Comprehensive Lake Management Plan

Big Chetac Lake

Sawyer County, Wisconsin

SEH No. BIGCC 108473

June 2010

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June 1, 2010

RE: Big Chetac Lake
Comprehensive Lake Management Plan
Sawyer County, Wisconsin
SEH No. BIGCC 108473

Mr. Jim Krietlow, Northern Region Central Lakes Coordinator
Wisconsin Department of Natural Resources
107 Sutliff Avenue
Rhinelander, WI 54501

Dear Mr. Krietlow:

Please accept the following Comprehensive Lake Management Plan for Big Chetac Lake and the Big Chetac Chain of Lakes on behalf of the Big Chetac Chain Lake Association and SEH. This plan is the end result of a multi-phased lake management planning project entitled “Getting Rid of the Green.” A tremendous amount of data has been analyzed, and recommendations based on that data have been made that encompass aquatic plant, nutrient, watershed, and near shore management. While no management plan can effectively cover every variable, it is believed that this plan provides what is necessary for beginning the process of implementing activities to improve the quality of the overall system. The plan acknowledges the need for additional information while using what is currently available to make recommendations that are reasonable and feasible.

Future plans related to this Comprehensive Lake Management Plan include application for lake protection and aquatic invasive species control grant funding by the Big Chetac Chain Lake Association to begin.

Sincerely,

Dave Blumer

Dave Blumer
Lakes Scientist

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Comprehensive Lake Management Plan

Big Chetac Lake
Sawyer County, Wisconsin

Prepared for:
Big Chetac Chain Lake Association
Sawyer County, Wisconsin

Prepared by:
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Dave Blumer ______________________ June 1, 2010 ______________

Dave Blumer
Lakes Scientist

Date

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Executive Summary

Lake Chetac, known locally as "Big Chetac" is located in southwestern Sawyer County, Wisconsin in the Town of Edgewater (T37N, R9W, Section 19 NE NE). It is considered to be the headwaters of the Red Cedar River Basin. During recent summers, the lake has been experiencing severe algae blooms such that during the summer of 2005, the Sawyer County Land and Water Conservation Department placed environmental hazard warning signs on the lake due to the high blue-green algae concentrations. Deteriorating water quality conditions in Big Chetac Lake drove the Big Chetac Chain Lake Association (BCCLA) to pursue a series of Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grants to complete a comprehensive "Getting Rid of the Green" lake study. The goal of this study was to identify the contributors and sources to the blue-green algae bloom in Big Chetac, Little Birch, and Big Birch Lakes. It included a comprehensive look at the nutrient levels in the system, their sources, and the impact they have. It included a whole- lake early season curly-leaf pondweed and mid-summer point intercept aquatic plant survey, groundwater and watershed assessment, septic system survey, and a paleoecological study of the sediments in the lake to determine historical conditions. This comprehensive lake, nutrient, and aquatic plant management plan is the end result of that study.

Historical data collected during this study indicates that the Big Chetac Chain has been a nutrient rich system since well before European settlement occurred in the area. Therefore it is unlikely that the system will ever become a "clear water" lake system. However, more recent shifts in water quality to severe blue-green algae dominated conditions considered toxic may be reduced by implementing certain management activities over time. There are six primary goals for set forth in this management plan, each associated with a number of objectives and actions to complete. The management goals are as follows:

- reduce the number of days the lake experiences severe algae blooms (chlorophyll concentrations >30 µg/L) that impact lake use by implementing phosphorous reduction activities in the larger watershed, near shore area, and within the lake
- reduce the impact of the non-native invasive plant species curly-leaf pondweed through aquatic plant management activities including large-scale harvesting and use of early season chemical herbicides
- protect and enhance the native plant population in the lake through invasive species management, improvements in water clarity, and native species re-introduction
- prevent new, undesirable non-native invasive species from entering and establishing in the lake by implementing a prevention and early detection program that includes watercraft inspection, in-lake monitoring, and rapid response planning
- maintain the current fishery by working closely with WDNR fisheries management to help minimize impacts that may be caused by lake management activities
- educate lake residents and users as to how the lake "works" and what they can do to help protect, maintain, and improve the lake

The objectives and actions associated with these goals vary in cost, level of difficulty, level of impact, and in the amount of additional study or assessment needed to begin implementation. A general timeline of events, and potential sources of funding are included in an implementation plan. It is strongly recommended that the BCCLA begin steps aimed at forming a Lake District to help with these and future management activities.

