, ditching, building roads or restricting or eliminating natural processes such as fire; and
- spreading invasive species through various methods:
    - moving watercrafts between waterbodies without removing invasive plants and animals;
    - carrying seeds of invasive plants on footwear or pet fur;
    - mowing along roadsides;
    - importing firewood and leaving in campgrounds;
    - driving and biking with invasive seeds in tire treads.

The net result of invasive species spread is a loss of diversity of native plants and animals. About 42 percent of the species on the Federal Threatened or Endangered species lists are at risk, primarily because of invasive species.

[11] Information from the Wisconsin Department of Natural Resources web site: http://dnr.wi.gov/topic/Invasives

Japanese and Giant Knotweed Management

Japanese and giant knotweed are non-native invasive species found near Cedar Lake. A stand of Japanese knotweed was identified on 10th Avenue, near the bridge above Horse Creek close to where it flows into Cedar Lake in 2012. In 2013, 5 additional locations were documented around the lake. Since that time, both giant and Japanese knotweed have spread dramatically especially along the north/south powerline on the west side of the lake from the Polk County line to the north.

There are also locations where giant knotweed grows along the lakeshore. Planting or transplanting this state-prohibited species is illegal. This plant is extremely difficult to control and spreads rapidly.

Because a large infestation of knotweed is along the powerline, control efforts have been coordinated with the Polk Burnett Electric Cooperative. Polk Burnett has sent their contractor to spray the right of way in the fall of 2016.[12] Results to date are reported to be favorable. Polk-Burnett and board members and volunteers will monitor for future spraying needs. [13]

Lake volunteers (Doug Dixon and Kevin Furlong) have worked with board member Dan Early to talk with residents and spray areas not included in the right-of-way. The board also plans to send letters to private owners with identified knotweed. This letter will be co-authored by the appropriate County official and local DNR officer emphasizing the WI DNR Regulation prohibiting this species.

Lake residents were encouraged to familiarize themselves with the appearance of knotweed in Lake District newsletter articles. Volunteers are established for resident notification of suspected plants:
Don Demulling, CLP&RD Chairman (715) 338-4460
Dan Early, Board member and AIS committee (763) 442-2666
Doug Dickson, Cedar Lake AIS volunteer (715) 410-5105

More information about this invasive plant is available in the Polk County LWRD project report, *Giant and Japanese Knotweed Control in Polk and Burnett Counties* found at http://www.co.polk.wi.us/landwater/reports.asp.

[12] Dan Early. October Cedar Lake P&R District Board Meeting.
[13] Dan Early. Email communication. 2/7/17.

Aquatic Plant Management

This section reviews, permitting requirements, existing management activities, and presents aquatic plant management goals and strategies for Cedar Lake. The potential available aquatic plant management methods are found in Appendix A.

Permitting Requirements

The Department of Natural Resources regulates the removal of aquatic plants when chemicals are used, when plants are removed mechanically, and when plants are removed manually from an area greater than 30 feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin. This includes granular herbicides available through mail order and internet purchase. A Department of Agriculture, Trade, and Consumer Protection pesticide applicator certification (aquatic nuisance control category) may be required to apply chemicals in the water.

The requirements for manual and mechanical plant removal are described in NR 109 – Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations. A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants (with the exception of wild rice) from his/her shoreline limited to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal means the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.[14]

[14] More information regarding DNR permit requirements and aquatic plant management contacts is found on the DNR web site www.dnr.wi.gov.

Eurasian Water Milfoil Management

Eurasian water milfoil is an invasive, submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Eurasian water milfoil grows best in mucky sediments. It has a history of becoming dominant in nutrient-rich lakes, although this pattern is not universal. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, Eurasian water milfoil is adapted for rapid growth early in spring and can form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in single-species stands. These stands of Eurasian milfoil provide only a single habitat and can disrupt predator-prey relationships by fencing out larger fish and reduce the number of nutrient-rich native plants available for waterfowl.

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms in infested lakes. [15]

Eurasian water milfoil might be confused with a number of other submersed plants, including other water milfoils. Northern water milfoil (present in Cedar Lake) has fewer than 12 leaf segments on each side of the leaf axis, whereas Eurasian water-milfoil has 14 or more leaf segments on each side of the leaf axis. Northern water milfoil has somewhat stouter stems than Eurasian water-milfoil. Hybrids of Eurasian and northern water milfoil are also found in Wisconsin Lakes. Like pure Eurasian water milfoil, EWM-NWM hybrids grow very quickly and can choke waterways, hampering boat access, fish passage, and water supply intakes.

Figure 16. Eurasian Water Milfoil

[15] Taken from WDNR, 2014 http://dnr.wi.gov/topic/Invasives/fact/EurasianWatermilfoil.html

Discovery and Monitoring

Eurasian water milfoil was first discovered in Cedar Lake in June 26, 2015. It was found during an aquatic invasive species survey conducted by Lake District consultant Steve Schieffer from Ecological Integrity Service. The Department of Natural Resources followed up with a full lake plant survey and lake perimeter aquatic invasive species survey on Monday, June 30th. Steve completed a follow-up survey and mapped the areas of dense Eurasian water milfoil growth on Wednesday, July 1. Eurasian water milfoil growth appears to be limited to the south end of the lake, except one sprig was found and removed near the north landing.

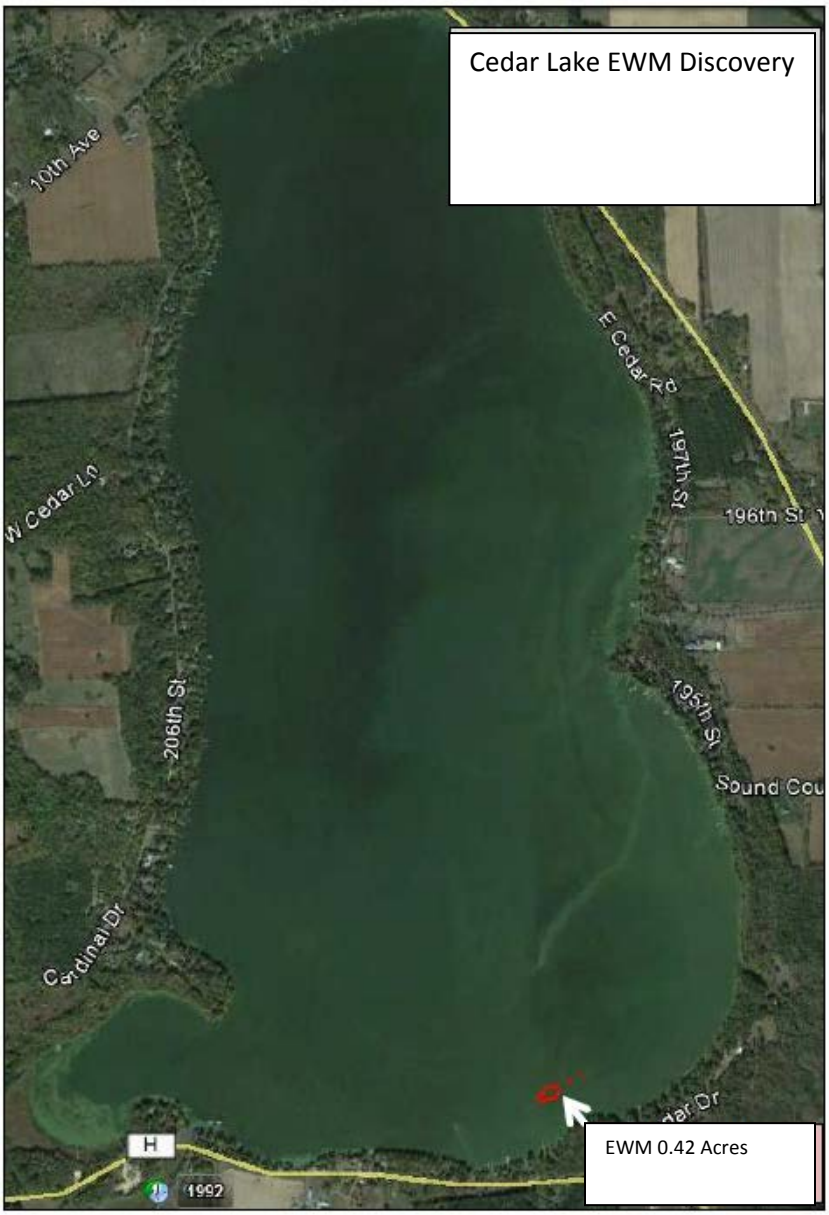


Figure 17. Initial Cedar Lake Eurasian Water Milfoil Discovery June 2015

Eurasian Water Milfoil Control

Eurasian Water Milfoil (EWM) management continues in Cedar Lake after its initial discovery in June 2015. An area of dense EWM growth was sprayed with an aquatic formulation of 2,4-D in early July of 2015 and again in May of 2016. In 2015 a high percentage of EWM was killed with limited damage to native plants. The treatment was repeated in 2016 with less success: more EWM remained after the herbicide treatment. (Schieffer 2016) (S. Schieffer 2015)

Herbicides can dissipate off of a small treatment site very rapidly, and the small treatment bed size likely limited effectiveness. The strategy used in 2015 was repeated because it worked relatively well in 2016.

Table 9. Cedar Lake EWM Treatment

	Acres Treated (4 ppm of DMA 4)	Mean Depth (ft.)	Water Temp. (F)	Pre-Treatment Frequency	Post-Treatment Frequency	Post-Treatment Density
July 2015	3.0	4.6	76 degrees	81.2%	20.3%	0.22
May 2016	2.4	4.75	60 degrees	51.4%	45.9%	0.68

No statistically significant reduction in native plant species was found in the 2016 post-treatment survey according to a chi square analysis (p value < 0.05), and there was an increase in many native species. Appendix B includes the 2016 Herbicide Treatment Analysis with a description of monitoring methods and more detailed pre and post treatment monitoring results.

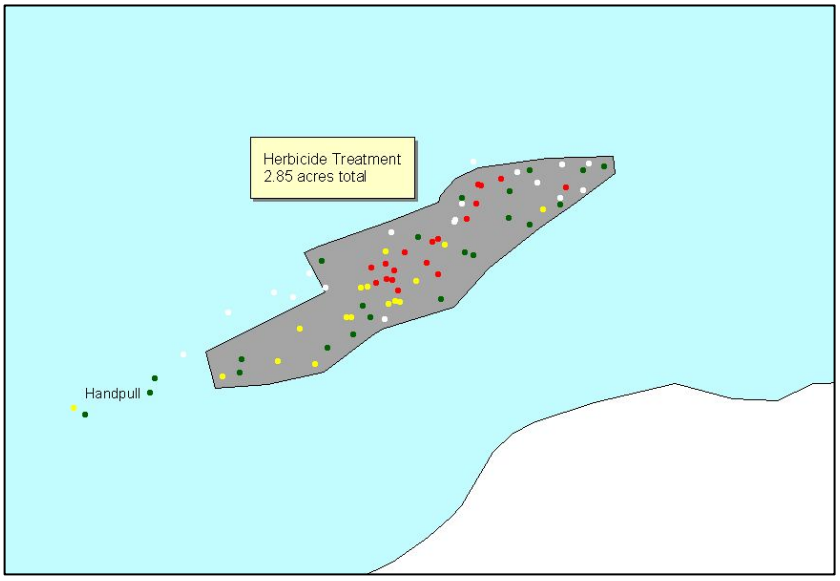


Figure 18. Eurasian Water Milfoil Treatment Area 2015

Hand pulling with SCUBA divers was planned for early August 2015. Unfortunately, poor water clarity made it impossible to see well enough to locate and pull plants. Water clarity was only a bit better in 2016, but divers were able to pull some scattered EWM by hand. Divers removed a total of 9 ft^3 of EWM in 2016. Further evaluation of EWM coverage in August and September 2016 was not possible because of on-going poor water clarity.

Figure 19. Divers pulled 2 garbage pails of EWM from the lake on July 5th, 2016

Figure 20. EWM Hand Removal Sites 2016

Alternatives and Recommendations

Herbicide Treatment

Early season herbicide treatments are planned to target EWM and avoid damage to native aquatic plants. By treating in the spring when water temperatures range between 50 and 60 degrees F, an EWM treatment can occur before there is much native plant growth. The ultimate goal is not only to eradicate the EWM , but to replace EWM with native plants,.

2,4-D

The liquid aquatic formulation of 2,4-D at a target concentration of 4 ppm was used in 2015 and 2016. Treatment was later in 2015 because EWM was discovered in late June of that year. This chemical is intended to target dicot plants such as EWM. Many native plants are monocots which are typically not affected or are less affected by 2,4-D. However, 2,4-D is a systemic herbicide. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides because they must move through the plant. Rapid dissipation with small treatment areas can limit the effectiveness of systemic herbicides. A containment barrier such as a sediment curtain might be used to slow the dissipation of herbicide.

Diquat and/or Endothall

A combination Diqiat/Endothall herbicide treatment using the maximum label application rate was used in 2017. Because Diquat and Endothall are broad spectrum herbicide, an early season treatment that occurs before native plant growth is imperative to avoid damage to native plants. Diquat and Endothall are contact herbicides with more rapid action than 2, 4-D, a systemic herbicide. However, the trade-off is that it will kill plants it contacts for an (unknown) minimum contact time. Because of potential impact to native plants, the more selective 2-4-D will be used if there is some native plant growth below 60 degrees F.

Hand Pulling with Divers

Diver removal can be an effective tool in small areas of EWM growth where herbicide use cannot be justified or within the treatment areas to remove EWM that remains after herbicide treatment. In Cedar Lake the timing for diving is important as the water clarity can change very quickly. If diver removal is used, it should occur before early July to ensure the water clarity allows for viewing EWM underwater. The diver removal should be directed by a professional. If volunteers are utilized, they need to be trained so that only EWM is removed. The planned Cedar Lake alum treatment is expected to increase water clarity and extend the time available for hand pulling and monitoring.

DASH (Diver Assisted Suction Harvesting)

A DASH trial could be considered for Cedar Lake if plants remain following herbicide treatment or as a substitute for a spring herbicide treatment. It would be useful to compare the cost-effectiveness of DASH compared with hand pulling with SCUBA divers. A recent contractor cost estimate for 2017 was $2,500/day. EWM removal rates will vary with area and density of plant growth.

Targeted Level of Control

- Contain EWM growth to the SW side of Cedar Lake where it was originally discovered in 2015.

- Seek >80% removal efficiency with each control measure.

- Use multiple control measures in sequence to reach 90% observed seasonal removal (i.e., no visible EWM remaining). This standard is dependent upon good water clarity for plant visibility. Hand removal methods may be repeated up to twice within a single year.

- Control measures result in no statistically significant (p value for the chi square < 0.05)[16] decline in native plant frequency.

Ongoing Monitoring

Regular monitoring is critical to an effective invasive species control program. Pre and post monitoring should be conducted for any areas where control measures are implemented. Meandering surveys of the littoral zone should be used to identify potential spread of the target invasive species. For effective long-term control, monitoring must continue indefinitely once target control is initially achieved.

Herbicide Treatment Pre and Post Monitoring

Standard methods are available from the WDNR. These methods must be used with any herbicide treatment.

Late season monitoring will occur following treatment measures. Late season monitoring will be timed to be as late in the growing season as water clarity will allow. Water clarity improvement is anticipated with a planned 2017 alum treatment. Frequency of EWM and rake density (if present) will be recorded within EWM treatment area. Locations of EWM plants outside of control areas will be recorded with GPS points. Plants will be hand pulled following or during the late season survey where feasible.

Hand Pulling (SCUBA and DASH) Pre and Post Monitoring

Standardized monitoring methods are not available from the WDNR. They will be used if they become available.

Proposed monitoring method:

a. A sampling grid will be established over the area of past and present EWM growth (2015-2017)
b. Pre-treatment: A point intercept survey will be taken across this grid. Presence and absence will be recorded. Rake density will be recorded for both EWM and native plants.
c. Post-treatment: A point intercept will be conducted across the grid. Rake density will be recorded for both EWM and native plants.

[16] Standard DNR pre and post treatment statistical spreadsheets will be used. A p value for the chi square <0.05 means there is only a 5% probability that the difference before and after treatment is due to chance.

AIS Meandering Surveys

An AIS meandering survey includes the entire littoral zone with special attention in high traffic areas, near landings, and in high nutrient bays/points. AIS are looked from the water surface and using underwater view scopes. Occasional rake samples are taken.

Preventing Invasive Species

There are five major elements the Cedar Lake P&R District and others can consider to prevent invasive species: education to lake users, Clean Boats Clean Waters program, landing surveillance cameras, lake monitoring, and a rapid response strategy for any new invasive species.

Education to Lake Users

Education efforts focus on identification and prevention of new invasive species. Activities might include aquatic invasive species (AIS) information presented at annual meetings and workshops, signage at the public landings and private boat launch areas, lake maps and brochures with AIS messages, and web site and newsletter information.

Clean Boats Clean Waters (CBCW) Program

Clean Boats Clean Waters educators provide boaters with information on the threat posed by Eurasian Milfoil and other invasive species. They offer tips on how to keep boats, trailers, and equipment free of aquatic hitchhikers. They also collect information on boater behavior, concerns, and knowledge of existing local and state laws related to anti-AIS measures. Staff were hired by the Beaver Creek Reserve on behalf of the Cedar Lake District from 2009 – 2013. Student staffers were also hired directly by the Lake District. The Lake District began managing the Clean Boats, Clean Waters Program on its own beginning in 2014. A WDNR Clean Boats, Clean Waters grant can currently provide 75% funding as long as a minimum of 200 hours are covered at the landings.

Landing Surveillance Cameras

Some lake organizations use video cameras at public landings to record landing activity. Videos are reviewed, and if watercraft are launched with vegetation attached, action is taken. Violations of the ordinance and state rule which prohibits transporting and launching boats and trailers with vegetation attached can be enforced by local law enforcement officers. The camera also serves as a reminder for boaters to check their equipment. Surveillance cameras are in place at nearby Bass Lake in St. Croix County and Church Pine Lake in Polk County. WDNR AIS Education, Prevention and Planning grants can be used to support camera installation (up to $4,000 in grant funds for each). Maintenance and video/photo review are not grant-eligible expenses.

Boat Washing/Decontamination

A boat decontamination unit was trialed in August 2016. The trial was a partnership between the Cedar Lake Protection and Rehabilitation District, the Polk County Land and Water Resources Department, and the Wisconsin Department of Natural Resource.

The Wisconsin Department of Natural Resources Water Guard staffed the unit and cleaned boats at risk for spreading AIS. Cedar Lake P&R District volunteers and staff were also present at the landing that day. The Cedar Lake P&R District could consider requesting the WDNR water guard decontamination unit again or purchasing its own equipment for decontamination.

Lake Monitoring

The objective of lake monitoring is to look for new invasive species. Monitoring for invasive species is generally focused around boat landings and other areas of high public use. Trained volunteers or consultants may complete the monitoring. Divers may be used. It is critical to complete aquatic invasive species visual surveys when algae growth is low and visibility is good.

Rapid Response for New Invasive Species

The activity is intended to control any new invasive species that are found in the lake. Rapid response protocols include the following:

- monitoring for invasive species
- education of lake residents and visitors
- contacts to confirm invasive species identification
- procedures for notification for new invasive species found
- plans for removal and control
- funding contingencies and grants.

Invasive species information is available on the DNR website http:/dnr.wi.gov/invasives.

A rapid response plan is included as Appendix C.

Lake Management Activities

A range of management activities are available to address water quality and habitat concerns. Categories for consideration include the following:

- Information and Education
- Incentives
- Conservation Practices
- Land Preservation
- Enforcement/Land Use Planning
- Lake Studies/Evaluation
- In-Lake Management

Potential lake management activities are described in more detail in Appendix D.

Choosing Management Options

To choose from the many management options that are available, it is important to do the following:

- Set clear goals and objectives
- Understand potential results
- Prioritize activities
- Consider social and political feasibility
- Investigate funding possibilities
- Seek available assistance

The goals, objectives, and action items in the implementation plan seek to incorporate the above considerations.