Table of Contents

SEH is a registered trademark of Short Elliott Hendrickson Inc.

Table of Contents (Continued)

Table of Contents (Continued)

List of Tables

List of Figures

Table of Contents (Continued)

List of Appendices

Comprehensive Lake Management Plan

Big Chetac Lake

Prepared for Big Chetac Chain Lake Association

1.0 Introduction

Lake Chetac, known locally as "Big Chetac" is located in southwestern Sawyer County, Wisconsin in the Town of Edgewater (T37N, R9W, Section 19 NE NE). It is considered to be the headwaters of the Red Cedar River Basin and is within the Lower Chippewa River Wisconsin Department of Natural Resources (WDNR) Water Management Unit. This lake is frequented often for fishing, recreational boating, rest and relaxation, and wildlife viewing. During recent summers, the lake has been experiencing severe algae blooms and during the summer of 2005, the bloom was so bad it caused the Sawyer County Land and Water Conservation Department to place environmental hazard warning signs due to the high blue-green algae concentrations. Deteriorating water quality conditions in Big Chetac Lake drove the Big Chetac Chain Lake Association (BCCLA) to pursue a series of WDNR Lake Management Planning Grants to complete a comprehensive "Getting Rid of the Green" lake study. This comprehensive lake, nutrient, and aquatic plant management plan is the end result.

2.0 Understanding How a Lake Works

Understanding the processes going on in a given body of water is essential for making reasonable management decisions. Every lake "works" a little differently than the next. Studying how a lake works is called limnology.

2.1 Basic Limnology

Lake water is typically turned green when algae, tiny plant species known as phytoplankton, become the dominant vegetative growth in a body of water. When this happens, many larger plants called macrophytes often disappear or their make-up or diversity changes. Only a few macrophytes do well under degraded conditions and in some cases the plants that remain may be non-native invasive species. As more macrophytes disappear, certain species of phytoplankton becomes even more dominant further degrading the system.

All plants large or small need certain things to grow. Sunlight is necessary to trigger the process called photosynthesis whereby carbon dioxide is converted into organic plant building material and oxygen in the green cells of plants that contain chlorophyll. It is chlorophyll that gives plants their green color. Plants also require about twenty other elements for growth. Of particular importance are nitrogen and phosphorous because their natural supply is generally low. Both are considered "limiting" nutrients in an aquatic setting, because often the amount of plant or algae growth that can occur is limited by their availability in nature.

There is a huge reserve of nitrogen in the air that is breathed, however, only a few plant species are capable of pulling their nitrogen needs directly from this source. In most cases, plants and algae take in nitrogen from other forms including ammonium, nitrate, and nitrite that are not as plentiful. These three forms of nitrogen are collectively known as dissolved inorganic nitrogen. Phosphorous is relatively scarce in natural environments. It is bound to clay and soil particles, and only when it is in a dissolved state known as phosphates, is it immediately available for use by plants (Moss et al, 1996).

Both nitrogen and phosphorous, in a variety of forms, are in the water that runs off from the land and into lakes. Dissolved inorganic compounds, small particles of soil that contain absorbed phosphates, and fragments of dead and dying plant and animal material referred to as detritus all contain nitrogen and phosphorous that may become available for the growth of algae or plants in a lake, either directly or by following simple chemical reactions or transformations that occur naturally under the right conditions. Collectively, these nutrients are referred to as total nitrogen (TN) and total phosphorous (TP).

The amount of nitrogen and phosphorous naturally available in a lake is often the result of the type of catchment or watershed the lake is situated in. A catchment or watershed in an upland or highland area that has little soil build up through weathering or erosion and a natural or undisturbed environment tends to have large, deep, oligiotrophic lakes. Oligiotrophic lakes generally have clear deep water and limited aquatic plant growth. A catchment or watershed that is in a lowland generally has more soil build up through weathering or erosion and tends to contain shallow eutrophic (high in nutrients) lakes with lots of plant material. This type of catchment may contain rivers with wider floodplains and cut-off meanders known as oxbow lakes, glacial lakes left when ice chunks buried under glacial deposits melted, and many shallow depressions that collect surface runoff. These lakes may not be suffering negative consequences from nutrient enrichment if still in a natural state.

A natural state implies that land cover is generally in an undisturbed state. Land cover is an important natural regulator of the total amount of nitrogen and phosphorous that makes it to a water body. Natural catchments generally contain large areas of undisturbed plant growth from grasses to forests. This plant growth holds soil in place preventing erosion, and uses up large amounts of the available nutrients before they can reach a lake. Natural wetlands may also be present on the landscape. Wetlands are areas where surface or ground water pools up on the landscape creating shallow, highly fertile, areas where plant growth is abundant. A wetland may have previously been a lake that has now filled in, or a natural shallow depression in the landscape. Wetlands can lock up huge amounts of phosphorous and nitrogen before they reach a lake, and provide habitat for thousands of creatures. Increasing the amount of disturbance in a watershed either from development or agriculture generally increases the amount of phosphorous and nitrogen that comes off the land and into water bodies.

Another important component of a lake or aquatic setting is the level of oxygen dissolved in the water. Most underwater creatures still need to “breathe” oxygen like their land counterparts. The oxygen these creatures breathe is dissolved in the lake water itself. Plants on the land make oxygen when the green portions of them convert carbon dioxide into organic building material used to grow new plant matter and pure oxygen which is released back into the air. Plants, including the tiny phytoplankton or algal species in an aquatic setting do the same thing. Thus oxygen is both pulled into the lake water from the air at the surface of the lake, and released into the lake water by plants growing in the water. But in a lake, it is possible to lose oxygen more rapidly than it is replaced when there is a large amount of organic material present in the bottom of the lake.

Water temperature also plays an important role in how a lake works. Water at different temperatures has different densities. Warm water is generally lighter or less dense than cold water, until the water freezes. Ice is less dense than water in its liquid form, which is why it floats. Water in the summer warms up on the surface, but remains cooler deeper down. Water in the winter freezes on the surface but remains warmer deeper down. Deeper lakes will often form two separate areas of water called stratification during the open water season; warmer water near the surface (epilimnion) and colder water near the bottom (hypolimnion). When this occurs a barrier is formed called the thermocline that keeps the two areas separated. The same barrier will often prevent any new oxygen pulled in from the air or made by plants in the water from reaching the colder bottom waters. Plant and animal material in the bottom of the lake continues to decay using up available oxygen. When no more oxygen is available and no new oxygen can be added lots of things happen. Fish leave the area for more oxygen rich water, decay of plant and animal material may stop, and different chemicals in the sediment begin to react with each other causing phosphorous formerly locked up in the sediment to be released back into the lake. The longer bottom waters of a lake remain devoid of oxygen, the more likely it is that this internal source of phosphorous will negatively impact the lake.

Shallow lakes may not stratify making new oxygen available all the way to the bottom of the lake. However, at the same time, the rapid decay of plant and animal material may still use up oxygen faster than it can be replaced, but the lack of oxygen does not typically last as long. In both shallow and deep lakes events occur, some natural and some man-made, that allow oxygen rich water to be circulated into the entire column of water. In Wisconsin lake water cools in the fall, and warms up in the spring. At some point a time is reached where all the water in the lake is the same temperature and density. During this time period, referred to as turnover, the entire lake mixes, recharging oxygen and nutrients. Large storm events and windy days can sometimes cause a lake to mix, even if it is stratified. Boating can stir up a lake and cause mixing in some lakes. Waves also mix sediment from the bottom with the water up above. This kind of mixing can make a lake look muddy and also trigger a release of phosphorous into the lake. Whenever more phosphorous than a lake can handle is introduced to the lake, be it from runoff from the land or from internal sources, increased levels of algal growth called an algae bloom, generally occur. The severity of this surge in algae growth can range from barely noticeable to levels considered toxic to those that would use the water.

Two lakes in a catchment or watershed are seldom if ever the “same”. All of the water in a lake comes directly from precipitation (rain and snow) falling from the sky, runs off the surface of the land (runoff, streams, or rivers), or enters the lake from below the ground’s surface (groundwater or springs). Within the catchment are different types of soil and substrate and various surface land features that affect the lake. Groundwater and the soils that surround a lake may or may not be high in phosphorous content. The morphometry of a lake, its shape, area, maximum and mean depths, and volume, also affects the lake (Moss et al, 1996). Shape and depth are important in determining the potential for aquatic plants and algae to grow in a lake.