Public Survey Results

A single question in the 2013 public survey asked lake residents what they thought about a list of eighteen activities. For each activity, residents were asked if the Lake District should pursue an activity. The responses ranged from definitely no = 0 to definitely yes = 4. The most positive responses are reported below. A full list of responses is shown in Appendix A of the 2014 Lake Management Plan.

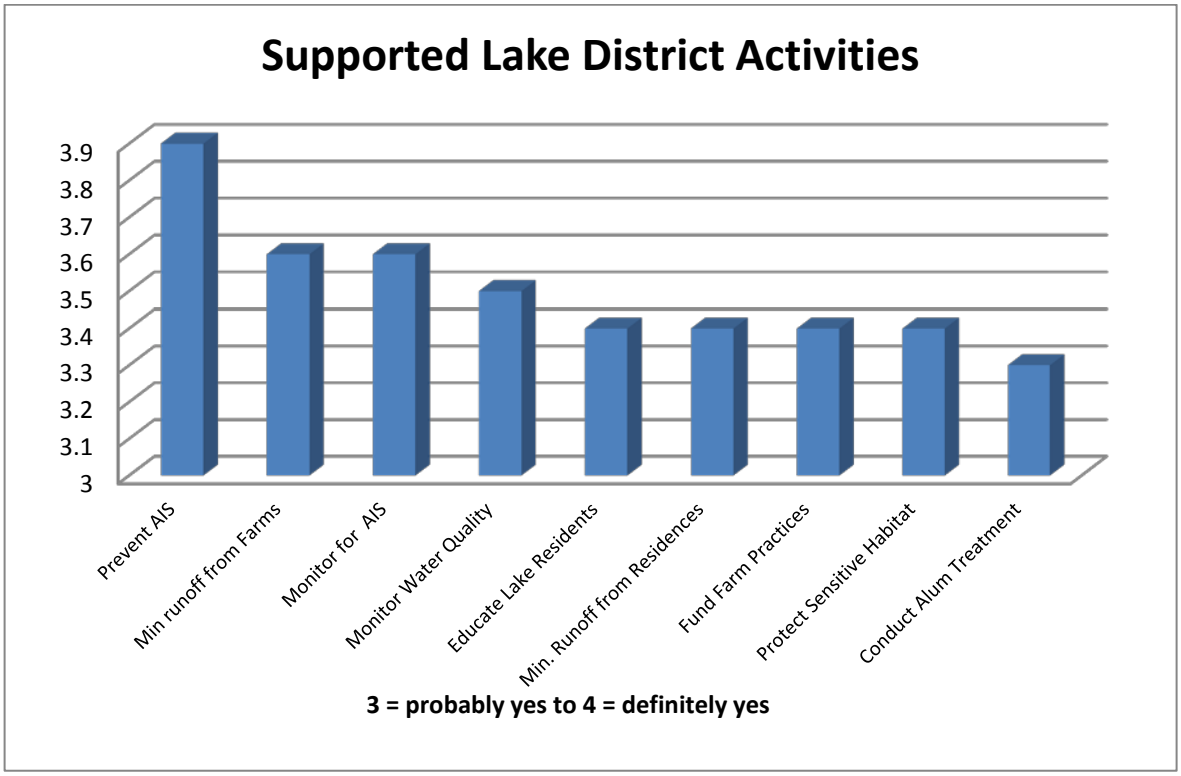


Figure 21. Survey Response: Should the Lake District Pursue These Activities?

Information, Education, and Citizen Engagement

Providing information and educating lake residents, visitors, and policymakers is an important component of any lake management program. In the end, these efforts seek to change behavior and engage everyone in lake management efforts.

Information can be distributed using a variety of methods including:

- Web site
- Newsletters
- Signs
- Newspapers
- Workshops and training sessions
- Packets of information for new homeowners
- Notebooks with pertinent information
- Brochures
- Social media
- Email distribution

There is an abundance of printed and web information to help explain lake ecology and management methods. The University of Wisconsin Extension (http://learningstore.uwex.edu) and the Wisconsin Department of Natural Resources (http://dnr.wi.gov/lakes/publications) have many resources available. The Cedar Lake P&R District can also develop informational materials specific to Cedar Lake and implementation of the Cedar Lake Management Plan.

An informed, motivated, and engaged lake community is critical to achieving all of the lake management goals.

Information Distribution

Distributing information can increase knowledge. A key consideration is that sometimes people have the knowledge of lake concerns, but still don't make desired behavioral changes. It is important to identify the specific behaviors to be changed and the barriers to those behavioral changes, then to design programs that overcome these barriers. For example, concerns about native vegetation blocking views to water where children are swimming can be a barrier to planting native vegetation next to the water. To address this concern, information about shoreland native plantings can emphasize planting lower growing plants and maintaining viewing corridors so the waterfront is still visible. Surveys and focus groups can be used to identify barriers and methods to overcome barriers.

Incentives

Incentives are frequently provided along with information and education to encourage behavior changes. Examples of incentives include payments, tax credits, and recognition. The Burnett County Shoreland Incentive Program uses cost sharing, an annual property tax rebate, participation shirts and hats, and shoreline signs as incentives to encourage participation. Enrollment in the program involves signing a perpetual covenant to restore and maintain a shoreland buffer on a waterfront property in Burnett County. Recognition of volunteer efforts can encourage ongoing involvement.

Citizen Engagement and Participation

The Lake District board is made up entirely of citizen volunteers with considerable responsibilities. Advisory committees for the update of the lake management plan and development of the alum special assessment are recent examples of citizen engagement for Cedar Lake. The volunteer AIS Monitoring Team will seek to expand this engagement to more lake residents.

Efforts Underway

The Cedar Lake District has a website at http://www.cedarlake-wi.org/. Board Secretary, Dan Davison manages the website.

A newsletter is distributed twice each year, generally in January and July. The newsletter is professionally produced and printed. Signs and a display board (new board in 2017) are present at the north landing. Information is distributed and presentations are made at the annual meeting each August.

Implementation Plan

Advisory Committee Recommendations

The advisory committee examined consultant and advisor recommendations and analyzed available information to make recommendations regarding strategies to meet lake plan goals. Potential management activities and their impacts were considered in the development of the recommendations that follow. Management actions were chosen by the original advisory committee in 2013. The alum strategy was updated in 2017. Strategies for AIS prevention and EWM and knotweed control were developed with assistance from the advisory committee in 2017.

Water Quality Recommendations

A two-pronged approach is recommended for improving water quality in the lakes. External loading to Cedar Lake is already low for an agricultural watershed. Further reductions of external load are important for improving localized lake characteristics and for maintaining effectiveness of internal load management. However, it is recognized that significant water clarity improvement will not occur without reducing the phosphorus load from lake sediments – the internal load. It is valid to assume that a high reduction in internal loading will cause the biggest, quickest change. It would not be prudent to ignore the external loading because reducing the external load will increase the longevity of internal load reductions.

Plan Timeframe

This plan covers a ten year time frame (2017 – 2026). As new knowledge is acquired and events unfold, it will be updated as appropriate.

Adaptive Management and Implementation Plan

An implementation plan is found in the following section. The implementation plan or work plan details how action steps will be carried out over the next two year period. Monitoring results and new information will influence and may change the actions used to reach lake plan goals. The implementation plan will be updated annually in June to keep actions and budgets current.

Funding Plan Implementation

Grant Sources

The DNR Lake Management Grant Program has two main types of lake management grants: planning and lake protection grants. Lake planning grants are available at two scales – large scale up to $25,000 and small scale up to $3,000. Applications are due each year on December 10th. DNR lake protection grants for plan implementation have a maximum grant amount of $200,000. These grants are due each year by February 1st. Plan activities that fit the lake protection grant program will be eligible for lake protection grant funds following approval by the DNR. The WDNR approved the 2014 Cedar Lake Management Plan in January 2015.

The Department of Natural Resources also manages Targeted Runoff Management (TRM) grants for urban and agricultural practices as described in the state runoff rule: NR151. Cities, villages,

towns, counties, regional planning commissions, tribal governments, and special purpose districts such as lake, sewerage, and sanitary districts are eligible to apply for TRM grants.

DNR Lake Planning Grants (up to 67% state share)

Large scale – up to $25,000
Small scale – up to $3,000

Applications due December 10th
These grant applications could proceed without final plan approval.

DNR Lake Protection Grants (up to 75% state share)

Up to $200,000
Requires DNR approval of tasks in the comprehensive plan (allow 60 days)

Applications due February 1st

DNR Targeted Runoff Management (up to 70% state share)

Small Scale: Up to $150,000 (only land purchase and structural practices)
Large Scale: Typically $500,000 to $1 million (cropping practices and staffing costs also eligible)
Agricultural activities in this plan may be eligible. Projects must address state agricultural performance standards.

Application due April 15th

Current Cedar Lake P&R District Grants

Alum Treatment

Costs for the alum treatment over the next ten years are expected to be more than $2 million. An additional treatment with a cost of over $500,000 is expected beyond this time period. Grants will be sought to pay for the alum treatment and other program costs. WDNR grants secured for the initial 2017 alum treatment include the following:
Lake Protection Grant (LPT-476-15.1) $200,000 – 75% state share
Targeted Runoff Management Grant (TMD03010LY16) $165,311 – 70% state share
Lake Planning Grants (Alum Monitoring) (LPL161917 and LPL162017) $50,000 – 67% state share

Grants from the Wisconsin Department of Natural Resources (the most likely funding source) are available on a reimbursement basis. This means that money must be borrowed for the alum treatment up front.

Eurasian Water Milfoil Rapid Response

The WDNR Eurasian Water Milfoil Rapid Response grant provides funding for monitoring, control efforts including herbicide application and hand pulling with SCUBA divers, and the development of an aquatic plant management plan.

Rapid Response Grant (AIRR-191-16) $19,852.50 – 75% state share

Clean Boats, Clean Waters

The WDNR currently provides 75% funding for Clean Boats, Clean Waters programs as long as a minimum of 200 hours of coverage is provided at one or both Cedar Lake landings. The current grant will provide up to $4,000 with 75% state funding.

Special Assessment for Alum Treatment

The special assessment for the alum treatment is described in previous pages. The assessment is in place from 2017-2026. It assesses Lake District properties based on benefits to each parcel including size and proximity to the lake. The special assessment will collect approximately $169,000 each year beginning in 2018.

Cedar Lake Management Implementation Plan

Planning Timeframe – 2017 - 2026

The Vision for Cedar Lake in the Year 2030

Cedar Lake is a healthy lake that provides clear water, excellent aquatic and nearshore fish and wildlife habitat, and quality recreation.

The Cedar Lake Management Plan guides an active Protection and Rehabilitation District Board and a broad range of partners.

Lake and watershed residents and lake visitors practice good lake and watershed management.

GOALS, OBJECTIVES, and ACTIONS

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Objective A. Prevent the introduction of non-native, invasive species not yet found in Cedar Lake.

Actions

1. Carry out educational activities to reach residents and visitors to the lake.
    - Use existing resources when available.
    - See Goal 7 Educational Strategy.

2. Continue a Clean Boats, Clean Waters Program at the North Boat Landing.
    - Seek annual WDNR grant funding for the CBCW program.
    - Add hours at the private landing at Jackelen's as staff is available.

3. Pursue the use of landing surveillance cameras for the North Boat Landing.

Objective B. Identify introduction of invasive species as soon as possible and understand extent of existing invasive species in the lake.

Actions

1. Monitor the lake for aquatic invasive species in areas of high public use.
    - Use professional and volunteer monitoring.
    - Establish a volunteer monitoring program for Cedar Lake.

2. Annually update the Rapid Response Protocol for newly introduced invasive species.
    - See Appendix C.

EURASIAN WATER MILFOIL MANAGEMENT

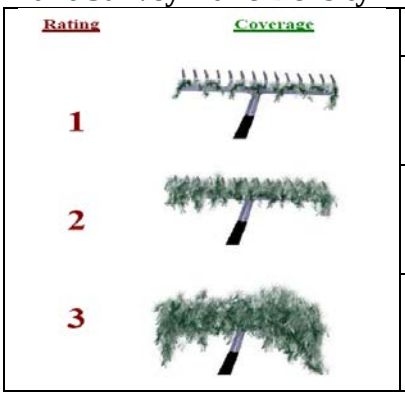
Objective C1. Contain EWM growth to the SE side of Cedar Lake where it was originally discovered in 2015.

Objective C2. In areas where EWM grows (within EWM sampling grid), EWM mean rake density is <1.

Objective C3. Control measures result in no statistically significant decline in native plant frequency of occurrence (within treatment area, in EWM sampling grid, and throughout Cedar Lake).

- Seek >80% reduction in frequency of occurrence with each control measure.
- Use multiple control measures in sequence to reach 90% observed seasonal reduction in frequency of occurrence of EWM. This standard is dependent upon good water clarity for plant visibility.

Plant Survey Rake Density



Rake Fullness Rating	Criteria
1	Plant present, occupies less than ½ of tine space
2	Plant present, occupies more than ½ tine space
3	Plant present, occupies all or more than tine space

EWM Rapid Response Containment (Years 2015-2018)

Actions

1. <u>Herbicide Treatment (expected in mid to late May)</u>
   - Complete pre-treatment survey
   - Delineate treatment area based on presence of EWM
   - Use early season (water temps range between 55 and 60 degrees F) herbicide treatment to target EWM and avoid damage to native aquatic plants.
   - Herbicide: Diquat or Diquat/Endothall combination (or 2,4-D if native plants present) at application rate suitable to meet required contact time.
   - Maximize contact time by applying when wind is <10 mph (2017 bid document conditions) or preferably <5 mph day of treatment (use for 2018)
   - Investigate additional measures to maximize contact time (2018) such as containment curtains. (Cost estimate for entire area = $10-$15,000) Consider multiple containment zones to minimize cost of curtain.

2. Post-Treatment Monitoring will assess frequency of occurrence and density of all aquatic plant species within herbicide treatment area (expected in early to mid-June). Compare to pre-treatment and previous years' monitoring results.

3. Volunteer AIS Monitoring Team will monitor in zones around the lake. Report findings to monitoring consultant.

4. Meandering Survey will look for EWM outside of treatment area to target hand pulling (coordinate with Post Treatment Monitoring).

5. Hand pulling with SCUBA or DASH (July (1st removal) and August (2nd removal)):
   Following herbicide post treatment, hand pull remaining EWM plants.
   If >1/2 acre remaining with a mean rake density of 1 or more, seek contracted DASH removal.
   If <1/2 acre with EWM growth, remove with SCUBA.

6. Measurement: Divers will measure removed EWM volume in known sized containers. An established standard of mass/volume will be used to complete a mass calculation to quantify wet EWM mass removed.

7. Repeat Meandering Survey to prepare for potential second hand pulling event.

8. Post Hand Pulling Monitoring (late-August to early September) will assess effectiveness of hand removal and outline potential herbicide treatment beds for 2018.

Monitoring/Evaluation Methods

Consultant Pre and Post-Monitoring is completed to guide any chemical treatment. Standard WDNR methods will be followed. Volunteer monitoring may be considered in the future for chemical treatment if qualified monitors are available.

Volunteer AIS Monitoring Team

- Establish monitoring zones, emphasizing areas where professional monitoring occurs less frequently.
- Recruit volunteers from around the lake by zones.
- Provide training to identify, describe likely habitat, and describe reporting protocol for (suspected) EWM findings.
- Distribute equipment and supplies to volunteers (rakes, bags, ID information).
- EWM findings reported to Monitoring Consultant to coordinate with Meandering Survey results and hand-pulling efforts.

AIS Meandering Survey (June and August – prior to each hand removal action)

An AIS meandering survey includes the entire littoral zone with special attention near areas where EWM was previously identified, in high traffic areas, near landings, and in high nutrient bays/points. AIS are looked for from the water surface and using underwater view scopes. Occasional rake samples are taken. Monitoring Consulting will complete.

SCUBA and DASH (Hand Pulling Pre and Post-Monitoring)
Standardized monitoring methods are not available from the WDNR. They will be used if they become available. Monitoring Consultant will complete.

Proposed monitoring method:

d. A sampling grid will be established over the area of past and present EWM growth (2015-2017).
e. Pre-treatment: A point intercept survey will be taken across this grid. Presence and absence will be recorded. Rake density will be recorded for both EWM and native plants.
f. Post-treatment: A point intercept will be conducted across the grid. Rake density will be recorded for both EWM and native plants.

Point Intercept Surveys
WDNR will conduct point intercept aquatic plant surveys at least every 3-5 years. The aquatic plant survey was last conducted in 2015. Because of the alum treatment, another point intercept survey is planned for 2017.

If a whole lake treatment is conducted, point intercept surveys would be required by the WDNR for one season pre-treatment and two seasons post-treatment. A whole lake treatment is defined as a treatment in which the concentration of herbicide after complete dissipation will impact aquatic plants lake wide, based on the most recent herbicide residual/plant data.

EWM Long Term Management (2019-2021)

Herbicide Treatment
Thresholds:
Bed size: 5 acres or greater
EWM frequency of occurrence: at least 20%
Mean rake density: at least 1.5

Early season herbicide treatment to be used as described for EWM Containment Strategy. Adaptive management will allow for changes to strategy based on lessons learned at Cedar Lake and other lakes.

Hand removal methods (SCUBA or DASH) will substitute for or follow herbicide treatment. Method chosen will be according to standards described in Containment Strategy or as adapted based on lessons learned.

Monitoring and Evaluation
As described in Containment Strategy.

Objective D. Control terrestrial invasive species in the shoreland zone.

JAPANESE AND GIANT KNOTWEED MANAGEMENT

Objective: Limit the growth and spread of Japanese and giant knotweed around Cedar Lake.

Actions

1. Continue liaison with Polk Burnett Electric Cooperative to encourage control of knotweed along the utility right of way on the west side of Cedar Lake.
    a. Polk Burnett monitors and maintains right-of-way every 3 years (upcoming in 2017 and 2020).

2. Provide direction to lake residents to discourage knotweed establishment and control existing knotweed.
    a. Mow before the third week of June
    b. Mow repeatedly to avoid seed development and maturation
    c. Herbicide treatment occurs in late fall, recommended chemicals may require a licensed applicator
    d. Seek additional guidance from Polk County LWRD

Monitoring/Evaluation
Encourage resident reporting to track growth of knotweed around the lake.
Identify responsible person to maintain knotweed records.

Goal 2. Achieve and maintain clear water throughout the summer.

Objective A. Achieve and maintain a summer[17] and annual total phosphorus mean of less than 40 ug/L.

EXPECTED RESULTS[18]
Following Alum Treatments only
Annual TP= 33ug/L[19]
Following Alum Treatments and 30% Reduction in Watershed P loading
Annual TP = 25 ug/L

It is difficult to predict water quality results in lakes for a given time period, because there is so much variation in rainfall, temperature, wind, and natural systems. Following completion of full alum treatment dose alone, the following results are predicted:

[17] To achieve removal of the lake from the impaired waters list, measurements will be reviewed from June 1 to September 15.
[18] Results from James 2013.
[19] Empirical models predict annual mean phosphorus concentrations. Summer mean phosphorus concentrations are expected to be even lower.

- Water clarity will increase from an average summer[9] Secchi depth of 6.5 feet to 13 feet.
- The frequency of nuisance summer algae blooms (i.e., 30 ug/L) will decrease from 44% of the time to 7% of the time.
- The presence of toxin-producing algae blooms will be minimized. For example, chlorophyll concentrations >50 ug/L will be reduced from 17% of the summer to 1% of the summer.

Objective B. Decrease the internal phosphorus load from lake sediments by 90 percent or more.