The area of a lake where enough sunlight penetrates to the bottom to allow rooted plants to grow is referred to as the littoral zone. The littoral zone can be impacted by the morphometry of a lake. A deep lake with steeply sloping shores may have a very small littoral zone. A lake that is shallow may be considered all littoral zone. In addition, light penetration in a lake can be impacted by what is dissolved in the lake water and by what is suspended in the water. Stained water limits light penetration. Suspended particles including sediment (soil) or algae in the water can limit light penetration, and light penetration can be blocked by excessive large plant growth. In many lakes, a point is reached where light penetration is no longer adequate to allow rooted plant growth from the bottom of the lake. Where this occurs is essentially the end of the littoral zone. Free floating algal species, and free floating or non-rooted larger plants are often not as impacted by restricted light penetration, as they are able to move around and remain in that portion of the water column that provides enough light to grow.

Many lakes have an inlet (river or stream flowing in), an outlet (river or stream flowing out), or both. Inorganic particles including clay, sand, and minerals; and organic particles including plant and animal remains are carried into a lake by an inlet. Most of these particles settle to the bottom of a lake to become sediment. Many things are attached to or contained in the particles that get carried into a lake including nitrogen and phosphorous. Some of the nitrogen and phosphorous settles to the bottom with the particles where it can be used by rooted plants. Some is left dissolved in the water and used up by a variety of plants (both rooted and non-rooted) and algae. Still more is carried through and out of the lake by an outlet, if one exists, a process known as flushing. As more nutrients become available more plants often grow. As more plants grow, more organic debris is deposited on the bottom adding to the level of organic sediment in a lake, in most cases known as muck. More muck often grows more plants, binds up more nutrients, and in deeper portions of the lake use up more oxygen. Eventually a lake may get completely filled in or become a shallow wetland. This natural aging of a lake generally takes hundreds if not thousands of years.

The amount of phosphorous and nitrogen that gets into a lake only becomes a problem when the naturally occurring processes in that lake can no longer handle the input. If more phosphorous gets into a lake than it can naturally handle, conditions in the lake may change substantially. Plant growth may increase or decrease. The diversity of that plant growth and the area it can grow in may decrease. Oxygen levels in the water may decrease or disappear all together. Algae blooms may occur. These and other changes can cause a shift from a clear water plant dominated system to a free-floating plant and algae dominated system with very green water.

2.2 Human Influence

The natural processes that give a lake its characteristics can and are severely altered by human activity. Changes to the landscape around lakes and within the watershed by development, farming, logging, etc. affects the amount of soil and nutrients that run off these areas and into a lake. With changes in runoff often come increased or more rapid sedimentation or filling in of lakes caused by increased erosion from the watershed or by erosion of the near shore area around the lake. Phosphorous and other things attached to the sediment are carried into a lake in increased amounts. Sewage associated with human development, manure from animal faming, and commercial fertilizers applied to lawns and fields can add more phosphorous and nitrogen to surface runoff and ground water. Dirt and dust from roads, open areas, and fields can be blown over and into the water or cleansed from the air by precipitation. This too is a source of phosphorous and other contaminants. Changes in climate may be fueling changes in the amount of precipitation received or in the number and severity of large rain events that carry with them tremendous erosion and runoff potential.

Natural and man-made sources of phosphorous, nitrogen, and other things can be classified into two categories, point and non-point sources. Point sources can be easily identified and quantified and may be easily targeted for “repair”. They may include a discharge pipe from a factory or municipal wastewater treatment plant, a direct pipe carrying human waste or grey water from a residential home to a lake or river, or even runoff directly from a large livestock operation. Non-point sources may be easily identified, but not necessarily easily quantified. Phosphorous in groundwater, cleansed from the air, carried in from across the landscape, added by the decay of plant or animal material, or recycled from nutrients already in a lake are good examples of non-point sources of phosphorous and other nutrients. While relatively easy to identify, these sources are generally very difficult to quantify, and in some cases very difficult to repair. Generally, as phosphorous and nitrogen levels increase in a lake, the amount of algae (measured by determining the amount of chlorophyll a in a water sample) also goes up. As the amount of algae goes up, water clarity goes down.

Increased development around lakes and human use of lakes can bring with it plants, animals, disease, and other things never before known to exist in a given body of water. Called non-native species, these things could come from across the ocean or from the neighboring lake. What is considered native in one location may be considered completely foreign in another. Of the thousands of non-native plants, animals, insects, bacteria, viruses, etc that have been spread around by human activity, only a few are considered to be really problematic, and in some cases may be so only under certain conditions. One of the criteria used to judge the potential problems associated with a non-native species, is if that species becomes invasive or capable of replacing other species that are considered native or beneficial to the environment they are in. A non-native, invasive species may out-compete native species for light, nutrients, food, or habitat; may prey on a desirable species so much as to remove that species entirely; alter habitat by changing the chemical and/or biological make-up of that habitat; or simply dominate an area so that nothing else can exist there unless the invader is removed.

3.0 Big Chetac Chain of Lakes

All of these factors come into play in the Big Chetac Chain. Though a good portion of the watershed remains in a natural state, certain areas have been disturbed by agriculture and development. The near shore area around the lake has been significantly altered by development. Individual water quality parameters indicate that the system has high concentrations of phosphorous, limited light penetration, and limited growth of desirable native plants. There are no easily identified point source contributions for phosphorous to the lake, but substantial non-point sources. Curly-leaf pondweed, an aquatic invasive plant species, dominates early season plant growth in the majority of littoral zone. Early summer senescence or death and decay of this plant contributes additional nutrients to the system at a time when it is already overwhelmed with excess phosphorous from other sources helping to shift the lake from large aquatic plant dominance to algae dominance each season. More desirable native plant species are prevented from growing due to the curly-leaf pondweed and because of the lack of light penetration caused by the algae dominated water. The overall quality of the Big Chetac Chain is in question.

Many things enter into the discussion when talking about the “quality” of a body of water. Depending on its uses, different bodies of water have different measurements of overall quality. For recreational and aesthetic purposes like swimming and boating and providing high lake shore property values, a lake that has clean, clear water and few plants is often considered the highest quality. Most high quality fishing lakes have much greater levels of plant growth and often have “green” nutrient-rich water. According to Frank Pratt, WDNR

Fish Biologist for the Big Chetac Chain, the lake has a very productive warm water fishery including walleye, largemouth and smallmouth bass, bluegill, and crappie. However, it is not aesthetically pleasing to many people during the summer months, and lake conditions during this time often prevent other lake uses including swimming, enjoying the view, fishing, and skiing/tubing (2009 Lake User Survey).

4.0 Questions Answered in this Report

The questions that this report tries to answer are whether or not the lake is meeting its desired uses; is it in a natural or disturbed state, meaning has it "always" been the way it is; what is causing the lake to be the way it is; should lake or plant management be considered; and what management alternatives are available for making improvements to the lake.

4.1 Desired Uses

A Lake User Survey was developed by Short Elliott Hendrickson Inc. (SEH®), the BCCLA, and the WDNR as part of the final phase of the "Getting Rid of the Green" lake and plant management project. In September 2009, 380 copies of the survey were distributed by the BCCLA to Big Chetac Chain users. Results from the survey helped to determine the final plant and lake management recommendations to improve the lake included in this report. The survey was broken down into seven sections which included residency, lake stewardship, lake use and lake issues, aquatic plant growth, aquatic invasive species, aquatic plant management, and community support and can be viewed in Appendix A. Survey responses can be seen in Appendix B. Out of the 380 copies of the survey which were mailed out, 183 surveys (48%) were returned to SEH. Out of this, 182 respondents owned or rented property on the lake and only 1 respondent was a non-property owner. Seasonal users (73%) made of the majority of the respondents, while 27% respondents were permanent residents. When asked how long the survey respondents have been using the lake, 6-10 years was the dominant answer.