Action[20]

*** 1. Conduct an alum treatment according to the updated treatment strategy.
   - Application rate of 130g Al/m2 at depths greater than 25 feet and 100g Al/m^2 at depths between 20 and 25 feet.
   - Apply alum in mid-June to maximize initial absorption of phosphorus to alum and maintain more effective binding sites.
   - Split the alum dose to 4 to 5 application periods with the initial 1/5 dose applied in 2017.
   - Monitor sediment Al and mobile P fractions following each alum application according to the monitoring plan in Appendix G.

[20] High priority actions are indicated with ***. Medium high priority actions are indicated with **.

Objective C. Decrease watershed phosphorus loading by 30 percent.

Actions

** 1. Support the Horse Creek Farmer-Led Council to carry out recommended activities.
- Recognize their efforts
- Partner on activities when possible
- Support incentives for practices the council administers

2. Promote county, state, and federal cost sharing for best management practices.
- Polk County Land and Water Resources Department activities outlined for the Implementation Plan for the Lake St. Croix TMDL are shown in the implementation chart for Goal 2.

Recommended agricultural watershed activities (Wojchik 2017)
- Continue crop field data collection. More data is needed over a longer period of time.
- Compare modeled data with edge-of-field monitoring data to verify model estimates.
- Better understand delivery of dissolved vs. particulate phosphorus.
- Emphasize more complete nutrient management plans and planning. Implement plans!
- Inform agricultural community of elevated soil test levels in the main drainage and work to lower them slightly to optimum levels (18-35 ppm).
- Promote cover crop establishment on cropland acres suitable for cover crop establishment.

** 3. Encourage residential best management practices.
- Provide how-to information to install best management practices including shoreland restoration and runoff management.
- Use soil test results to discuss phosphorus use.
- Consider lake resident-led incentive program and small scale cost sharing.

Actions considered but not selected for initial implementation. These actions may be added during the plan implementation period.
- Design and cost share assistance

Monitoring/Evaluation[21]

- Hydrology and tributary phosphorus loading
- In-Lake Monitoring: Secchi transparency, Total Phosphorus, Chla (bi-weekly, from beginning of May to end of October)
- Sediment phosphorus concentrations and release rates
- Monitor carp population to assess potential impact on water quality.

Goal 3. Maintain a high quality sport fishery in Cedar Lake.

Objectives[22]

A. Improve and support fish habitat.
B. Meet species-specific management objectives.

Actions

1. Use effective regulations to improve game and pan fish populations/size structure.
** 2. Complete fish habitat improvement projects.
3. Stock musky in alternate years

Monitoring/Evaluation

4. Maintain Cedar Lake as a "Trend Monitoring" lake with fish population monitoring every four years.
5. Conduct a creel survey to assess the results of pan fish habitat improvement actions and angler walleye harvest. (Approval for survey is through DNR's treaty assessment team.)

[21] Monitoring details provided in Appendix G.
[22] High priority actions are indicated with ***. Medium high priority actions are indicated with **.

Cedar Lake Detailed Fisheries Recommendations

Walleye Management

- Maintain a high quality walleye fishery with at least 2 adults per acre.
- Maintain safe harvest levels.
  - Change walleye bag limits as needed to adjust for treaty harvest.
- Evaluate the effectiveness of the walleye slot size limit implemented in 2008 with electrofishing in 2017 and 2021.

Musky Management

- Provide a low density, high quality, trophy musky fishery.
  - Alternate year stocking of 1,000 large fingerling
  - Monitor every four years

Northern Pike Management

- Maintain a low density, high quality, self-sustaining population.
- Promote musky over northern pike.

Pan Fish Management

- Improve pan fish populations through habitat enhancement and regulations.
- Complete creel survey in 2017 to evaluate the effectiveness of a 2004 bag limit reduction and the 2004-2013 installation of fish cribs.

Goal 4. Protect and improve near shore habitat both in the water and on the land.

Actions

*** 1. Encourage restoration of near shore (shoreline) habitat.
2. Provide education about the importance of maintaining vegetation on the land and in the water.
3. Encourage installation of woody habitat/fish sticks and leaving trees that fall in the water (for low energy sites not impacted by ice push).
4. Establish demonstration sites to showcase nearshore habitat improvements.
5. Protect existing high quality shoreline habitat through land purchase, donation, or conservation easements.

Goal 5. Balance recreational uses so that residents and lake users can enjoy the natural benefits Cedar Lake provides.

Objective. Lake users follow existing state and local regulations.

Objective. Participants with varied recreational interests are respectful of other users and residents.

Objective. Lake recreation occurs without negative impact to the lake environment.

Objective. Prevent re-suspension of bottom sediments from boating.

Actions

1. Institute slow no-wake at north landing
2. Encourage enforcement of existing regulations

***3. Education (signs, web, brochures) [23]

4. Improve parking at north landing
5. Engage lake users

Goal 6. Carry out the Cedar Lake Management Plan effectively and efficiently with a cooperative spirit.

Objective. Support and strengthen the leadership of the Cedar Lake P&R District.

Objective. Build and support partnerships.

Objective. Lake residents are informed about plan activities.

Objective. Select cost effective implementation actions.

Actions

1. Support board with education and recruitment
    - Education methods
        - Conferences
        - Lake Leadership participation
        - Encourage use of available resources (people, print, and web)
    - Recruitment
        - Establish board expectations

***2. Outreach to lake residents
    - Education methods
        - Welcome packet
        - Newsletters
        - Committees
        - Annual plan update meeting

3. Engage youth

[23] High priority actions are indicated with ***. Medium high priority actions are indicated with **.

Goal 7. Encourage and engage lake residents and visitors to be active lake stewards.

The education and engagement strategies that follow relate back to other plan goals 1 through 6.

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Volunteer Aquatic Invasive Species Monitoring Team

A volunteer monitoring team is being established to assist the Eurasian water milfoil management program and identify potential new AIS in the lake. Volunteers will be designated throughout the lake – especially where EWM has not yet been found. Early detection allows for more effective control efforts.

Education to Lake Owners

Education efforts focus on prevention and identification invasive species. Methods will include aquatic invasive species (AIS) information presented at annual meetings and workshops, signage at the public landings and private boat launch area, and web site and newsletter information. Electronic communication methods such as an email list serve and Facebook account will also be pursued.

Clean Boats Clean Waters (CBCW) Program

Clean Boats Clean Waters educators provide boaters with information on the threat posed by Eurasian water milfoil, zebra mussels, and other invasive species. They offer tips on how to keep boats, trailers, and equipment free of aquatic hitchhikers. They also collect information on boater behavior, concerns, and knowledge of existing local and state laws related to anti-AIS measures. The District hires both adult and student staffers.

Objective: An active volunteer AIS monitoring program is developed and sustained.

Desired Behavior Change

Cedar Lake residents participate in AIS monitoring – especially with the AIS Monitoring Team

Barriers to Change

Lack of awareness

No one has asked them to participate

Methods to Encourage Participation

Designate Team Leaders and tasks

Recruit volunteers

- Look to neighbors (everyone on committee ask 3 or 4 people)
- Network at restaurants and other businesses
- Use publicity (event/demo, newsletter, website, postcard, Facebook, establish email list serve, Cedar Creek neighbors)
- Provide adequate training

The volunteer monitoring team will seek support for training from other lake leaders with experience (Bone Lake), Polk County, and the Wisconsin Department of Natural Resources.

Provide recognition (T-shirts, picnics – use east side park)

Objective: Lake visitors take appropriate action to prevent introduction of aquatic invasive species.

Desired Behavior Change

1. Inspect boats, trailers, and equipment; remove vegetation; and drain live wells upon entering and when leaving the lake
2. Don't transport invasive species
3. Avoid EWM area when boating

Barriers to Change

- Boaters are in a hurry
- Lack of awareness
- Don't care enough about the lake
- Don't think it is important
- People cannot identify invasive species

Messages to Address Barriers

- Clean your boats, trailers, and other equipment.
- Polk County and the state of Wisconsin have regulations that make it illegal to transport aquatic plants on public roads.
- Notify Clean Boats, Clean Waters staff if you suspect you found an invasive species.
- Don't introduce invasive species from ponds or aquaria. Do not purchase invasive species from landscapers, nurseries, or the internet.
-

Methods to Deliver

- On-on-one contact with CBCW staff
- Printed information distribution (through CBCW)
- Signs at landings
- Landing cameras

Objective: Lake residents follow lake district guidance for AIS management and take appropriate action to prevent, identify, and report aquatic invasive species.

Desired Behaviors

1. Understand AIS concerns
2. Actively watch for and identify AIS
3. Inspect boats, trailers and equipment; remove vegetation; and drain live wells upon entering and when leaving the lake – INFORM VISITING FRIENDS
4. Avoid EWM area when boating
5. Take ownership of/responsibility for lake

Barriers to Change

- Lack of knowledge
- Apathy
- No one asked them to help
- Need to develop sense of community
- Don't think it is their problem

Messages

- Clean your boats, trailers, and other equipment
- Polk County and the state of Wisconsin have regulations that make it illegal to transport aquatic plants on public roads.
- Call AIS ID Volunteers if you suspect you found an invasive species
- Limit impacts to native aquatic plants by traveling with no wake in shallow areas, using hand removal methods near docks and swimming areas, etc.
- Identification of EWM, zebra mussels, and other AIS (include illustrations) report to Volunteer AIS ID Leads
- ID knotweed, report sightings
- Native aquatic plant values
- Don't introduce invasive species from ponds or aquaria. Do not purchase invasive species from landscapers, nurseries, or the internet.

Methods

- Facebook (need volunteer leader to establish page and distribute information)
- Recognize participation
- Lake steward welcome packet (need volunteers to establish and distribute)
- Newsletter (consider wider distribution such as at local business and to SPF&G)
- Website
- Annual meeting (presentations, hand on demonstrations)

Goal 2. Achieve and maintain clear water throughout the summer.

Objective C. Decrease watershed phosphorus loading by 30 percent.

Actions

Support the Horse Creek Farmer-Led Council to carry out recommended activities.

- Recognize their efforts.

Encourage residential best management practices.

- Provide how-to information to install best management practices including discouraging geese on the lake.

Goal 4. Protect and improve near shore habitat both in the water and on the land.

Actions

Encourage restoration of near shore (shoreline) habitat.

Provide education about the importance of maintaining vegetation on the land and in the water.

Encourage installation of woody habitat/fish sticks and leaving trees that fall in the water - for low energy sites not impacted by ice push.

Desired Behavior Change

1. Lake residents acknowledge farmer efforts for clean water
2. Allow vegetation next to the water to grow
3. Plant native vegetation
4. Install woody habitat in appropriate areas (TBD)

Barriers to Change

- Lack of understanding of farm practices and economics
- Lack of awareness of farm clean water efforts
- I like my lawn
- Want to see kids and grandkids
- Desire neatness – native plants are messy weeds
- Well cared for lawn = responsible owner

Messages to Address Barriers

- Farms in Horse Creek Watershed currently have low rates of phosphorus contribution to Cedar Lake. Further improvement is expected – 30% decrease.
- Farmers are making progress for clean water with Farmer-Led Council
- Describe phosphorus soil test results from residential lakeshore property and ways to limit phosphorus in runoff.
- Non chemical lawn care options

- Care for the lake, not your lawn
- Native plants provide the basis for in-lake and shore habitat
- Native plants can be attractive
- Natural shorelines discourage geese
- How-to restore shore information
- Use of view corridors and low-growing plants
- Wood in water benefits

Methods to Deliver

- Website – post native planting how-to information
- Newsletter
- Native Planting Incentives (3502ft^2 planting)
- Info/display at annual meeting
- Bring lake residents and farmers together to support each other.

Goal 5. Balance recreational uses so that residents and lake users can enjoy the natural benefits Cedar Lake provides.

Objective. Lake users follow existing state and local regulations.
Objective. Participants with varied recreational interests are respectful of other users and residents.
Objective. Lake recreation occurs without negative impact to the lake environment.

Actions
Education (signs, web, brochures)
Engage lake users

Desired Behavior Change

1. Boaters observe no-wake rules close to shore and to each other and within 100 ft of buoys and 500 feet of Cedar Creek outlet
2. Boaters operate under the legal alcohol limit of .08
3. Boaters are considerate of others on the lake
    a. Noise is limited
    b. Safety is observed
    c. Don't litter

Barriers to Change

- Boaters just out to have fun
- Boaters may not be aware of the rules
- Boaters may not be aware of their impact on others

Messages to Address Barriers

- Clean water will make lake use more fun for everyone
- Avoid stirring up lake sediments with your boat. Stay deep, especially with wake boats and high power motors.

- Cute kid in a canoe – don't tip me over
- Cruise in the middle – the shoreline is a slow zone
- Explain no-wake rules
- Greet your lake neighbors

Methods to Deliver
- Testimonials/stories in newsletters
- Share *Wisconsin Lake Courtesy Code* at landing (revise for Cedar Lake)
- Post no-wake regulations at landing
- Info at restaurants and other businesses

Goal 6. Carry out the Cedar Lake Management Plan effectively and efficiently with a cooperative spirit.

Objective. Lake residents are informed about plan activities.

Actions

Outreach to lake residents

Education methods

Welcome shoreland stewardship packet

Newsletters

Committees

Annual plan update meeting

Engage youth

Desired Behavior Change

Lake residents support lake management activities

Barriers to Change
- Costs of lake management
- Not aware of rationale for management decisions
- Lack of involvement

Messages to Address Barriers
- Use lake plan summary topics to understand alum treatment and plan implementation
- Break down each goal and explain what CLPRD is doing to implement
- Explain progress toward alum treatment
- Report grant applications and results
- Provide updates on lake monitoring planned and results

Methods to Deliver
- Newsletter
- Website
- Annual meeting presentations

IMPLEMENTATION CHART

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Aquatic Invasive Species Committee: Dan Early

Actions[24] a. steps	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties/ Partners[25]**	**Funding Sources**	**Board/Consultant Assignment**
Objective A. Prevent the introduction of non-native, invasive species not yet found in Cedar Lake.						
1. Educational activities See Goal 7 implementation	Ongoing			CLPRD WDNR UWEX	CLPRD DNR AIS Grant	Board
2. Clean Boats, Clean Waters	Summer	$5,000	10	CLPRD	CLPRD DNR AIS Grant	Tamara Early
a. Secure grant funding annually	December 10		4	CLPRD WDNR	DNR Aquatic Invasive Species Grants	Dan Early w/ support from consultant
b. Hire staff	February		12	CLPRD	CLPRD	Tamara Early
3. Pursue landing cameras	2018	$7,500 (install) $1,500 (monitor)	20	CLPRD	DNR AIS Grant	

[24] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.

[25] CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPF&G = Star Prairie Fish and Game

IMPLEMENTATION CHART

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Aquatic Invasive Species Committee: Dan Early

Actions[24] a. steps	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties/ Partners[25]**	**Funding Sources**	**Board/Consultant Assignment**
Objective B. Identify introduction of invasive species as soon as possible and understand extent of existing invasive species in the lake.						
1. Monitor for aquatic invasive species	Summer	(w/EWM meander survey)	10	CLPRD WDNR	CLPRD	DNR plant survey (every 3 years)
2. Update the rapid response protocol for new invasive species	June (annually)		5	CLPRD WDNR	CLPRD AIS Grant	Board
EURASIAN WATER MILFOIL MANAGEMENT **Objective C1. Contain EWM growth to the SE side of Cedar Lake where it was originally discovered in 2015.** **Objective C2. In areas where EWM grows (within EWM sampling grid), EWM mean rake density is <1.** **Objective C3. Control measures result in no statistically significant decline in native plant frequency of occurrence (within treatment area, in EWM sampling grid, and throughout Cedar Lake).**						
1. Complete herbicide treatment according to plan treatment strategy		$1,500 (coordination)			AIRR19116 (through 12/31/17) AIS Control Grant	Board Plan Consultant Coordination
a. Seek bids from qualified contractors	January	w/above				
b. Apply for APM permits	January	$145				
c. Complete pre-treatment monitoring	April/May	$675				
d. Complete treatment	May	$1,000 - $4,000	0	Herbicide Contractor		

IMPLEMENTATION CHART

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Aquatic Invasive Species Committee: Dan Early

Actions[24] a. steps	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties/ Partners[25]**	**Funding Sources**	**Board/Consultant Assignment**
e. Consider containment barrier	May	$5,000-$15,000		Monitoring/Planning Consultants		
f. Complete post treatment monitoring	June	$1,000		Monitoring Consultant		
g. Complete meandering survey (2X)	June and August	$1,000		Monitoring Consultant		
h. Follow up with hand pulling (2X)	July and August	$1,000 - $2,500/each time		Monitoring/Planning Consultants	SPF&G	
i. Post hand pulling monitoring	August	$1,000		Monitoring Consultant		
2. Establish and support volunteer AIS monitoring team	2017	$2,000	120	CLPRD AIS Team Leaders		AIS Team Leaders: Nick Rude Dennis Peterson Jim Reckinger
a. Appoint leaders	May 2017			CLPRD		Board
b. Recruit volunteers	June 2017			Team Leaders		AIS Team Leaders
c. Assign monitoring segments	June 2017			Team Leaders		AIS Team Leaders
d. Provide training	June 2017	$100		Monitoring Consultant Polk County		AIS Team Leaders

IMPLEMENTATION CHART

Goal 1. Prevent the introduction of aquatic invasive species and effectively manage those introduced into the lake.

Aquatic Invasive Species Committee: Dan Early

Actions[24] a. steps	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties/ Partners[25]**	**Funding Sources**	**Board/Consultant Assignment**
e. Distribute equipment and supplies	June 2017	$500				AIS Team Leaders
f. Report findings to Monitoring Consultant	Ongoing			Team Leaders		AIS Team Leaders
3. Complete point intercept surveys	2017 (every 3 years)	$0 (unless WDNR not available)	0	WDNR CLPRD		
Apply for AIS Control Grant	February 2018	$1,000	0	CLPRD	CLPRD	Board Consultant
Objective D. Control terrestrial invasive species in the shoreland zone. JAPANESE AND GIANT KNOTWEED						
1. Continue liaison with Polk Burnett Electric Cooperative for control in ROW	Ongoing		10	Polk County LWRD CLPRD SPF&G	DNR AIS Grant	
2. Provide direction to lake residents to prevent and control knotweed			20	CLPRD		
a. Review control efforts with Polk LWRD/Eric W.			5	Polk County LWRD CLPRD		5a. Doug Dixon =volunteer for knotweed control

IMPLEMENTATION CHART
Goal 2. Achieve and maintain clear water throughout the summer.
Objective B. Decrease internal phosphorus load from lake sediments.

Actions[26]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties Partners**[27]	**Funding Sources**	**Board/Consultant Assignment**
1. Conduct initial alum treatment	June 2017	$504,671	80	CLPRD DNR UW Stout	CLPRD Special Assessment WDNR TRM Grant WDNR LPT	CLPRD Board (rotating for alum meetings)
a. Coordinate and supervise alum treatment		$15,000 $5,000		Attorney Fees	CLPRD	Consultant Project Manager
2. Prepare for subsequent alum treatments		(Included above)				
a. Apply for TRM grant for next treatment	April 15, 2018	$1,500 (included above)		CLPRD WDNR Consultant	CLPRD	Consultant/Board
b. Apply for Lake Protection grant for next treatment	Feb 1, 2018	$1,000 (included above)		CLPRD WDNR	CLPRD	Consultant/Board
3. Seek bids for third alum treatment	December 2019				CLPRD	Consultant/Board

[26] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[27] CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

IMPLEMENTATION CHART
Goal 2. Achieve and maintain clear water throughout the summer.
Objective C. Decrease watershed phosphorus load.