In the lake use and issues section, most of the respondents chose fishing from a boat, pontoon boating, and fishing from shore as the top three activities which they participated in. The two biggest issues of concern for respondents were "icky" or "green" water and too much weed growth. Regarding water quality, 40% believe the water quality has stayed the same over the years, and 37% believe the water quality has gotten worse. Greater than 50% of respondents believe that algae growth in the lake has increased since they have been using the lake. Approximately 40% said it has remained the same. Only 6% thought it had decreased. Most of the respondents (52%) believe the current state of the water quality is in poor or very poor condition. Activities impaired by water quality include swimming, enjoying the view, fishing, and skiing/tubing. Regarding aquatic plant growth, 79% of respondents believe the amount of aquatic plant growth in the lake is a moderate or large problem and that growth has increased in the time they have been using Big Chetac Lake. Swimming, fishing, motorized boating, and enjoying the view are the activities most impaired by plant growth. Most respondents believe excessive plant growth is the worst from July to September.

General comments and survey responses seem to support the WDNR ascertain that Big Chetac Lake has a very productive fishery. When respondents were asked to list all issues of concern to them, only 46% listed poor fishing as an issue. When asked to just pick their top two issues of most concern, only 9% chose poor fishing. Big Chetac Lake is not currently on Wisconsin's impaired water list, so under US Environmental Protection Agency guidelines it is assumed that the lake does meet its expected uses.

4.2 Has the Lake Always Been this Way?

In order to answer this question it is first important to know what conditions currently exist in the lake. Much of the “Getting Rid of the Green” study was used to quantify current lake status. Water quality was assessed, conditions in the watershed and near shore area were evaluated, lake water and nutrient budgeting was completed, and existing aquatic plant conditions were evaluated. At the same time a paleolimnological study of the lake was completed. Paleolimnology, also referred to as paleoecology is the study of the history of lakes revealed in the chemical and fossil contents of their sediments (Moss et al, 1996). Sediments are laid down in a chronological sequence in a lake. Dependent on the conditions in the lake under which the sediment was laid down, each sediment layer will carry a great deal of information from which historical changes in water chemistry and community structure can be deduced.

4.2.1 Water Quality

Citizen Lake Monitoring Network (CLMN) volunteers sporadically collected water quality data from 1995-2008. The CLMN program, sponsored by the Wisconsin Lakes Partnership (WDNR, UW-Extension Lakes, & Wisconsin Association of Lakes) trains ordinary citizens to collect basic water quality data on their lake. The purpose of the monitoring is to establish long term trends associated with several surface water quality parameters including Secchi readings of water clarity, chlorophyll concentrations in the lake water, and total phosphorous concentrations in the lake water. On Big Chetac Lake, three CLMN sites were created: the north, central, and south basins. Included in this data are Trophic State Index (TSI) values generated for all these parameters as well. Lake level, appearance, color and perception of the lake were also recorded. Color is predominately green and public perception recordings indicate that enjoyment of the system is somewhat impaired due to algae dominated water.

Below are the summer averages (July and August) for Secchi readings in feet recorded by the Citizen Lake Monitoring Network volunteers from 1995-2008. Long term trend analysis based on this data suggests there have been no drastic shifts in lake water clarity throughout this time period.

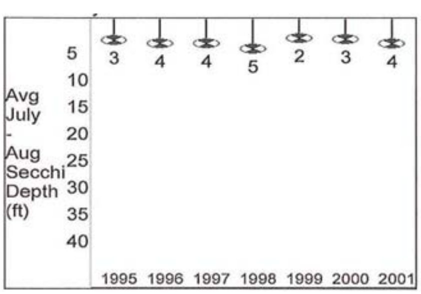


Figure 1 – North Basin

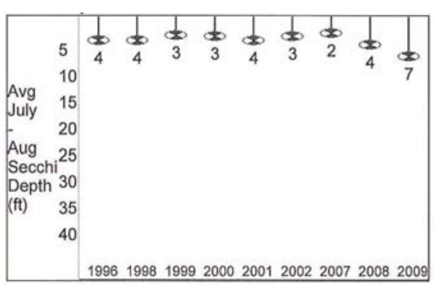


Figure 2 – Central Basin

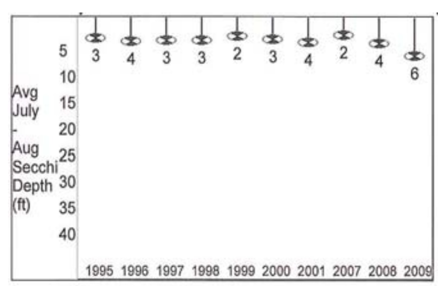


Figure 3 – South Basin

In 2007, additional water quality data was collected to help establish a more complete analysis of the water quality in the lake. Nutrient sampling was completed on fifteen different dates starting on April 25 and ending on October 7 in all three basins. Total phosphorous, total nitrogen and chlorophyll *a* concentrations were measured at the following depths: 0-2m, 2.5m, 3.5m, 4.5m, 5.5m, 6.5m, and 7.5m if the depth of the basin permitted it. North was sampled at all of these depths, Central was sampled through 5.5m, and South was sampled through 4.5m. Secchi disk readings and temperature & dissolved oxygen profiles, and pH measurements were also taken. The goals of this sampling were to determine seasonal changes in phosphorus mass, algal abundance and pH; determine the total time period each basin became anoxic or devoid of oxygen in the bottom waters; and to determine if Big Chetac Lake was nitrogen or phosphorous limited.

Figure 4 shows the average surface water sampling results for all three basins for each of these parameters over the five month sampling period in 2007. Trend lines are added to show the relationship associated with increased phosphorous concentrations leading to increased chlorophyll a concentrations leading to decreased water clarity readings.

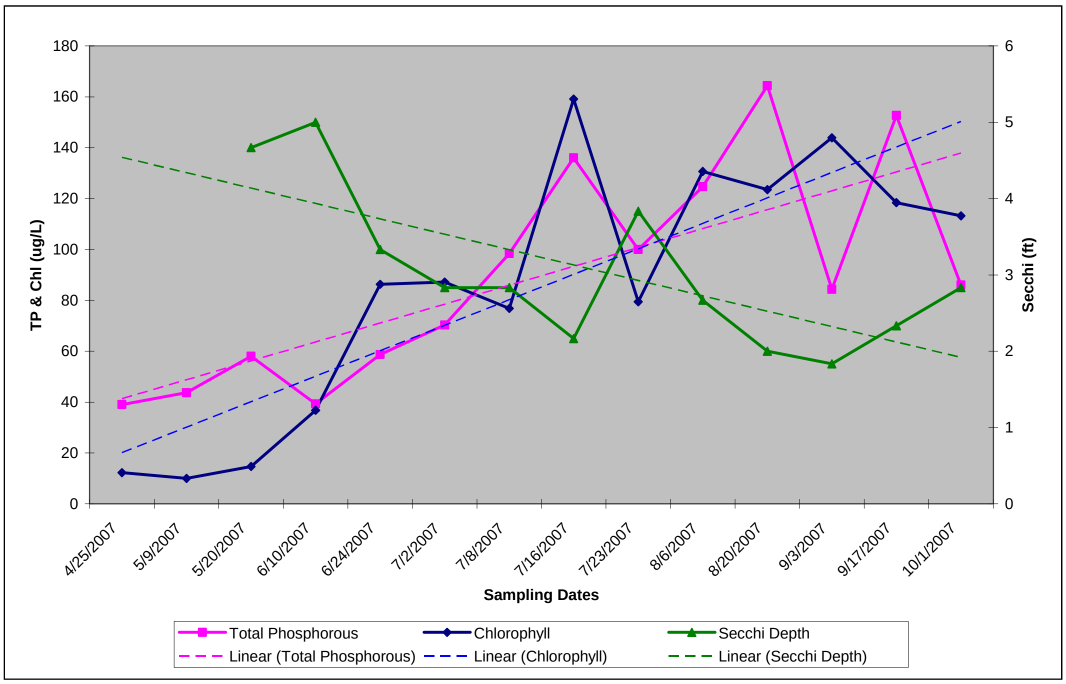


Figure 4 – Total P & Chlorophyll Concentrations (0-2m) and Secchi Disk Averages for Big Chetac Lake

More information about water quality and the in-lake phosphorous mass can be found in Appendix C.

Chlorophyll concentrations in 2007 exceeded 30 µg/L by early June in all three basins and remained above this value until early to mid October (Figure 5). Concentrations ranged from lows in the 30's to highs approaching or exceeding 200 µg/L. Severe algae blooms lasting through the entire summer season are the norm in all three basins. Trophic State Index Values (TSI) were consistently in the high 60's to low 70's indicating hyper-eutrophic conditions. Average seasonal chlorophyll concentrations were 121 µg/L, 100 µg/L, and 94 µg/L respectively for the north, central, and south basin.