Actions[28]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[29]	**Funding Sources**	**Board/Consultant Assignment**
1. Support Horse Creek Farmer Led Watershed Council a. Offer $ for incentives for BMP installation	Ongoing	$2,000 - $3,000	0	Watershed Council UWEX Polk County LWRD	DATCP CLPRD	*Farmer Led Council Committee:*
2. Promote state and federal cost sharing for agricultural best management practices	Ongoing		0	Polk County LWRD FSA NRCS	DATCP FSA NRCS	

[28] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[29]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
DATCP = Department of Agriculture, Trade, and Consumer Protection
FSA = Farm Services Agency
NRCS = Natural Resources Conservation Service

Polk County Land and Water Resources Department Best Management Practice Implementation

(from the *Addendum to the Implementation Plan for the Lake St. Croix TMDL. June 2014*)

ACTIVITY	*IMPLEMENTATION DATES*	*ESTIMATED COST*	*ESTIMATED PHOSPHORUS REDUCTION* (LBS/YR)*
Horse Creek/Cedar Lake Projects:	*2013-2020*		
*1. Incentives***		*1. $20,000*	*1. 200*
2. 5,000 acres in Nutrient Management Plans (NMPs)		*2. $280,000*	*2. 5,000*
*3. 5 BMPs***			*3. 100*
4. 1 FTE for 6 years		*3. $100,000*	*4. N/A*
		4. $528,000	

**Phosphorus reduction estimates based on 1 lb./ac for NMPs, 1 lb./shoreline restoration, 20 lbs./pond (retention or detention), and 20 lbs./BMP.*

***BMP's include barnyard runoff management, filter strips, animal waste systems, field buffers, etc.*

****Incentives include grid soil sampling, field buffers, grassed waterways, stalk nitrate testing, and nutrient management.*

IMPLEMENTATION CHART ***Goal 2. Achieve and maintain clear water throughout the summer.*** ***Objective. Decrease watershed phosphorus load.***						
Actions[22]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties[23]**	**Funding Sources**	**Board/Consultant Assignment**
3. Encourage residential best management practices a. educate lake residents (newsletter, web site, boat landing education) See Goal 7 implementation	a. 2018	$1,500 print/mail $500 (web)	20	Polk County LWRD WDNR	WDNR Lake Protection Grant	*Shoreland Buffer Committee – Warren Wood and Don Demulling*
b. Review 10X35 incentives and consider options	2018					

IMPLEMENTATION CHART
Goal 2. Achieve and maintain clear water throughout the summer.
Monitoring and evaluation

Actions[30]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[31]	**Funding Sources**	**Board/Consultant Assignment**
Monitor Secchi depth, total phosphorus, chlorophyll a, etc.	Annually	$0	80	WDNR CLPRD Citizen Lake Monitor	WDNR	Volunteers
Post-alum treatment monitoring (see Lake Plan Appendix G)	2017-2019	$28,000/year $4,200 (CLPRD match)		CLPRD DNR UW Stout	WDNR LPL Grants	Board Bill James, UW-Stout
Monitor carp populations	2017	$?	?	WDNR	WDNR	

[30] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[31] CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

IMPLEMENTATION CHART
Goal 3. Maintain a high quality sport fishery in Cedar Lake.
No activity at this time.

Actions[32]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[33]	**Funding Sources**	**Board/Consultant Assignment**
1. Use effective regulations	Ongoing	$0	20	WDNR	WDNR	
2. Fish habitat improvement projects	Ongoing	$0	40	CLPRD SPFG WDNR	WDNR SPFG	
3. Stock musky in alternate years	Alternate years	$0	0	WDNR	WDNR	
4. Maintain Cedar Lake as a trend monitoring lake	Ongoing	$0	0	WDNR	WDNR	
5. Conduct a creel survey	2017	$0	0	WDNR	WDNR	

[32] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[33]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPFG = Star Prairie Fish and Game

IMPLEMENTATION CHART
Goal 4. Protect and improve near shore habitat both in the water and on the land.
Shoreland buffer committee: Warren Wood, Don Demulling

Actions[34]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[35]	**Funding Sources**	**Board/Consultant Assignment**
1. Encourage restoration of shoreline habitat a. consider cost sharing mini-plantings Review 10X35 plantings and consider options	Ongoing a. 2018	$3,000 (2018) $2,000 consult support	40	CLPRD LWRD SPFG WDNR	CLPRD WDNR LPT LWRD SPFG	1._____
2. Provide education about the importance of habitat (newsletter, web site, handouts). See Goal 7 Implementation.	Ongoing		20	CLPRD LWRD SPFG WDNR	CLPRD WDNR LPT LWRD SPFG	
3. Encourage installation of woody habitat 3a. Review woody habitat installation and locations with DNR Fisheries	Winter	$0	20	CLPRD LWRD SPFG WDNR	CLPRD WDNR LPT LWRD SPFG	3a. Marty Engel discouraged installation but ok to let fallen trees be

[34] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[35]CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPFG = Star Prairie Fish and Game
SPLPT = Star Prairie Land Preservation Trust

IMPLEMENTATION CHART
Goal 5. Balance recreational uses so that residents and lake users can enjoy the natural benefits Cedar Lake provides.
Committee Assignment: Dan Davison

Actions[36]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[37]	**Funding Sources**	**Board Assignment**
1. Slow no-wake at the north landing	2019	$?	40	CLPRD Town of Alden WDNR		Pursue later
2. Encourage enforcement of existing regulations	Ongoing	$0	20	CLPRD WDNR Polk County St. Croix County		
3. Education (newsletter, web site, handouts). See Goal 7 Implementation	Ongoing		40	CLPRD WDNR Polk County St. Croix County	CLPRD WDNR LPT Polk County St. Croix County	
4. Improve parking at north landing	2018	$?	20	CLPRD Town of Alden WDNR	WDNR ADLP CLPRD Town of Alden	
5. Buoy and landing maintenance	Ongoing	$1,700				

[36] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[37] CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources

IMPLEMENTATION CHART
Goal 6. Carry out the Cedar Lake Management Plan effectively and efficiently with a cooperative spirit.
Public Relations, Education, Newsletter Committee: Dan Davison

Actions[38]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[39]	**Funding Sources**	**Board Assignment**
1. Support board with education/recruitment	Ongoing	$500	80	CLPRD WDNR	CLPRD WDNR LPT	
a. Identify training opportunities for board						1a._____
3. Engage youth	Ongoing	$0	40	CLPRD WNDR School Districts Youth Organizations SPLPT		
Dam Maintenance		$1,500				Assigned to: Dick Hoppe and Irv Erickson

[38] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.
[39] CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPLPT = Star Prairie Land Preservation Trust

IMPLEMENTATION CHART

Goal 7. Encourage and engage lake residents and visitors to be active lake stewards.

Actions[40]	**Timeline**	**$ Estimate (annually)**	**Vol. Hours (annually)**	**Responsible Parties**[41]	**Funding Sources**	**Board Assignment**
Website Development/Maintenance	Ongoing	$150	20	CLPRD	CLPRD	Dan Davison
Newsletter	2X/year	$1,500		CLPRD	CLPRD	Board Consultant
Maintain Landing Signs	Updated in 2017			CLPRD Town of Alden	CLPRD	Board
Printed Information Distribution	Ongoing	$500		CLPRD	AIS Grants	
Annual Meeting Presentations	July/August					Board
New Activities to Consider						
Social Media Outreach: Facebook	Establish in 2018			Volunteer Lead		
Email List Serve				Volunteer Lead		
Volunteer Recognition	Ongoing	$250		Volunteer Lead		
Welcome Packet		$500		Volunteer Lead		

[40] See previous pages for action item detail. Estimates are for annual budgets once implementation begins.

[41] CLPRD = Cedar Lake Protection and Rehabilitation District
LWRD = Land and Water Resources Department
WDNR = Wisconsin Department of Natural Resources
SPLPT = Star Prairie Land Preservation Trust

Appendix A. Aquatic Plant Management Methods

Techniques to control the growth and distribution of aquatic plants are discussed in following text. The application, location, timing, and combination of techniques must be considered carefully.

Manual Removal[42]

Manual removal involving hand pulling, cutting, or raking plants will effectively remove plants from small areas. It is likely that plant removal will need to be repeated during the growing season. The best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants that possess rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment and for private landowners who wish to remove small areas of curly leaf pondweed growth. Raking can be used to clear nuisance growth in riparian area corridors up to 30 feet wide. Recent costs for hand-pulling EWM using divers on Minocqua and Kawaguesaga Lakes in Oneida County were about $28,000 to remove an estimated <4,000 lbs.

Hand pulling requires good enough water clarity to identify plants prior to pulling. In Cedar Lake hand pulling of EWM was not an option in 2015 because of poor clarity. In 2016, SCUBA divers hand pulled some plants following the herbicide treatment. However, water clarity was very limited, and plants were difficult to find. Hand pulling with divers remains an option for Cedar Lake.

Mechanical Control

Larger-scale control efforts require more mechanization. Mechanical cutting, mechanical harvesting, diver assisted suction harvesting, and rotovating (tilling) are the most common forms of mechanical control available. Department of Natural Resources permits under Chapter NR 109 are required for mechanical plant removal.

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment, and generally cut to depths from 1 to 6 feet. A conveyor belt on the cutter head brings the clippings onboard the machine for storage. A harvester can also be used to gather dislodged, free-floating plant fragments such as from coontail or wild celery. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel.

The size, and resulting harvesting capabilities of these machines, vary greatly. As they move, harvesters cut a swath of aquatic plants that is between 4 and 20 feet wide, and can be up to 10 feet deep. The on-board storage capacity of a harvester ranges from 100 to 1,000 cubic feet (by volume) or 1 to 8 tons (by weight).

In some cases, the plants are transported to shore by the harvester itself for disposal, while in other cases, a barge is used to store and transport the plants in order to increase the efficiency of

[42] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

the cutting process. The plants are deposited on shore, where they can be transported to a local farm to be used as compost (the nutrient content of composted aquatic plants is comparable to that of cow manure) or to an upland landfill for proper disposal. Most harvesters can cut between 2 and 8 acres of aquatic vegetation per day, and the average lifetime of a mechanical harvester is 10 years.

Mechanical harvesting of aquatic plants presents both positive and negative consequences to any lake. Its results—open water and accessible boat lanes—are immediate and can be enjoyed without the restrictions on lake use which follow herbicide treatments. In addition to the human use benefits, the clearing of thick aquatic plant beds may also increase the growth and survival of some fish. By eliminating the upper canopy, harvesting reduces the shading caused by aquatic plants. The nutrients stored in the plants are also removed from the lake, and the sedimentation that would normally occur as a result of the decaying of this plant matter is prevented. Additionally, repeated treatments may result in thinner, more scattered growth.

Aside from the obvious effort and expense of harvesting aquatic plants, there are environmentally-detrimental consequences to consider. The removal of aquatic species during harvesting is non-selective. Native and invasive species alike are removed from the target area. This loss of plants results in a subsequent loss of the functions they perform, including sediment stabilization and wave absorption. Sediment suspension and shoreline erosion may therefore increase. Other organisms such as fish, reptiles, and insects are often displaced or removed from the lake in the harvesting process. This may have adverse effects on these organisms' populations as well as the lake ecosystem as a whole.

While the results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Much like mowing a lawn, harvesting must be conducted numerous times throughout the growing season. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow the invasive plant species such as Eurasian water milfoil to propagate and colonize in new, previously unaffected areas of the lake. Harvesting may also result in re-suspension of contaminated sediments and the excess nutrients they contain.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures do not make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the cost and time efficiency of the operation.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. For curly leaf pondweed, it should also be before the plants form turions (reproductive structures) to avoid spreading the turions within the lake. If the harvesting is conducted too early, the plants will not be close enough to the surface, and the cutting will not do much damage to them. If too late, turions may have formed and may be spread, and there may be too much plant matter on the surface of the lake for the harvester to cut effectively.

If the harvesting work is contracted, the equipment should be inspected before and after it enters the lake. Since contracted machines travel from lake to lake, they may carry plant fragments with them, and facilitate the spread of aquatic invasive species from one body of water to another. One must also consider prevailing winds, since cut vegetation can be blown into open areas of the lake or along shorelines. Harvesting is not recommended for Cedar Lake at this time.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on a barge or pontoon boat. The dredge hoses are from 3 to 5 inches in diameter and are handled by one diver. The hoses normally extend about 50 feet in front of the vessel. Diver dredging is especially effective against pioneering establishment of submersed invasive plant species. When a weed is discovered in a pioneering state, this methodology can be considered. To be effective, the entire plant including the subsurface portions should be removed.

Plant fragments can be formed from this type of operation. Fragmentation is not as great a problem when infestations are small. Diver dredging operations may need to be repeated to be effective. When applied toward a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates can play an important part in the effectiveness of a diver dredging operation. Soft substrates allow easy harvesting. Divers can remove the plant and root crowns with little problem. Hard substrates, however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment.

Diver Assisted Suction Harvesting (DASH)

With Diver Assisted Suction Harvesting (DASH) divers hand pull aquatic invasive plants from the lake-bed. A suction line transports removed plants to the surface. This method is probably most appropriate for relatively small and less dense areas of invasive plant growth. Poor water clarity will make it more difficult to use DASH.[43]

The Tomahawk Lake Association (TLA) developed and has used a DASH system for several years, although they call their system a hydraulic conveyor system (HCS). HCS is an automated system that removes, filters, and bags harvested EWM after it has been hand harvested from the lake bed by divers. The TLA HCS includes a floating chassis, a “jet pump” water system, a three tiered separation system, and a Hookah diver air supply system.[44] Use of the TLA HCS began in the summer of 2007. A second generation HCS began operation in 2011. Capital costs for the system are just over $25,000, and annual operating costs are about $31,000. The TLA harvested about 20,000 lbs. each year through 2014.

[43] Wisconsin Lakes Convention Presentation. 2016.

[44] Wisconsin Lakes Convention presentation, TLA Hydraulic Conveyor System. Ned Greedy, 2014.

Figure A-1. TLA Hydraulic Conveyor System (Greedy)

Because of the mechanical elements of the system, a WDNR aquatic plant management harvesting permit is required. Contracted DASH systems are available. Decontamination of the system is especially important with a contracted DASH system that moves between lakes. A DASH trial might be considered for Cedar Lake. A recent estimate for 2017 from a contractor was $2,500/day with harvesting amounts varied with total EWM acreage and density. With high density, the contractor reported removing 3,000 pounds in a single day.[45]

Rotovation involves using large underwater rototillers to remove plant roots and other plant tissue. Rotovators can reach bottom sediments to depths of 20 feet. Rotovating may significantly affect non-target organisms and water quality as bottom sediments are disturbed. However, the suspended sediments and resulting turbidity produced by rotovation settles fairly rapidly once the tiller has passed. Tilling sediments that are contaminated could possibly release toxins to the water column. If there is any potential of contaminated sediments in the area, further investigation should be performed to determine potential impacts from this type of treatment. Tillers do not operate effectively in areas with many underwater obstructions such as trees and stumps. If operations are releasing large amounts of plant material, harvesting equipment should be on hand to collect this material and transport it to shore for disposal.

Biological Control[46]

Biological control is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control counteracts the problems that occur when a species is introduced into a new region of the world without a complex or assemblage of organisms that feed directly upon it, attack its seeds or

[45] TSB Lakefront Restoration Email Communication. January 2017.
[46] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005 except as otherwise noted.

progeny through predation or parasitism, or cause severe or debilitating diseases. With the introduction of native pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

There are advantages and disadvantages to the use of biological control as part of an overall aquatic plant management program. Advantages include longer-term control relative to other technologies, lower overall costs, as well as plant-specific control. On the other hand, there are several disadvantages to consider, including very long control times of years instead of weeks, lack of available agents for particular target species, and relatively narrow environmental conditions for success.

While this theory has worked in practice for control of some nonnative aquatic plants, results have been varied (Madsen, 2000). Beetles are commonly used to control purple loosestrife populations in Wisconsin with good success. Weevils are used as an experimental control for Eurasian water milfoil once the plant is established. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, an herbivorous fish, is sometimes used to feed on pest plant populations. Grass carp introduction is not allowed in Wisconsin.

Eurasian Water Milfoil Biocontrol

A potential management method for EWM is the use of the native weevil *Euhrychiopsis lecontei*. This weevil has a larvae stage that feeds on both native milfoils and Eurasian water milfoil. The larvae tunnel into the stem causing the plant to presumably lose the ability to transport nutrients and gases. *E. lecontei* adults swim and climb from plant to plant, feeding on leaflets and stem material. After mating, the female lays an average of 1.9 eggs a day, usually 1 egg per watermilfoil apical meristem (growing tip). One female may lay hundreds of eggs in her lifetime. The eggs hatch, and the larvae first feed on the apical meristem and then mine down into the stem of the plant, consuming internal stem tissue. Weevils pupate inside the stem in the pupal chamber, a swelled cavity in the stem. Adults emerge from the pupal chamber to mate and lay eggs. In the autumn, adults travel to the shore where they over-winter on land. In the laboratory, *E. lecontei* take 20 to 30 days to complete 1 life cycle, depending on water temperatures. For complete development, weevils require about 310 degree-days with temperatures above 10 degrees C. Two to four generations per year are generally observed in the field.[47]

Since this weevil naturally occurs in many Wisconsin Lakes, its use involves the augmentation of the natural population of weevils present in the lake. This augmentation can significantly increase the population of larvae per stem of milfoil. The premise is that this increase will lead to more destruction of the plants. Weevil biocontrol may be considered for Cedar Lake in the future, especially if chemical treatment effectiveness is limited.

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[47] *Euhrychiopsis lecontei* fact sheet. Cornell University Research Ponds Facility.
< http://www.eeb.cornell.edu/ponds/weevil.htm>

Purple Loosestrife Biocontrol[48]

Biocontrol may be the most viable long term control method for purple loosestrife control. The WDNR and University of Wisconsin-Extension (UWEX), along with hundreds of citizen cooperators, have been introducing natural insect enemies of purple loosestrife, from its home in Europe to infested wetlands in the state since 1994. Careful research has shown that these insects are dependent on purple loosestrife and are not a threat to other plants. Insect releases monitored in Wisconsin and elsewhere have shown that these insects can effectively decrease purple loosestrife size and seed output, thus letting native plants reduce its numbers naturally through enhanced competition.

A suite of four different insect species has been released as biological control organisms for purple loosestrife in North America and Wisconsin. Two leaf beetle species called "Cella" beetles that feed primarily on shoots and leaves were the first control insects to be released in Wisconsin, and are the insects available from WDNR for citizens to propagate and release into their local wetlands. A root-mining weevil species and a type of flower-eating weevil have also been released and are slowly spreading naturally. The Purple Loosestrife Biocontrol Program offers cooperative support, including free equipment and starter beetles from WDNR and UWEX, to all state citizens who wish to use these insects to reduce their local purple loosestrife.

The length of time required for effective biological control of purple loosestrife in any particular wetland ranges from one to several years depending on factors such as site size and loosestrife densities. The process offers effective and environmentally sound control of the plant, not elimination, in most cases. It is also typically best done in some combination with occasional use of more traditional control methods such as digging and herbicide use. Biocontrol with beetles may be appropriate at some point in time should purple loosestrife become established around Cedar Lake.

Re-vegetation with Native Plants

Another aspect to biological control is native aquatic plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols 1991; Smart and Doyle 1995). However, in communities that have only recently been invaded by nonnative species, a propagule (seed) bank probably exists that will restore the community after nonnative plants are controlled (Madsen, Getsinger, and Turner, 1994). Re-vegetation following plant removal is probably not necessary on Cedar Lake because a healthy, diverse native plant population is present.

Physical Control[49]

In physical management, the environment of the plants is manipulated, which in turn acts upon the plants. Several physical techniques are commonly used: dredging, drawdown, benthic (lake bottom) barriers, and shading or light attenuation. Because they involve placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 WDNR permit would be required.

[48] http://dnr.wi.gov/topic/Invasives/loosestrife.html

[49] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson 1982). Lakes that are very shallow due to sedimentation tend to have excess plant growth. Dredging can form an area of the lake too deep for plants to grow, thus creating an area for open water use (Nichols 1984). By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community (Nichols 1984). Results of dredging can be very long term. However, due to the cost, environmental impacts, and the problem of disposal, dredging should not be performed for aquatic plant management alone. It is best used as a lake remediation technique.

Dredging is not suggested for Cedar Lake as part of the aquatic plant management plan.

Drawdown, or significantly decreasing lake water levels, can be used to control nuisance plant populations. With drawdown, the water body has water removed to a given depth. It is best if this depth includes the entire depth range of the target species. Drawdowns need to be at least one month long to ensure thorough drying and effective removal of target plants (Cooke 1980a). In northern areas, a drawdown in the winter that will ensure freezing of sediments is also effective. Although drawdown may be effective for control of hydrilla for one to two years (Ludlow 1995), it is most commonly applied to Eurasian water milfoil (Geiger 1983; Siver et al. 1986) and other milfoils or submersed evergreen perennials (Tarver 1980). Drawdown requires a mechanism to lower water levels. The Cedar Lake dam is a small dam with a structural height of 6 feet and a hydraulic height of 1 foot. (DNR Surface Water Data Viewer, 2014). In 2015, plants grew to a depth of 13 feet. Eurasian water milfoil grew to a depth of about 8 feet in 2015 and 2016.

Although drawdown is inexpensive and has long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the drawdown period. Lastly, species respond in very different manners to drawdown and often not in a consistent fashion (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy species, particularly annuals. While partial drawdown is a potential management option because of the dam, it would only alter lake level up to 1 foot and is not recommended for Cedar Lake at this time.

Benthic Barriers, or other bottom-covering approaches, are another physical management technique. The basic idea is that the plants are covered over with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic, and synthetic materials; sediments such as dredge sediment, sand, silt or clay; fly ash; and combinations of the above (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984). The problem with synthetic sheeting is that the gasses evolved from decomposition of plants and sediment decomposition collect under and lift the barrier (Gunnison and Barko 1992). Benthic barriers will typically kill plants under them within 1 to 2 months, after which they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler

et al. 1995). Synthetic barriers, if left in place for multi-year control, will eventually become sediment-covered and will allow colonization by plants. Benthic barriers may be best suited to small, high-intensity use areas such as docks, boat launch areas, and swimming areas. However, benthic barriers are too expensive to use over widespread areas, and they heavily affect benthic communities by removing fish and invertebrate habitat. A Department of Natural Resources permit would be required for a benthic barrier and are not recommended for Cedar Lake.

Shading or light attenuation reduces the light plants need to grow. Shading has been achieved by fertilization to produce algal growth, by application of natural or synthetic dyes, shading fabric, or covers, and by establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general, these techniques are of only limited applicability. Physical control is not currently proposed for management of aquatic plants in Cedar Lake.

Herbicide and Algaecide Treatments

Herbicides are chemicals used to kill plant tissue. Currently, no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability, or persistence in the environment (Joyce, 1991). Thus, there are a limited number of active ingredients that are assured to be safe for aquatic use (Madsen, 2000).

An important caveat is that these products are considered safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. Wisconsin Department of Natural Resources permits under Chapter NR 107 are required for herbicide application. **Aquatic herbicides must be applied only by licensed applicators.**

General descriptions of herbicide classes are included below.[50]

Contact Herbicides

Contact herbicides act quickly and are generally lethal to all plant cells that they contact. Because of this rapid action, or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants. They are generally more effective on annuals (plants that complete their life cycle in a single year). Perennial plants (plants that persist from year to year) can be defoliated by contact herbicides, but they quickly resprout from unaffected plant parts. Submersed aquatic plants that are in contact with sufficient concentrations of the herbicide in the water for long enough periods of time are affected, but regrowth occurs from unaffected plant parts, especially plant parts that are protected beneath the sediment. Because the entire plant is not killed by contact herbicides, retreatment is necessary, sometimes two or three times per year. **Endothall, diquat,** and **copper** are contact aquatic herbicides.

[50] This discussion is taken directly from: Managing Lakes and Reservoirs. North American Lake Management Society.

Systemic Herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil active herbicides, and those that are absorbed by leaves are referred to as foliar active herbicides. **2,4-D, dichlobenil, fluridone, and glyphosate** are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides because they must move within the plant. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides also generally have more selectivity than contact herbicides.

Broad Spectrum Herbicides

Broad spectrum (sometimes referred to as nonselective) herbicides are those that are used to control all or most vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad spectrum aquatic herbicide. **Diquat, endothall, and fluridone** are used as broad spectrum aquatic herbicides, but they can also be used selectively under certain circumstances.

Selective Herbicides

Selective herbicides are those that are used to control certain plants but not others. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, timing, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

Environmental Considerations

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats and otters). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect one or more of the organisms in the community that can, in turn, affect other organisms. Or, weed control operations can affect water chemistry that, in turn, affects organisms.

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[51] Chemicals commonly used in Wisconsin lakes are listed and described in Table A-1below.

[51] These descriptions are taken from Hoyer/Canfield: Aquatic Plant Management. North American Lake Management Society. 1997.

Table A-1. Herbicides Used to Manage Aquatic Plants in Wisconsin

Brand Name(s)	Chemical	Target Plants
Captain, Nautique, Cutrine Plus	Copper compounds	Free floating and filamentous algae, also coontail, curly leaf pondweed, water celery, pondweeds
Aquathol K, Hydrothal	Endothall	Curly leaf pondweed also other submergent plants: coontail, milfoil, pondweed, water celery
Reward	Diquat	Pondweeds, coontail, Eurasian water milfoil
Aquakleen, Navigate	2,4-D	Eurasian and other milfoils

Copper[52]

Copper is an essential trace element that tends to accumulate in sediments and can be toxic to aquatic life at elevated concentrations (United States Environmental Protection Agency, June 2008).

A study completed by MacDonald et al. (2000) developed consensus based numerical sediment quality guidelines for metals in freshwater ecosystems. This study provides guidelines for metals in freshwater ecosystems that reflect threshold effect concentrations (TECs, below which harmful effects are unlikely to be observed) and probable effect concentrations (PECs, above which harmful effects are likely to be observed). The consensus based TEC for copper is 31.6 mg/kg and the consensus based PEC for copper is 149 mg/kg.

2,4-D

2,4-D photodegrades on leaf surfaces after applied to leaves and is broken down by microbial degradation in water and sediments. Complete decomposition usually takes about 3 weeks in water and can be as short as 1 week. 2,4-D breaks down into naturally occurring compounds.

Recent WDNR studies contradict the above information. Under certain conditions, residual concentrations of 2,4-D above 100 ug/L may be present well past label irrigation restriction guidelines of 21 days. Degradation takes longer in some lakes:

- Oligotrophic (low-nutrient) lakes
- Low alkalinity lakes
- Lakes with no history of herbicide usage
- When water temperatures are cool. (WDNR 2011)

Granular formulations of 2,4-D and other herbicides dissipate at about the same rate as liquid formulations of herbicides (WDNR 2011).

[52] Copper background information is from the Long Lake Management Plan prepared by the Polk County Land and Water Resources Department March 2013.

Some recent studies indicate a need to consider the long-term effects of 2,4-D use. One is the effect on the endocrine system and reproduction of fat head minnows (DeQuattro, 2015). There is also some evidence that hybrid EWM can acquire resistance to 2,4-D (LaRue et al, 2013).

Diquat

When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and bound tightly to particles in the water and bottom sediments. When bound to certain types of clay particles, diquat is not biologically available. When diquat is bound to organic matter, it can be slowly degraded by microorganisms. When diquat is applied foliarly, it is degraded to some extent on the leaf surfaces by photodegradation. Because it is bound in the plant tissue, a proportion is probably degraded by microorganisms as the plant tissue decays.

Endothall

Like 2,4-D, endothall is rapidly and completely broken down into naturally occurring compounds by microorganisms. The by-products of endothall dissipation are carbon dioxide and water. Complete breakdown usually occurs in about 2 weeks in water and 1 week in bottom sediments.

Fluridone

Dissipation of fluridone from water occurs mainly by photodegradation. Metabolism by tolerant organisms and microbial breakdown also occurs. Microbial breakdown is probably the most important method of breakdown in bottom sediments. The rate of breakdown of fluridone is variable and may be related to time of application. Applications made in the fall or winter when the sun's rays are less direct and days are shorter result in longer half-lives. Fluridone usually disappears from pondwater after about 3 months but can remain up to 9 months. It may remain in bottom sediment between 4 months and 1 year.

Glyphosate

Glyphosate is not applied directly to water for weed control. However, when it does enter the water, it is bound tightly to dissolved and suspended particles and to bottom sediments and becomes inactive. Glyphosate is broken down into carbon dioxide, water, nitrogen, and phosphorus over a period of several months.

Algaecide Treatments for Filamentous Algae

Copper-based compounds are generally used to treat filamentous algae. Common chemicals used are copper sulfate and Cutrine Plus, a chelated copper algaecide.

Curly Leaf Pondweed

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies three herbicides for control of curly leaf pondweed: diquat, endothall, and fluridone. Fluridone requires exposure of 30 to 60 days making it infeasible to target a discreet area in a lake system. The other herbicides act more rapidly. Herbicide labels provide water use restriction following treatment. Diquat (Reward) has the following use restrictions: drinking water 1-3 days, swimming and fish consumption 0 days. Endothall (Aquathol K) has the following use restrictions: drinking water 7 – 25 days, swimming 0 days, fish consumption 3 days.

Early season herbicide treatment:[53]

Studies have demonstrated that curly leaf can be controlled with Aquathol K (a formulation of endothall) in 50 - 60 degree F water, and treatments of curly leaf this early in its life cycle can prevent turion formation. Since curly leaf pondweed is actively growing at these low water temperatures and many native aquatic plants are yet dormant, this early season treatment selectively targets curly leaf pondweed.

Because the dosage is at lower rates than dosage recommended on the label, a greater herbicide residence time is necessary. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration, and be rendered ineffective.[54]

Eurasian Water Milfoil

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil: complexed copper, 2,4-D, diquat, endothall, fluridone, and triclopyr. Early season treatment of Eurasian water milfoil is also recommended by the Department of Natural Resources to limit the impact on native aquatic plant populations. 2,4-D is frequently used to target EWM (a dicot) over many other native plants (monocots).

However, large-scale treatments can result in significant damage to both monocots and dicots.

- Dicots susceptible to both 2,4-D and fluridone include native watermilfoils (particularly northern), bladderworts, water lilies, and coontail.
- Monocot species such as elodea, several narrow leaf pondweeds, and naiads are also impacted by fluridone and some 2,4-D use.
- Fewer natives are affected at lower dosages. (WDNR 2011)

Wisconsin DNR research indicates that larger scale treatments seem to have more consistent reduction from herbicide use than smaller treatments. These results are based upon data collection in many Wisconsin lakes where herbicides were used for EWM control. (Nault 2015)

[53] Research in Minnesota on Control of Curly Leaf Pondweed. Minnesota Wendy Crowell, Minnesota Department of Natural Resources. Spring 2002.
[54] Personal communication, Frank Koshere. March 2005.

Herbicides can dissipate off of a small treatment site very rapidly. 2,4-D dissipated rapidly after treatment after it was applied to 98 small (0.1-10 acre) treatment areas across 22 study lakes with application rates of 2-4 ppm. The following results were found:

- Initial 2,4-D concentrations detected in the water column were well below application targets.
- Herbicide moved quickly away from treatment sites within a few hours after treatment.
- The rapid dissipation of herbicide indicates that the concentrations in target areas may be lower than what is needed for effective EWM control. (Nault 2012)

Native Plant Aquatic Plant Management

The WDNR Northern Region released an Aquatic Plant Management Strategy in the summer of 2007 to protect the important functions aquatic plants provide in lakes. As part of this strategy, the WDNR prohibited management of native aquatic plants in front of individual lake properties after 2008 unless management is designated in an approved aquatic plant management plan.[55] Permits for waterfront corridors were issued in 2008 only for formerly permitted sites where impairment of navigation and/or nuisance conditions were demonstrated. Because of the importance of the native plant population for habitat, protection against erosion, and as a guard against invasive species infestation, plant removal with herbicides as an option for individual property owners is carefully reviewed. The WDNR has not allowed removal after January 1, 2009 unless the "impairment of navigation" and/or "nuisance" conditions are clearly documented.

The WDNR recommends (and may require) that residents who wish to maintain an opening for boating and swimming use rakes or other hand methods.

[55] Aquatic Plant Management Strategy. DNR Northern Region. Summer 2007.

Appendix B. Herbicide Treatment Analysis (and hand removal)
Myriophyllum spicatum-Eurasian watermilfoil

Cedar Lake, Polk and St. Croix County Wisconsin
2016

Treatment supported by: *Wisconsin DNR and Cedar Lake P&R District*
Data collection and analysis provided by: *Ecological Integrity Service, LLC*
Amery, WI

Abstract
An herbicide application of 2,4-D (DMA4) was conducted in a 2.41-acre bed of EWM (*Myriophyllum spicatum)* on May 18, 2016 on Cedar Lake, St. Croix County Wisconsin. A post treatment survey on July 6 resulted in a frequency of occurrence of EWM of 45.9% and a mean density of 0.68 (scale of 0-3). This was an increase from an August 2015 survey (20.3%) within the same treatment area and a slight decrease from the April/May pretreatment survey which had a frequency of 51.4%. The density after the 2016 treatment was higher than the density following the 2015 treatment (0.22 vs 0.68). There was no statistically significant reduction in EWM based upon a chi-square analysis. There was no reduction in native plant species within the treatment bed. Hand pulling efforts using SCUBA removed 9ft^3 of EWM, but efforts were difficult due to low water clarity. Further evaluation of EWM coverage in August and September were nullified by reduced water clarity.

Introduction

On May 18, 2016 herbicide was applied to target the aquatic invasive species Eurasian water milfoil (EWM)- *Myriophyllum spicatum* on Cedar Lake, St. Croix County, Wisconsin. The treatment was conducted when the water temperature was 60°F with light and variable winds. The herbicide DMA-4, which is a liquid herbicide with the active ingredient 2,4-D, was utilized. This treatment covered an area of 2.41 acres and is a subsequent treatment from 2015 (3 acres) in same bed location.

This analysis is to determine the effectiveness of the herbicide treatment targeting EWM on Cedar Lake. The analysis involves a survey conducted in August 2015 following herbicide treatment, and in April 2016 before treatment and following herbicide application in July 2016.

Analysis Methods

In August, 2015 a survey was conducted following a July herbicide treatment to determine the EWM within the delineated bed and outside of the bed. Unfortunately the water clarity was poor and remained poor so determining EWM by viewing was impossible. As a result, a spring 2016 survey was also used to determine the coverage of EWM in and around the delineated bed.

The spring pretreatment survey (conducted on April 24 and follow up on May 4) utilized rake samples and a high definition underwater camera to evaluate the bed to ensure all EWM was accounted for. The end result was a 2.41 acre bed, which included at minimum, a 20 foot buffer around the nearest EWM growing within the polygon boundary. Each sample point within the polygon boundary was sampled for EWM with a 1-meter rake tow with the density rating recorded. The rake sample was used to identify all native plants at each sample location. There was no EWM observed or sampled outside of the treatment area. The applicator commented that a few EWM plants were observed just outside of the treatment boundary on the day of treatment.

The post treatment survey was conducted on July 6, 2016 and involved using the same sampling points at predetermined sample locations within the treatment polygon in the pretreatment survey. A 1-meter rake tow was used at each sample point with each species (including EWM) on the rake identified and given a density rating of 1, 2 or 3. The diagram below shows the density standards.

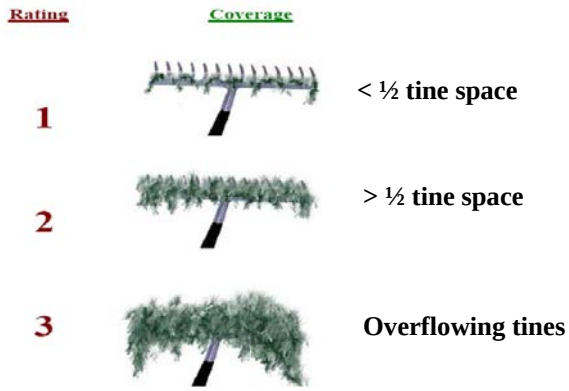

Figure 1: Density rating graphic.

After the surveys were completed, a chi-square analysis was conducted on the EWM frequency changes as well as the native plant species frequency changes. This allows for the determination of whether the herbicide treatment reduced the frequency of EWM and whether the native plant species were adversely affected by the herbicide. Typically the pretreatment survey reference is in late summer/fall the year prior to treatment. However, reduction comparison is also calculated using the spring (immediately before treatment) due to poor water clarity in summer/fall and changes in the EWM growth since August 2015. Density is difficult to assess in the spring due to small size of the new EWM plants. The spring survey was not used for density evaluation.

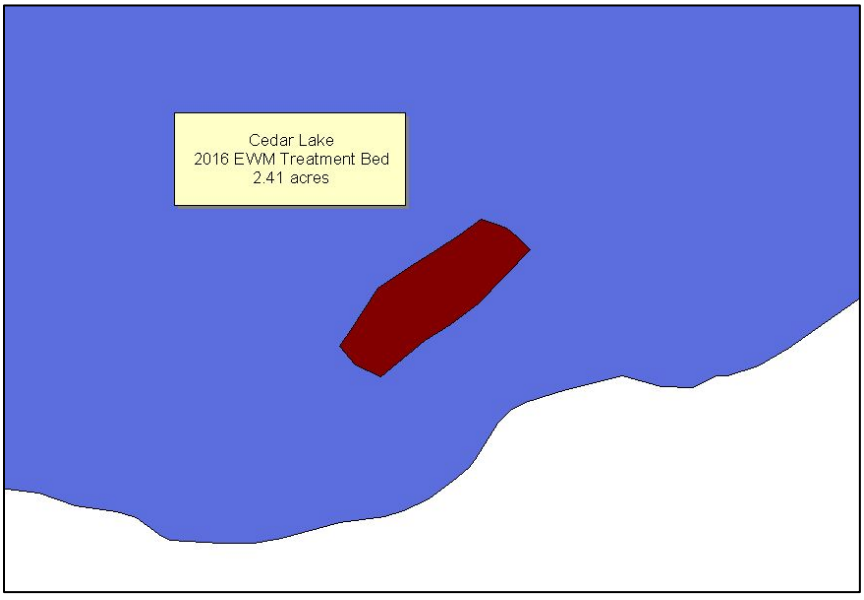

Figure 2: Map of 2016 treatment area on Cedar Lake.

Table 1 summarizes the bed characteristics, treatment and conditions during treatment.

Area (Acres)	Acre feet (from mean depth)	Target concentration	Gallons of herbicide applied	Water Temp	Wind speed
2.41	11.1 (4.6 ft)	4 ppm of DMA 4	31.5	60°F	0-2 mph variable direction

Table 1: EWM treatment bed information.

Results

The surveys conducted are represented by the maps in figures 3-5. The EWM frequency in August, 2015 was 19.4%. This frequency increased in April/May 2016 to 51.4%. After treatment, the post treatment survey frequency on July 6, 2016 was 45.9%. Table 2 summarizes the survey frequency and density data.

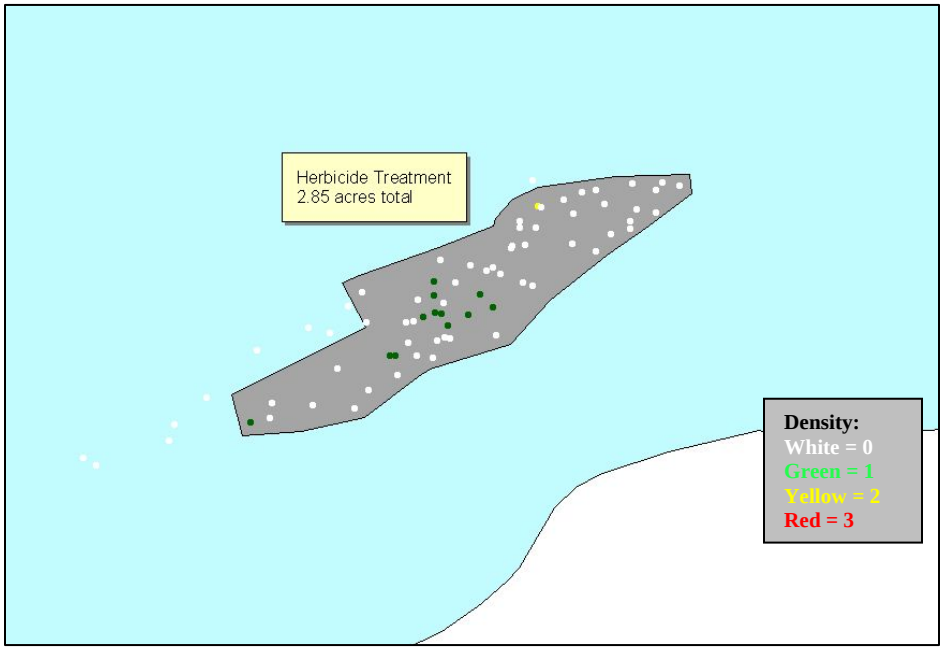

Figure 3: Map showing EWM locations (and density) within the treatment bed, August 2015.

April/May Pretreatment survey 2016

Figure 4: Map showing the EWM locations (no density) within the treatment bed, April/May 2016.

Survey	Number of EWM sampled (of 37)	EWM frequency of occurrence	Mean EWM Density
Sept. 2015	13 (of 67)	20.3%	0.22
Before treatment (May 2016)	19	51.4%	n/d
After treatment (July 2016)	17	45.9%	0.68
Change	Reduced by 2 sample points (increase from Sept. 2015)	No significant reduction in frequency before to after treatment(p=0.63) (increase from Sept. 2015)	Density increased from Sept. 2015 to July 2016.

Table 2: Summary of the frequency and density data from surveys used to evaluate treatment.

The results of the surveys show that the herbicide treatment had little effect on the reduction of the EWM. The frequency decreased slightly comparing the April 2016 (right before treatment) and the July,2016 survey (post or after treatment) but increased from August 2015 to July 2016. The density also increased from 2015 to 2016 within the treatment bed.

In 2015, the EWM was first discovered and was mostly confined to a pioneer bed. The treatment was successful, but obviously some EWM remained. Unfortunately the EWM has increased, but is still mostly confined within the original bed. Options for more successful reduction should be evaluated prior to 2017.

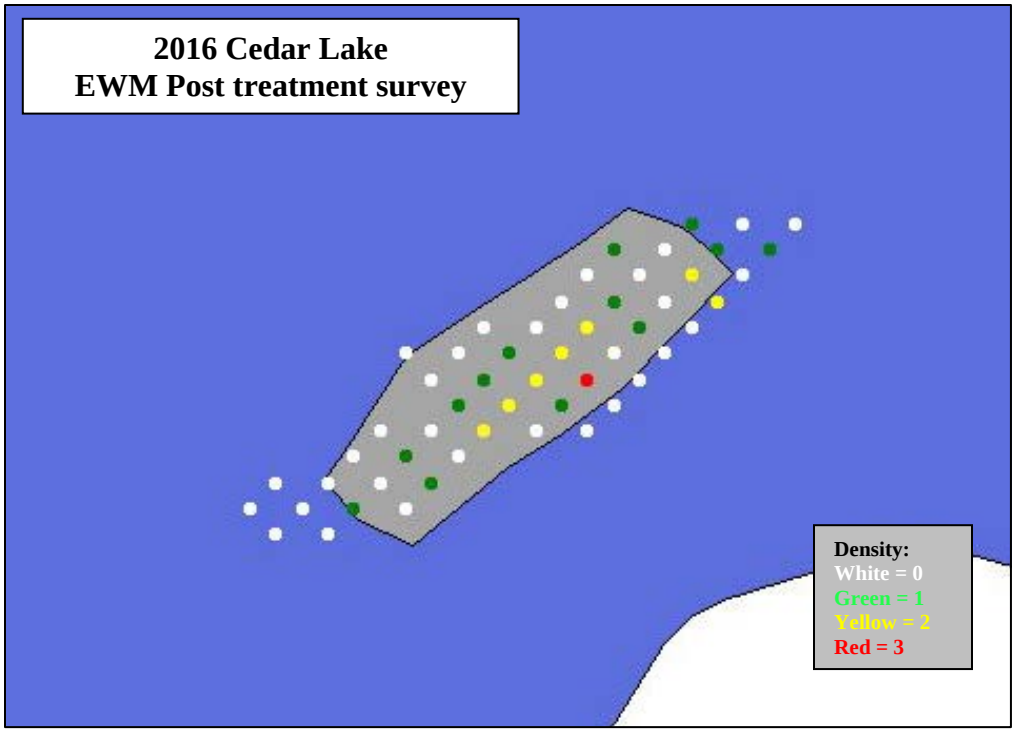

Figure 5: Map showing EWM locations and density following treatment in July 2016.

In addition to targeting and reduction the invasive species, another goal is to cause no reduction in native plant species. During the July post treatment survey, all native plants are identified and evaluated with a chi-square analysis.

Table 3 indicates that there was no statistically significant reduction in native plant species and there was an increase in many native species. This is not unusual since the herbicide had little to no effect on the EWM as well. There was some native species reduction in the 2015 treatment so it appears the native species are rebounding.

Native Species	Pre pts sampled 2015 frequency	Post pts sampled 2016 frequency	P value	Change	Significant change
Myriophyllum sibircum	0.25	0.32	0.44	+	no
Potamogeton pusillus	0.00	0.86	$5.8X10^{-20}$	+	yes
Potamogeton richardsonii	0.25	0.70	$8.5X10^{-6}$	+	yes
Potamogeton zosteriformis	0.03	0.00	0.29	-	no
Potamogeton strictifolious	0.00	0.14	0.002	+	yes
Vallisneria americana	0.57	0.86	0.002	+	yes
Potamgeton crispus	0.00	0.65	$5.6X10^{-14}$	+	yes
Ceratophyllum demersum	0.18	0.08	0.17	-	no
Elodea canadensis	0.09	0.16	0.27	+	no
Heteranthera dubia	0.04	0.03	0.65	-	no
Najas flexilis	0.01	0.03	0.67	+	no
Runnunculus aquatilis	0.01	0.00	0.46	-	no
Chara sp.	0.01	0.16	0.004	+	yes
Potamogeton praelongus	0.01	0.00	0.46	-	no
Stuckenia pectinata	0.00	0.08	0.02	+	yes
Potamogeton friesii	0.00	0.19	$2.3X10^{-4}$	+	yes

Table 3: Chi-square analysis results used to evaluate effect on native plant species.

Hand removal efforts

On June 21, the EWM was evaluated in and around the treatment bed as well as other areas of Cedar Lake, in order to locate areas to remove by hand utilizing SCUBA. The water clarity had already degraded so EWM location was difficult but some sites were identified. A follow up survey was conducted on June 28, and the water clarity was somewhat better but viewing was still difficult.

Hand pulling using SCUBA was conducted on July 5 and approximately 9 ft^3 of EWM was removed by hand. The areas that hand removal occurred are shown in figure 6.
Water clarity improved on July 6, and at this time the extent of EWM growth in the treatment bed was revealed and it was determined that the coverage was far too extensive to remove by hand. The areas outside of the treatment bed were visually evaluated and reduction in EWM coverage was evident.

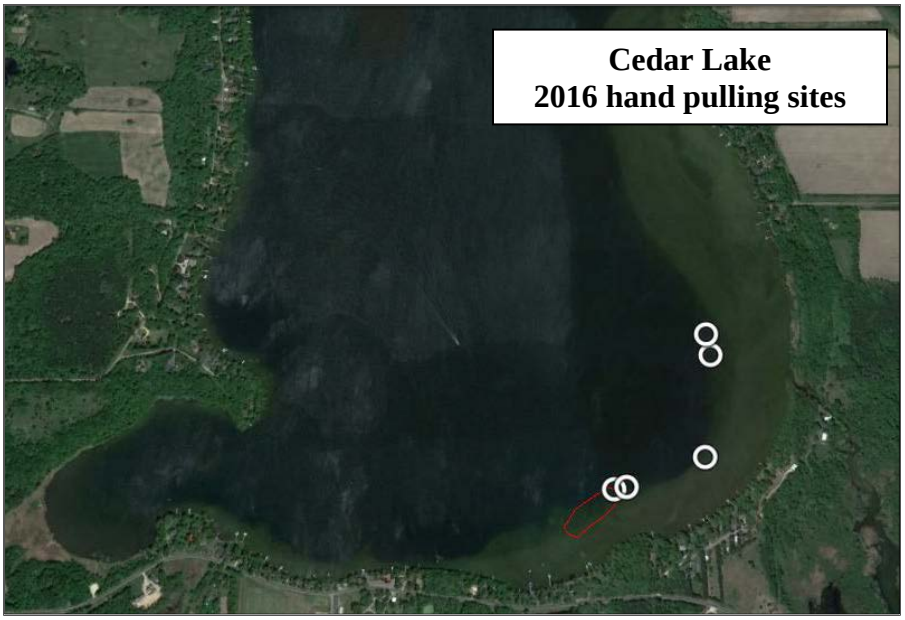

Figure 6: Locations of hand removal efforts in July 2016. The red outline is the treatment bed for location reference of EWM.

Hand removal can remain as a viable option to reduce/remove EWM in small areas in or out of an herbicide treatment bed. However, timing of water clarity and EWM growth is paramount. Hand pulling can only be effective in small, low dense areas of EWM. The larger areas and more dense areas will likely need to be reduced with herbicide application.

Potential 2017 Treatment

Two attempts were made to locate EWM outside of the treatment area in order to evaluate potential treatment outside of the original bed area. Water clarity never improved enough to evaluate with any validity. The result is no more knowledge of EWM locations after the July 6 survey. Areas will need to be checked in spring 2017, when water clarity allows a more valid evaluation. This is an optimal method to utilize; however with limited water clarity when EWM growth is best to survey, it is necessary to adjust the method.
Until further evaluation, it appears the treatment bed will need further treatment in 2017, possible expanding the coverage. The hand removal areas will also need to be evaluated for increased coverage. It is important to reduce the original bed as most EWM appears to still be confined in that location. Methods to increase herbicide efficacy should be reviewed prior to the 2017 treatment in increase degree of reduction.

References

Borman, Susan, Robert Korth and Jo Tempte. *Through the Looking Glass.* University of Wisconsin-Extension. Stevens Point, Wisconsin. 1997. 248 p.

Crow, Garrett E. and C. Barre Hellquist. *Aquatic and Wetland Plants of Northeastern North America*. The University of Wisconsin Press. Madison, Wisconsin. Volumes 1 and 2. 2000. 880p.

University of Wisconsin-Extension. *Aquatic Plant Management in Wisconsin*. April 2006 Draft. 46 p.

UW-Extension. Aquatic Plant Management website. http://www4.uwsp.edu/cnr/uwexlakes/ecology/apmguide.asp appendix d.

Appendix C. Rapid Response Protocol for Early Detection of Aquatic Invasive Species

<u>Definition: Aquatic Invasive Species (AIS)</u> are non-native plant and animal species that can out-compete and overtake native species damaging native lake habitat and sometimes creating nuisance conditions. AIS currently in Cedar Lake include Eurasian Water Milfoil (EWM), curly leaf pondweed (CLP), and rusty crayfish. Additional AIS threaten the lake and will be monitored throughout the lake by volunteers and at selected points in a periodic WNDR survey.

1. Develop and maintain a special line item within the non-lapsable fund for rapid response for invasive species (Board).

2. Establish EWM Volunteer Monitoring Team. Hold training for volunteer monitors and provide needed supplies (Board, Volunteer Monitoring Team Leads, Polk County LWRD, WDNR).

3. The Clean Boats, Clean Waters Crew will conduct monitoring at the public landing, the private landing at Jackelen's as time is available. If a suspected plant or animal is found, the staff will bag it, mark the location, and contact the Clean Boats, Clean Waters Coordinator.

4. The Monitoring Consultant will conduct AIS meandering surveys as part of regular EWM management. Special emphasis will occur near areas of EWM growth and at areas of high public use.

5. Direct lake residents and visitors to contact the Volunteer AIS ID Leads or Board Member if they see a plant or animal in the lake they suspect might be an AIS. Signs at the public boat landings, web pages, handouts at annual meeting, and newsletter articles will provide plant photos and descriptions, contact information, and instructions.

6. If a volunteer locates a likely AIS, instructions will request that the volunteer record the location of suspected AIS using GPS, if available, or mark the location with a small float. *Provide instructions on marking with float. Note that because EWM populations are of interest for management efforts, this includes EWM.*

   If suspected EWM: notify one of the AIS Monitoring Team Leads who will then notify APM Monitor Consultant.

   If a plant other than EWM:

   a. Take a digital photo of the plant in the setting where it was found (if possible). Then collect 5 to 10 intact specimens. Try to get the root system, and all leaves as well as seed heads and flowers when present. Place in a zip lock bag with no water. Place on ice and transport to refrigerator.

b. Inform Volunteer AIS ID Leads or Board Member.

If an animal other than a fish:

a. Take a digital photo of the animal in the setting where it was found (if possible). Then collect up to five specimens. Place in a jar with water; put on ice and transport to refrigerator. Transfer specimen to a jar filled with rubbing alcohol (except for Jellyfish – leave in water).

b. Inform Volunteer AIS ID Leads or Board Member.

7. A Volunteer AIS ID Lead will tentatively confirm identification of plant or animal AIS then,

   If a plant:

   a. Fill out plant incident form http://dnr.wi.gov/lakes/forms/3200-125-plantincident.pdf.
   b.
   c. Contact WDNR staff, then deliver collected plants to the WDNR (1300 West Clairemont, Eau Claire, WI 54701) as soon as possible (or to the location they specify).

   If an animal:

   a. Be sure the suspected invasive species has not been previously found on the waterbody
   b. Fill out form 3200-126 – Aquatic Invasive Animal Incident Report

8. If identification is positive:
   a. Inform the person who reported the AIS and the board (Volunteer AIS ID Leads or Board Member), who will then inform Polk County LWRD, St. Croix County LCD, and the lake management consultant.

   b. Mark the location of AIS with a more permanent marker. Special EWM buoys are available (Volunteer AIS ID Leads or Board Member).

   c. Post a notice at the public landing (DNR has these signs available) and include a notice in the next newsletter. Notices will inform residents and visitors of the approximate location of AIS and provide appropriate means to avoid its spread (Board).

9. Hire a consultant to determine the extent of the AIS introduction (Board). A diver may be used. If small amounts of AIS are found during this assessment, the consultant will be directed to identify locations with GPS points and hand pull

plants found. All plant fragments will be removed from the lake when hand pulling.

10. Select a control plan in cooperation with the WDNR (Board and Consultant). The goal of the rapid response control plan will be eradication of the AIS. Control methods may include hand pulling, use of divers to manually or mechanically remove the AIS from the lake bottom, application of herbicides, and/or other effective and approved control methods.

11. Implement the selected control plan including applying for the necessary permits. Regardless of the control plan selected, it will be implemented by persons who are qualified and experienced in the technique(s) selected.

12. Cedar Lake P&R District funds may be used to pay for any reasonable expense incurred during the implementation of the selected control plan, and implementation will not be delayed by waiting for WDNR to approve or fund a grant application.

13. The Board will work with the WDNR to confirm a start date for an Early Detection and Rapid Response AIS Control Grant as soon as possible. Thereafter, the Board shall formally apply for the grant.

14. Frequently inspect the area of the AIS to determine the effectiveness of the treatment and whether additional control measures are necessary (APM Monitor Consultant).

15. Review the procedures and responsibilities of this rapid response plan on an annual basis. Changes may be made with approval of the Board.

CONTACT INFORMATION[1]

AIS Committee Chair	Dan Early: 763-442-2666 danielearly@aol.com
Board Chair	Don Demulling: 715-338-4460 roosterd@frontiernet.net
Board Members	http://www.cedarlake-wi.org/ (contact info listed)
Clean Boats, Clean Waters Coordinator	Tamara Early: earlytamara@gmail.com

POLK COUNTY LAND AND WATER RESOURCES DEPARTMENT

AIS Coordinator	Jeremy Williamson: 715-485-8639 jeremyw@co.polk.wi.us
Director	Tim Ritten: 715-485-8631 TIMR@co.polk.wi.us

ST CROIX COUNTY LAND AND WATER RESOURCES DEPARTMENT

Director	VACANT

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Permits, AIS Identification and Notice	Scott Provost: 715-421-7881 scott.provost@Wisconsin.gov
Grants, AIS Identification and Notice	Jodi Lepsch: (715) 838-8385 Jodi.Lepsch@Wisconsin.gov

APM MONITOR

Consultant	Steve Schieffer: 715-554-1168 ecointegservice@gmail.com
AIS Monitoring Team Leads	Dennis Peterson: 715-220-5208 Nick Rude: 715-294-0271 Jim Reckinger: 651-895-3510

[1] This list will be reviewed and updated each year.

Volunteer AIS ID Leads	Dan Early: 763-442-2666 Dennis Peterson: 715-220-5208 Bob Goodlad: 715-248-7672
PLAN CONSULTANT	Cheryl Clemens: 715-268-9992 harmonyenv@amerytel.net
DIVERS	
Ecological Integrity Services	Steve Schieffer: 715-554-1168 ecointegservice@gmail.com

Appendix D. Lake Management Activities

A range of management activities are available to address water quality and habitat concerns. Categories for consideration include the following:

- Information and Education
- Incentives
- Conservation Practices
- Land Preservation
- Enforcement/Land Use Planning
- Lake Studies/Evaluation
- In-Lake Management

Information and Education

Providing information and education to lake residents, visitors, and policymakers is an important component of any lake management program. There is an abundance of printed and web information to help explain lake ecology and management methods. The University of Wisconsin Extension (http://learningstore.uwex.edu) and the Wisconsin Department of Natural Resources (http://dnr.wi.gov/lakes/publications) have many resources available. Lake organizations also develop informational materials specific to their lake and management program.

Information can be distributed using a variety of methods including:

- Packets of information for new homeowners
- Notebooks with pertinent information
- Brochures
- Web sites
- Newsletters
- Newspapers
- Workshops and training sessions

The Cedar Lake P&R District mails a newsletter to lake residents twice each year. The July edition serves as notice for the early August annual meeting where additional information is presented. The Cedar Lake web site http://www.cedarlake-wi.org/legals-reports-news/ is maintained by the board secretary.

Distributing information can certainly increase knowledge. A key consideration is that sometimes people have the knowledge of lake concerns, but still do not make desired behavioral changes. It is important to identify the specific behaviors to be changed and the barriers to those behavioral changes, then to design programs that overcome these barriers. For example, concerns about native vegetation blocking views to water where children are swimming can be a barrier to the installation of shoreland buffers. To address this concern, information about shoreland buffers can emphasize planting lower growing plants and maintaining viewing corridors so the waterfront is still visible.

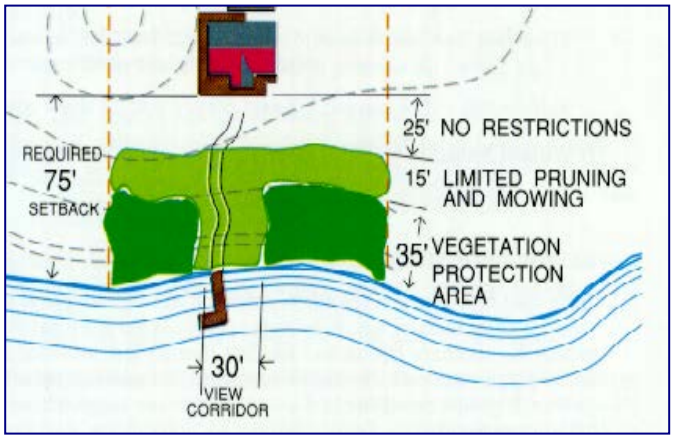

Figure C-1. Example Shoreland Buffer Diagram

Incentives

Incentives are frequently provided along with information and education to encourage behavior changes. Examples of incentives include payments, tax credits, and recognition. The Burnett County Shoreland Incentive Program uses cost sharing, an annual property tax rebate, participation shirts and hats, and shoreline signs as incentives to encourage participation. Enrollment in the program involves signing a perpetual covenant to restore and maintain a shoreland buffer on a waterfront property in Burnett County.

Conservation Practices

Conservation practices, frequently called best management practices, are installed to reduce pollutants and improve riparian habitat. For lake management, many conservation practices focus on reducing erosion, slowing water flow, and encouraging infiltration. Many times these practices use native vegetation to accomplish pollutant reduction objectives. For the most effective installation of conservation practices, the most likely participants where significant sources of pollution can be addressed are targeted.

Installation of conservation practices is likely to require some form of technical assistance. For simple practices, this assistance might be in the form of a factsheets or a guidebook. Many practices will require on-site visits with designs prepared by technicians. More complicated practices may require design by professional engineers.

Large scale practices and multiple small scale practices are likely to require significant funding for design and installation. Some lake organizations provide direct financial and technical assistance. It is more common for lake organizations to work together with a county and/or another nonprofit organization. DNR Lake Protection Grants are available for both small and large-scale practices with lake management plan approval. Because of watershed land use and pollutant load identification, conservation practices for Cedar

Lake are likely to focus on reducing runoff and pollutant loading from agricultural crop fields and/or waterfront property.

Agricultural Best Management Practices

Large-scale best management practices might involve changing tillage practices, implementing nutrient management plans, converting crop fields to a more permanent vegetative cover, restoring wetlands, and/or constructing sedimentation basins. A list of potential agricultural best management practices is included as Table C-1.

Table C-1. Selected Agricultural Best Management Practices[56]

Practice	**Description**
Conservation Tillage	Any tillage or planting system that maintains at least 30% of the soil surface covered by residue after planting to reduce soil erosion by water. Examples of conservation tillage include no-till, strip-till, or vertical-tillage.
Crop Rotation	Reduces soil erosion and nutrient applications by alternating row crops with forage crops such as alfalfa.
Cover Crops	Reduces soil erosion and improves soil tilth and structure by providing vegetative cover on fields in the fall after harvest and before spring planting.
Detention/Sedimentation Basin	Reduces the flood peak, sediment, nutrient, and contaminant loading by retaining runoff and letting soil particles and attached nutrients and contaminants settle out in the basin.
Grassed Waterways	Reduces erosion, nutrient, and contaminant loading by having runoff flow over a grassy area as it moves toward a waterbody. Soil is protected and grass helps utilize nutrients and trap contaminants.
Integrated Pest Management	Reduces pesticide applications, improves effectiveness of application, and uses more pest-resistant cultivars.
Livestock Fencing	Livestock exclusion from concentrated flow areas and other surface waters eliminates erosion and provides vegetated buffer areas to intercept nutrient laden surface runoff before it enters flow areas or surface water.
Nutrient Management Planning	Reduces nutrient loading by managing proper timing, amount, and form of fertilizer and manure application to fields.

Promoting nutrient management is recommended within the Cedar Lake watershed. Nutrient management planning helps to manage the amount, source, placement, form, and timing of the application of nutrients and soil amendments. All nutrient sources,

[56] Adapted from Managing Lakes and Reservoirs, (pg. 187) North American Lake Management Society, 2001.

including soil reserves, commercial fertilizer, manure, organic byproducts, legume crops, and crop residues are accounted for and properly utilized. These criteria are intended to minimize nutrient entry into surface water, groundwater, and atmospheric resources while maintaining and improving the physical, chemical, and biological condition of the soil.

A detention/sedimentation basin can be an effective way to treat agricultural and urban pollutants when treatment near the source is not possible. Sedimentation basins were used in nearby Deer Lake subwatersheds both to settle out sediment from farm fields and to reduce the flow rate in intermittent streams where erosion was occurring.

Figure C-2. A Sedimentation Basin in a Deer Lake Subwatershed

Funding for agricultural best management practices may be available through the Polk County Land and Water Resources Department which receives funding from the Department of Agriculture, Trade and Consumer Protection. Federal funding sources include the Farm Services Agency and Natural Resources Conservation Service. A DNR Lake Protection Grant or Targeted Runoff Management Grant may also fund some agricultural projects. Local tax revenue could also be used for agricultural projects.

Waterfront Runoff Practices

Waterfront runoff practices include rock pits or trenches, rain gardens, and shoreline buffers. It may be appropriate for Cedar Lake to consider offering design assistance and cost sharing for these practices. Nearby Deer Lake, Bone Lake, Balsam Lake, and Burnett County offer programs and education materials to encourage waterfront runoff practices. These programs could be used as examples, and educational materials developed for these programs could be used on Cedar Lake.

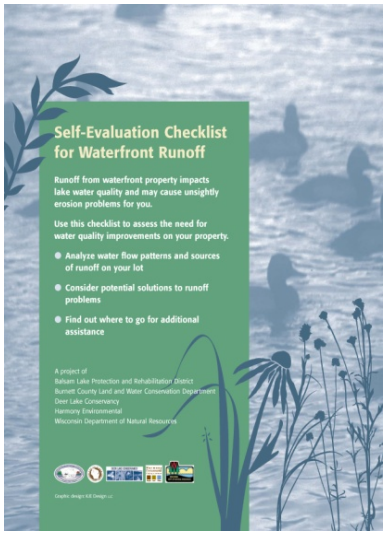

Figure C-3. A Checklist for Waterfront Runoff Evaluation

Figure C-4. Rain Gardens Collect and Infiltrate Runoff Water (photo by Steve Palmer)

The WDNR Healthy Lakes grant program provides limited funding for installation of best management practices on waterfront property.

Land Preservation

Land preservation involves purchasing land or putting land in conservation easements to preserve natural areas or to ensure that conservation practices will remain in place. A conservation easement is a voluntary legal agreement that restricts some land uses to protect important conservation values.

There are several nearby examples of land preservation donations, purchases, and conservation easements. The Cedar Lake Protection and Rehabilitation District and Star Prairie Fish and Game helped the Star Prairie Land Preservation Trust accept the donation of 63 acres of land with 1,400 feet of Cedar Lake shoreline in 2005. To ensure that conservation practices remain in place, the Deer Lake Conservancy has easements or owns land where the practices are installed. In some cases, the Deer Lake Conservancy purchased highly erodible crop lands planted to row crops and converted the fields to native prairie. The Half Moon Lake Conservancy accepted a donation of 40 acres of natural area along Harder Creek, the largest tributary flowing into the lake.

Figure C-5. McMurtrie Preserve during a Cedar Lake Winter (photo by Dan Davison)

District Involvement in Planning and Zoning

Lake District involvement in enforcement of state and local regulations and planning activities can help to protect lakes. Local regulations including shoreland zoning and plans are summarized in Appendix E. Shoreland zoning is in place within 1,000 feet of lakes and 300 feet of rivers and streams. Lake District members can report potential violations of regulations and ordinances to assist with appropriate enforcement. However, it is important to note that the Lake District cannot establish or enforce laws (except for boating laws under certain circumstances). Involvement in planning activities can help to ensure that land uses that protect the lake are in place in the watershed. Plans might be developed at the town, county, or state level.

The Cedar Lake Protection and Rehabilitation District has one seat on the board of directors for a representative appointed by the Polk County Board of Supervisors and another representative from the Town of Alden. These individuals help to bring concerns related to local planning and zoning to the Lake District board. As concerns are identified, commissioners may attend related meetings and hearings to express concerns and gather information.

Appendix E. Related Plans, Regulations, and Ordinances

Knowledge of and involvement in development and implementation of local plans and ordinances can assist the Cedar Lake Protection and Rehabilitation District in achieving the goals of this Lake Management Plan.

Polk County

Comprehensive Land Use Planning

The Polk County Comprehensive Land Use Plan was adopted in 2009. The plan includes an analysis of population, economy, housing, transportation, recreation, and land use trends. It also reports the physical features of Polk County. The purpose of the land use plan is to provide general guidance to achieve the desired future development of the county and direction for development decisions. The lakes classification outlines restriction on development according to lake features. Plan information is available online at http://www.co.polk.wi.us/landinfo.

Town, City and Village Comprehensive Plans are available at:
http://www.co.polk.wi.us/landinfo

Smart growth is a state mandated planning requirement to guide land use decisions and facilitate communication between municipalities. Wisconsin's Comprehensive Planning Law (Statute 66.1001, Wis. Stats.) was passed as part of the 1999 Budget Act. The law requires that if a local government engages in zoning, subdivision regulations, or official mapping, those local land use regulations must be consistent with that unit of local government's comprehensive plan beginning on January 1, 2010. The law defines a comprehensive plan as having at least the following nine elements:

- ✓ Issues and opportunities
- ✓ Housing
- ✓ Transportation
- ✓ Utilities and community facilities
- ✓ Agricultural, natural, and cultural resources
- ✓ Economic development
- ✓ Intergovernmental cooperation
- ✓ Land use
- ✓ Implementation
- ✓ Polk County added "Energy and Sustainability"

Polk County Comprehensive Land Use Ordinance

The Polk County Comprehensive Land Use Ordinance**,** more commonly known as the Zoning Ordinance, is currently being updated due to the passage of the Comprehensive Plan. Seventeen of Polk County's twenty four Towns have adopted county zoning, including: the Towns of Alden, Apple River, Beaver, Black Brook, Clam Falls, Clayton,

Clear Lake, Eureka, Georgetown, Johnstown, Lincoln, Lorain, Luck, McKinley, Milltown, Osceola, and West Sweden. The Towns of Farmington, Garfield, and St .Croix Falls have adopted Town Zoning and the Towns of Balsam Lake, Bone Lake, Laketown, and Sterling have no town or county zoning other than the state-mandated shoreland zoning. Land use regulations in the zoning ordinance include building height requirements, lot sizes, permitted uses, and setbacks among other provisions. The current Comprehensive Zoning Ordinance is available at:
http://www.co.polk.wi.us/landinfo

Shoreland Protection Zoning Ordinance

The State of Wisconsin's Administrative Rule NR 115 dictates that counties must regulate lands within 1,000 feet of a lake, pond or flowage and 300 feet of a river or stream. The Shoreland Protection Zoning Ordinance was recently rewritten to meet state maximum standards for shoreland protection http://www.co.polk.wi.us/landinfo

Subdivision Ordinance

The subdivision ordinance, adopted in 1996 and updated in 2017, requires a recorded certified survey map for any parcel less than 19 acres. The ordinance is available online at: http://www.co.polk.wi.us/landinfo

Animal Waste

The Polk County Manure and Water Quality Management Ordinance was revised in April 2017. A policy manual established minimum standards and specifications for animal waste storage facilities, feedlots, degraded pastures, and active livestock operations greater than 300 animal units for livestock producers regulated by the ordinances. The Land and Water Resource Department's objective was to have countywide compliance with the ordinance by 2006. The ordinance is available online at:
http://www.co.polk.wi.us/landwater

Storm Water and Erosion Control

The ordinance, passed in December 2005, establishes planning and permitting requirements for erosion control on disturbed sites greater than 3,000 square feet, where more than 400 cubic yards of material is cut or filled, or where channels are used for 300 feet more of utility installation (with some exceptions). Storm water plans and implementation of best management practices are required for subdivisions, survey plats, and roads where more than ½ acre of impervious surface will result. The Polk County Land and Water Resources Department administers the ordinance. The ordinance is a local mechanism to implement the Wisconsin Non-agricultural Runoff Performance Standards found in NR 151.

WI Non-Agricultural Performance Standards (NR 151)

Construction Sites >1 acre – must control 80% of sediment load from sites

Storm water management plans (>1 acre)
- Total Suspended Solids
- Peak Discharge Rate
- Infiltration
- Buffers around water

Developed urban areas (>1000 persons/square mile)
- Public education
- Yard waste management
- Nutrient management
- Reduction of suspended solids

Polk County Land and Water Resources Management Plan

The Polk County Land and Water Resources Management Plan describes the strategy the Land and Water Resources Department (LWRD) will employ from 2010-2018 to address agriculture and non-agriculture runoff management, stormwater discharge, shoreline management, soil conservation, invasive species and other environmental degradation that affects the natural resources of Polk County. The plan specifies how the LWRD will implement NR 151 (Runoff Management). It involves identifying critical sites, offering cost-share and other programs, identifying BMP's monitoring and evaluating projects for compliance, conducting enforcement activities, tracking progress, and providing information and education.

Polk County has local shoreland protection, zoning, subdivision, animal waste, and non-metallic mining ordinances. Enforcing these rules and assisting other agencies with programs are part of LWRD's ongoing activities. Other activities to implement the NR 151 Standards include information and education strategies, write nutrient management plans, provide technical assistance to landowners and lakeshore owners, perform lake studies, collaborate with other agencies, work on a rivers classification system, set up demonstration sites of proper BMP's, control invasive species, and revise ordinances to offer better protection of resources.

WI Agricultural Performance Standards (NR 151)

For farmers who grow agricultural crops

- Meet "T" on cropped fields
- Starting in 2005 for high priority areas such as impaired or exceptional waters, and 2008 for all other areas, follow a nutrient management plan designed to limit entry of nutrients into waters of the state

For farmers who raise, feed, or house livestock

- No direct runoff from feedlots or stored manure into state waters
- No unlimited livestock access to waters of the state where high concentrations of animals prevent the maintenance of adequate or self sustaining sod cover
- Starting in 2005 for high priority areas, and 2008 for all other areas, follow a nutrient management plan when applying or contracting to apply manure to limit entry of nutrients into waters of the state

For farmers who have or plan to build a manure storage structure

- Maintain a structure to prevent overflow, leakage, and structural failure
- Repair or upgrade a failing or leaking structure that poses an imminent health threat or violates groundwater standards
- Close a structure according to accepted standards
- Meet technical standards for a newly constructed or substantially-altered structure

For farmers with land in a water quality management area (defined as 300 feet from a stream, or 1,000 feet from a lake or areas susceptible to groundwater contamination)

- Do not stack manure in unconfined piles
- Divert clean water away from feedlots, manure storage areas, and barnyards located within this area

St. Croix County

A summary of St. Croix County ordinances from the county web site is included below.

Land Division

The Community Development Department is required to administer the Land Division ordinance in order to regulate and control subdivision development within St. Croix County. There are 2 types of land divisions - Certified Survey Maps (CSM's) - 4 lots or less and considered minor subdivisions. A major subdivision is a plat of 5 lots or more.

Sanitary Program – Private On-site Wastewater Treatment System

A State sanitary permit is required for the installation of a private on-site wastewater treatment system (POWTS) and may only be submitted by a licensed plumber. A County sanitary permit is required for the repair, reconnection, or rejuvenation of a POWTS or for the installation of non-plumbing sanitation (i.e. privy, composting toilet, etc).

A sanitary permit is required prior to obtaining a building permit from the Town. Staff will conduct at least one inspection for all work requiring a sanitary permit.

The proper maintenance of a POWT's is essential to ensure the longevity of your private sewage system and to avoid premature failure. When obtaining a sanitary permit you are required to submit a signed agreement indicating that as the property owner, you will maintain your septic system properly and report this maintenance to the Community Development Office.

Zoning

Special Exception permits are required for a use that is listed as a "Special Exception" within a zoning district. A list of possible special exceptions are included in the St. Croix County Zoning Ordinance under each Zoning District. A special exception request is reviewed by the Board of Adjustment. It is strongly recommended the applicant meet with staff to discuss the request before an application is submitted. Applications are due the first Monday of the month.

Variances allow development that is inconsistent with the dimensional standards contained in the ordinance, variances cannot be issued to approve uses that are inconsistent with the ordinance. The Board of Adjustment is authorized by statute to grant variances to the strict terms of the Land Use Ordinance only when certain criteria exist. It is the applicant's responsibility to prove that those criteria exist at the site and that a variance can be granted. Staff should be contacted if you believe you have a valid request for a variance. Applications are due the first Monday of every month.

Non-Metallic Mining

Non-metallic mining is part of the Special Exception permit process, but it has its own St. Croix County Ordinance, Chapter 14 Non-metallic mining. A Non-metallic Mining Supplemental Information Sheet is helpful in filling out the permit application.

Enforcement

When a violation of the Land Use Ordinance is discovered, staff will take all possible measures to rectify the problem. Individuals who feel that a violation of a Land Use Ordinance exists may file a complaint. Submit as much supporting evidence (i.e. photos, documents, etc.) as possible in support of the complaint.

Please be advised that under Wisconsin's Public Records Law, Wis. Stats. §19.31, et al., the complaint and supporting evidence will be available for public review upon request. Only in an exceptional case may access be denied.

Town of Alden

The Town of Alden regulates land divisions and driveways. Go to Town of Alden for more information.

Town of Star Prairie

The Town of Star Prairie regulates building permits and subdivisions. Go to Town of Star Prairie for more information.

Boating Regulations

The Department of Natural Resources regulates boating in the state of Wisconsin.[57] Wisconsin conservation wardens enforce boating regulations. A few highlights of boating regulations are found below.

- ✓ Personal watercrafts (PWCs) may not operate from sunset to sunrise.
- ✓ PWC operators must be at least 12 years old.
- ✓ There are 100-foot restrictions between boats or PWCs and water skiers, towropes, and boats towing skiers.
- ✓ It is unlawful to operate within 100 feet of shore or of any dock, raft, pier, or buoyed restricted area at a speed in excess of "slow-no-wake." Boats have specific lighting requirements after dark.
- ✓ Speed must be reasonable and prudent under existing conditions to avoid colliding with any object or person.

A town or village may delegate the authority to adopt lake use regulations to a lake district. These may include regulation of boating equipment, use, or operation; aircraft; and travel on ice-bound lakes.[58] Local ordinances may now extend the slow-no-wake zone to within 200 feet of shore with passage of WI Act 31.

[57] Boating regulations may be found online at www.dnr.wi.us/org/es/enforcement/docs/boating regs.pdf.
[58] Chapter 33. Wisconsin State Statutes.

Dredging Regulations (Sec 30.20 Wis. Stats.)[59]

A general permit or an individual permit is required to dredge material from the bed of a navigable waterway. Local zoning permits and U.S. Army Corps of Engineers permits may also be required.

[59] Information from http://dnr.wi.gov.org/water/fhp/waterway/dredging.

Appendix F. Works Cited and Additional References

Works Cited

Cahow, Jim and Craig Roessler. *Horse Creek Priority Watershed Water Resources Appraisal Report.* Wisconsin Department of Natural Resources, 1999.

Dekkeboom. "First Report of Spring Viremia of Carp Virus (SVCV) in Wild Common Carp in North America." *Journal of Aquatic Animal Health*, 2004: 16: 169-178.

Engel, Marty. *Cedar Lake St. Croix County Fisheries Information Sheet.* Wisconsin Department of Natural Resources, 2009.

Engel, Marty. *Cedar Lake St. Croix County Fisheries Information Sheet.* Wisconsin Department of Natural Resources, 2009.

Garrison, Paul. *Cedar Lake, Polk County Sediment Core Results.* Wisconsin Department of Natural Resources, 2002.

Horse Creek Priority Watershed Nonpoint Source Pollution Management Plan. Wisconsin Department of Natural Resources, 2001.

James, William F. *Phosphorus Budget and Management Strategies for Cedar Lake, WI.* University of Wisconsin Stout, 2013.

King, D. Whitney and Douglas P. Laliberte. "Analysis of the effects of Gloeotrichia echinulata on Great Pond and Long Pond, Maine." 2005.

Konkel, Deb. *Changes in the Aquatic Plant Community of Cedar Lake 1988-2000 and Sensitive Area Designation. St. Croix County, WI.* Wisconsin Department of Natural Resources, 2003.

Konkel et. al. *Designation of Sensitive Areas in Cedar Lake, St. Croix County.* Wisconsin Department of Natural Resources, 2003.

Lepsch, Jody. *Aquatic Plant Community Of Cedar Lake St. Croix County, Wisconsin 2012.* Wisconsin Department of Natural Resources, March 2013.
Managing Lakes and Reservoirs. North American Lake Management Society, 2001.

McComas, Steve. *Evaluating Influence of Carp on Aquatic Plants and Benthic Invertebrates Using Carp Exclosures in Cedar Lake, Polk and St. Croix Counties, WI.* Blue Water Science, 1998.

Panuska and Lillie. *Phosphorus Loadings from Wisconsin Watersehds: Recommended Phosphorus Export Coefficients for Agricultural and Forested Watersheds.* Research Management Findings, 1995.

Polk County Land and Water Resources Department. *Horse Creek Priority Watershed Final Report.*, 2009

Sorge, Buzz and Marty Engel. *Cedar Lake Management Plan.* Wisconsin Department of Natural Resources, May 1989.

St. Croix Basin Implementation Committee. *Addendum to the Implementation Plan for the Lake St. Croix Nutrient Total Maximum Daily Load*. June 2014.

The St. Croix/Red Cedar River Basin Farmer-Led Watershed Council Project. May 2014.

WDNR. "Order of the Department of Natural Resources." 1987.

WDNR. "Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM(for Clean Water Section 305(b), 314, and 303(d) Integrated Reporting." EGAD #3200-2013-01, 2013.

Wisconsin Department of Health and Family Services, *http://dhs.wisconsin.gov/eh/bluegreenalgae.* 2009.

Wisconsin Department of Health and Family Services. Division of Public Health. *Cyanobacteria and Human Health*, June 2004.

Wisconsin Department of Natural Resources *Alum Treatments to Control Phosphorus in Lakes*, 2003.

Wojchik, Erik. *Horse Creek Watershed Soil Fertility and Phosphorus Index Assessment.* Polk County Land and Water Resources Department, 2013.

Additional References

Caraco, Deb and Ted Brown. *Managing Phosphorus Inputs Into Lakes II. Crafting an Accurate Phosphorus Budget for Your Lake*. Urban Lake Management. p. 782-790.

Cooke, Dennis G., Lombardo Paola, & Brandt Christina. 2001. *Shallow Successful Management Alternatives: Determining Successful Management Alternatives*. Lakeline.

DeQuattro, Zachary A. and William H. Karasov. *Impacts of 2,4-D Aquatic Herbicide Formulations on Reproduction and Development of the Fathead Minnow* (*Pimephales promelas*). Environmental Toxicology and Chemistry. 2015.

LaRue, Elizebeth A., Mathew P. Zuellig, Michael D. Netherland, Mark A. Heilman, and Ryan A. Thum. *Hybrid watermilfoil lineages are more invasive and less sensitive to a commonly used herbicide than their exotic parent (Myriophyllum sibiricum).* Evolutionary Applications. ISSN 1752-4571. Blackwell Publishing Ltd. 2012.

Leith, Katherine McArthur, 1998. *Estimating Tributary Phosphorus Loads Using Flow Weighted Composite Storm Sampling.* Master of Science Thesis. Virginia Polytechnical Institute and State University.

Lin, Jeff P. 2004. *Review of Published Export Coefficient and Event Mean Concentration (EMC) Data.*

Nault, Michelle and Susan Knight, Scott Van Egeren, Eddie Heath, John Skogerboe, Martha Barton, Scott Provost. *Control of Invasive Aquatic Plants on a Small Scale.* LakeLine. Spring 2015.

North American Lake Management Society. *Managing Lakes and Reservoirs.* 2001.

Nürnberg, Gertrud. 1987. *A Comparison of Internal Phosphorus Loads in Lakes with Anoxic Hypolimnia: Laboratory Incubation versus In Situ Hypolimnetic Phosphorus Accumulations*. Limnology and Oceanography.

Nürnberg, Gertrud. 2001. *Eutrophication and Trophic State*. Lakelines.

Osgood, Dick. February 2004. *Lake and Watershed Planning and Analysis. Deer Lake Management Plan.*

Pilgrim, Keith, Brian Huser, and Patirck Brezonik. 2007. *A Method for Comparative Evaluation of Whole-lake and Inflow Alum Treatment.* Water Research.

Soerens, Thomas S. and Marc H. Nelson. *Sampling Strategies for Determining Nutrient Loads in Streams.* Project Report for Arkansas Water Resources Center.

Søondergaard, Martin, Jeppesen, Erik, and Jensen Jens P. 2003. *Internal Phosphorous Loading and the Resilience of Danish Lakes.* Lakeline.

Turyk N. and J. Stelzer. 2002. *Assessment of Lake and Groundwater Chemistry, Shallow Groundwater Flow, and the Aquatic Macrophyte Community, Peppermill Lake, Adams County, Wisconsin*. Center for Watershed Science and Education, University of Wisconsin-Stevens Point Report to Wisconsin DNR.

U.S. Army Corps of Engineers. 1996. *Simplified Procedures for Eutrophication Assessment and Predictions: User Manual.*

U.S. Army Corps of Engineers. 2005. *Phosphorus Budget and Water Quality Analysis of Cedar Lake, Wisconsin.*

U.S. Geological Survey, Wisconsin Department of Natural Resources. *Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin,* 1999-2001.

Wagner, Ken. 2001. *Limnology: The Science Behind Lake Management*. Lakeline.

Wilson, C. Bruce, Walker Jr., William W. 1989. *Development of Lake Assessment Methods Based Upon the Aquatic Ecoregion Concept.* Lake and Reservoir Management.

Wisconsin Department of Natural Resources. April 1995. Findings Number 23.

Wisconsin Department of Natural Resources. May 1993. Findings Number 35.

Wisconsin Department of Natural Resources. April 1995. Findings Number 38.

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Appendix G. Cedar Lake Post-Rehabilitation Monitoring and Evaluation Proposal

7 December, 2016

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Introduction

Multiple Al applications over a period of 12 years are planned for Cedar Lake in order to control internal phosphorus loading. It is critical to conduct post-treatment monitoring of water and sediment chemistry in order to document the trajectory of water quality improvement during rehabilitation to make better decisions regarding adjusting management to meet future water quality goals. Post-treatment monitoring will include field and laboratory research to document changes in 1) hydrology and watershed phosphorus loading, 2) the phosphorus budget and lake water quality, 3) binding of sediment mobile phosphorus fractions that have contributed to internal phosphorus loading by alum, and 4) rates of phosphorus flux from the sediment under anaerobic conditions. Overall, lake water quality is predicted to respond to watershed and internal phosphorus loading reduction with lower total phosphorus and chlorophyll concentrations throughout the summer, lower bloom frequency of nuisance chlorophyll levels, and higher water transparency. Al application should result in the binding of iron-bound phosphorus and substantial reduction in diffusive phosphorus flux from sediments under anaerobic conditions (i.e., internal phosphorus loading).

Approach

1. Hydrology and tributary phosphorus loading

A gauging station will be established on Horse Creek above Cedar Lake at 10th Ave for concentration, loading, and flow determination. Pool elevation changes in Cedar Lake will also be monitored. During the ice-free months, stage height will be monitored continuously and daily flows will be computed from a rating curve established between stage elevation and flow. During winter and ice-covered months, instantaneous flows will be determined at monthly intervals when ice conditions are safe. Daily precipitation will be monitored by local volunteers. Data collected from this effort will be used to construct a hydrological budget for Cedar Lake.

At weekly to biweekly intervals throughout the summer months, and less frequently during the winter, grab samples will be collected at the 10th Ave gauging station for chemical analysis. Water samples will be analyzed for TSS, total phosphorus, and soluble reactive phosphorus. Annual and seasonal tributary phosphorus loading will be calculated using the computer program FLUX.

2. In-lake monitoring

The deep basin water quality station 2 will be deployed in the lake for biweekly water sampling between the beginning of May and the end of October (~ 12 sampling trips). An integrated sample over the upper 2-m of total phosphorus, soluble reactive phosphorus, and chlorophyll a. An additional discrete sample will be collected within 0.5 m of the sediment surface for analysis of total and soluble reactive P. Secchi transparency and in situ measurements (temperature, dissolved oxygen, pH, and conductivity) will also be collected on each date. An additional integrated (0-3 m) water sample will be collected in August, September, and October at station 2 for determination of algal assemblage and biovolume (total samples = 3).

3a. Vertical variations in sediment characteristics

A sediment core will be collected within the alum-treated region of the lake (near station 2) in the third year following treatment (see Table 2) for determination of vertical profiles of various phosphorus fractions and aluminum. The goal of this task is to examine the location of the Al floc in the vertical column and monitor the extent of binding of iron-bound phosphorus by the alum floc over several years. The loosely-bound (Boström 1984) and iron-bound (Nürnberg 1988) sediment P fractions are readily mobilized at the sediment-water interface as a result of eH (i.e., oxidizing and reducing conditions) and pH reactions (Mortimer 1971, Boström 1984). Labile organic sediment P can be converted to soluble P via bacterial mineralization (Jensen and Andersen 1992) or

hydrolysis of bacterial polyphosphates to SRP under anaerobic conditions (Gächter et al. 1988; Gächter and Meyer 1993; Hupfer et al. 1995).

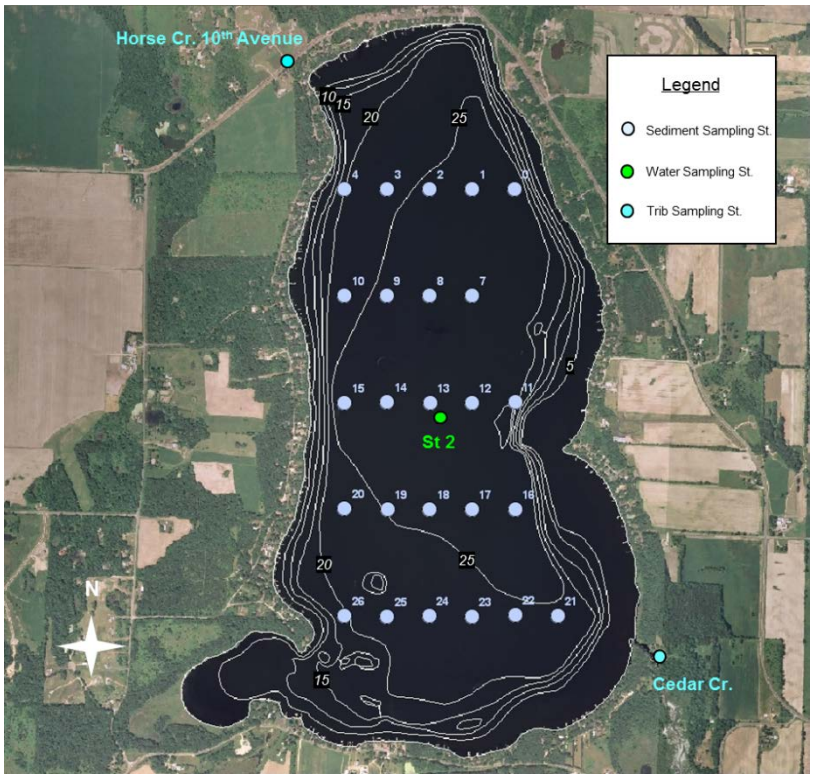
Sediment cores will be sectioned at 1-cm intervals between 0 and 6 cm, 2 cm intervals to 10 cm, and 2.5-cm intervals below the 10-cm depth for determination of;

Moisture content
Density
Loss-on-ignition organic matter
Loosely-bound P
Iron-bound P
Labile organic P
Aluminum-bound P
Total Al

The effectiveness of the alum treatment in binding and inactivating iron-bound P will be evaluated and used in an adaptive management approach to monitor dosage and effectiveness in controlling internal P loading.

3.b. Spatial variations in sediment characteristics

Sediment cores will be collected along a grid within the Al treatment area to examine Al concentrations in the upper 5 cm in the third year following treatment (Table 2). This task will provide important information on the distribution and movement of the Al floc in the treatment area and an estimate of observed versus target concentrations. The results will be used to adjust and improve future Al applications (i.e., adaptive management approach). For instance, the applicator may need to concentrate more Al on an area in the lake that has a low Al concentration relative to target goals.



The upper 5-cm will be sectioned for analysis of the following variables:

Moisture content
Density
Loss-on-ignition organic matter
Loosely-bound P
Iron-bound P
Labile organic P
Aluminum-bound P
Total Al

The information will be used to estimate spatial variations in the current Al concentration (g/m^2), Al-bound P, and the Al:P ratio.

4a. Laboratory-derived rates of phosphorus release from sediments under anaerobic conditions at a centrally-located station

Anaerobic phosphorus release rates will be measured from intact sediment cores collected in the alum-treated area on an annual basis (Table 2) to directly monitor alum treatment effectiveness. Replicate (3 each) intact sediment cores will be collected near station 2 for analysis. The sediment incubation systems will be placed in a darkened environmental chamber and incubated at a constant temperature for 1-2 weeks. The incubation temperature will be set to a standard temperature for all stations for comparative purposes.

The oxidation-reduction environment in each system will be controlled by gently bubbling nitrogen through an air stone placed just above the sediment surface to maintain anaerobic conditions. Post-treatment rates will be compared with pre-treatment rates over at least 3 years in order to evaluate the effectiveness of the Al floc in inactivating iron-bound phosphorus and controlling rates of phosphorus release under anaerobic conditions.

4b. Spatial variations in anaerobic phosphorus release rates

One additional core will be collected at each station along the grid established for Task 3b for determination of spatial variations in rates of P release under anaerobic conditions on an annual basis (Table 2). This task will be important in evaluating the effectiveness of the Al treatment on controlling anaerobic diffusive P flux spatially throughout the lake. The approach is outlined in Task 4a.

5. Interim report

An interim report describing results from the monitoring program will be delivered on an annual basis. Results will also be presented at a technical meeting for evaluation and management recommendations.

Table 1. Monitoring costs

			Full proposal years (2019, 2022) See Table 2			Other years (2017, 2018, 2020, 2021) See Table 2		
Task	Description		Cost	In-kind	Grant	Cost	In-kind	Grant
1	Hydrology and tributary phosphorus loading	Stream gauging	$500	$500		$500	$500	
		TP and SRP analyses	$912		$912	$912		$912
2	In-lake monitoring	12 Field trips	$1,200		$1,200	$1,200		$1,200
		Chemical analyses	$2,256		$2,256	$2,256		$2,256
		Phyoplankton	$600		$600	$600		$600
3a	Vertical sediment characteristics	Chemical analyses	$2,200		$2,200			
3b	Spatial sediment characteristics		$5,720	$2,908	$2,812			
4a	Anaerobic phosphorus release rates (replicates)	3 replicate incubations per year	$1,620		$1,620	$1,620		$1,620
4b	Spatial variations	1 incubation per 26 stations	$14,040	$14,040		$14,040	$10,928	$3,112
5	Interim report		$2,000		$2,000	$2,000		$2,000
	Total		$31,048	$17,448	**$13,600**	$23,128	$11,428	**$11,700**

Table 2. Cost and timeline analysis

Task	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
AI treatment	[redacted]			[redacted]			[redacted]			[redacted]			[redacted]	
1														
2														
3a														
3b														
4a														
4b														
5														
Grant cost	$11,700	$11,700	$13,600	$11,700	$11,700	$13,600	$11,700	$11,700	$13,600	$11,700	$11,700	$13,600	$111,700	$11,700
In-kind cost	$11,428	$11,428	$17,448	$11,428	$11,428	$17,448	$11,428	$11,428	$17,448	$11,428	$11,428	$17,448	$11,428	$11,428
Total cost	$23,128	$23,128	$31,048	$23,128	$23,128	$31,048	$23,128	$23,128	$31,048	$23,128	$23,128	$31,048	$123,128	$23,128

Appendix H. Horse Creek Farmer-Led Watershed Council

Submitted by: Eric Wojchik, Polk County LWRD

The Horse Creek Watershed Council was very productive during the 2014-2016 McKnight grant period. The council typically organized four to six meetings a year that involved six active council members with a Chair and a Vice Chair. Throughout the course of many meetings the council identified soil health and cover crops as their priorities.

With soil health and cover crops as their focus, the council began planning their incentive list and events early in 2015. In addition to offering incentives for soil sampling, soil health test analysis, P-Indexing, cover crop planting, and manure spreader calibration; the council planned for one large soil health seminar and began a cover crop test plot.

In 2016 the council identified their role as local experts on the practices eligible for incentives. They included their contact information on their incentive letter to offer new adopters assistance if needed. Practices eligible for incentives in 2016 were soil sampling, P-Indexing, cover crop planting, manure spreader calibration, and corn stalk nitrate testing. Field days in 2016 were a great success. In March, the Horse Creek Council hosted renowned regenerative agriculture expert Gabe Brown from North Dakota. This seminar hosted over 100 guests. Later that year, the council hosted a cover crop test plot open house that delivered test plot research to nearly 20 farmers and agronomists.

Conservation Practices and Units Installed by Incentive Participants

Year	Number of participants	Soil Sampling (ac)	P-Index (ac)	Cover Crop (ac)	Corn stalk N test (#)	Manure spreader Cal. (#)	Soil Health Test (#)
2015	8	1,133.8	845.3	150	8	0	2
2016	11	2,221.96	1,562.9	875	13	0	Discontinued

Nutrient Loading Inventories and Nutrient Reductions

Since the council has been making efforts to promote soil health and cover crops, there has been increasingly more evidence that their work is changing the agriculture community around them. There has been more conversation around cover crops, and other producers in neighboring watersheds are beginning to plant cover crops. State-wide, this model is being evaluated and replicated in other watersheds, largely due to the program developed by the St. Croix-Red Cedar Farmer-Led Watershed Council project. Each spring a cover crop inventory is performed in the Horse Creek watershed. The purpose of this inventory is to track the adoption of cover crops within the watershed where the council is most active. In the 2014/15 harvest year a thorough inventory of combined practices was completed. The following is a report on the acres of practices installed and estimated nutrient reductions from STEPL.

Total cropland acres in Horse Creek Watershed per 2006 Land Use inventory – 7,998.4

2014/15 harvest year BMP acres inventoried:
Cover Crops – 656.09 acres
No Till – 2,721.45 acres
Nutrient Management – 923 acres

STEPL Summary for harvest year 2014/15

Load before BMPs = 193,372.2 lbs/yr Nitrogen
Load after BMPs = 173,450.9 lbs/yr Nitrogen
Reduction = 19,921.3 lbs/yr Nitrogen

Load before BMPs = 38,738 lbs/yr Phosphorus
Load after BMPs = 34,030.5 lbs/yr Phosphorus
Reduction = 4,707.5 lbs/yr Phosphorus

The following is a report specific to cover crop installation within the Horse Creek watershed from 2014-2016 and its estimated P reductions.

Year	Cover Crop Acres Incentivized	Cover Crop Acres Inventoried	Phosphorus Reduction (lbs./year)	Nitrogen Reduction (lbs./year)
2014/15	0	656	488.3	2,588.8
2015/16	150	1088	809.8	4,293.6
2016/17	875	Not yet inventoried	649 (estimated)	3,441.2 (estimated)

* Average reduction of 0.74 lbs P/acre cover crop

A summary of harvest year 2016/2017 has not yet been completed because cover crop inventories are only feasible after spring snow melt. We will have a better idea of all of the cover crop acres planted within the Horse Creek watershed following an inventory planned for the spring 2017.

It is estimated that an additional 2,000 acres of cover crops were planted in neighboring watersheds as a result of the council's educational events in 2016. The producers who planted these acres attended one or more of the watershed council's informational events. The subject matter was intriguing enough to trial these practices on their operations, on their own. These additional acres have potential reductions of around 1,480 lbs of phosphorus.