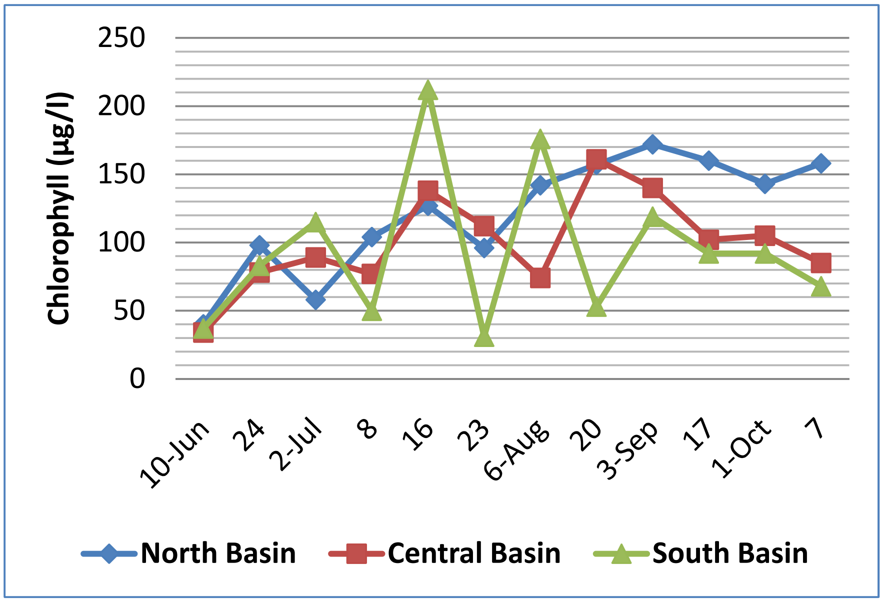


Figure 5 – 2007 Weekly Summer Chlorophyll A Concentrations For All Three Basins (Values >30 µg/L are considered indicative of severe algae blooms)

4.2.2 Historic Water Quality

A Paleoecological Study of Big Chetac Lake was completed in 2008 (Appendix D). Paleoecology offers a way to evaluate the past history of a lake, similar to the way the rings on a tree can help determine a history of favorable and unfavorable growing conditions for plant. Lakes act as partial sediment traps for particles that are created within the lake or delivered to the lake from the watershed (Garrison & LaLiberte, 2010) and laid down in layers on the bottom. This sediment traps a selection of fossil remains that are more or less resistant to bacterial decay and chemical dissolution. To evaluate these remains, a sediment core is removed from the lake that is deep enough to capture layers from pre-settlement times, often a couple hundred years or more in the past. Based on planktonic remains including diatom frustules, cell walls of certain algal species, and sub-fossils from aquatic plants and on the chemical composition of the sediments, conditions in the lake and the changes associated with them over time, can be estimated. On Big Chetac Lake, a 93-cm sediment core was taken from 25-ft of water in the North Basin. A complete diagnostic of the core was undertaken and results presented in Garrison & LaLiberte, 2010. The core was dated to estimate historical dates and sedimentation rates, the diatom community was analyzed to assess changes in nutrient levels, and geochemical elements were examined to determine the causes of changes in water quality.

Several things were learned about the water quality of the lake. Historically, Big Chetac Lake has always been eutrophic or nutrient rich, even in the mid to late 1800's. Sedimentation rates in the bottom of the lake have remained fairly consistent since pre-settlement time with the exception of two time periods, the 1910's and the 1940's. Current sedimentation rates are similar to what they were 150 plus years ago suggesting that erosion of sediment from the watershed has not been a big issue negatively affecting the lake. The increase in sedimentation in the 1910's can readily be associated with the installation of the dam on Birch Lake. What happened in the 1940's is unclear, but could be related to erosion associated with shoreline development, road way construction around the lake, or other short term disturbances in the watershed.

The diatom community examined in the core was used to estimate changes in water clarity (Secchi depth) and phosphorous levels during the last two centuries. It is estimated that prior to the arrival of Europeans in the mid-1800's the mean summer Secchi depth was about 3.5 ft. This is similar to what current readings are. In the first third of the 20th Century, mean Secchi depths were likely around 2-ft, less than they are today (Figure 6).

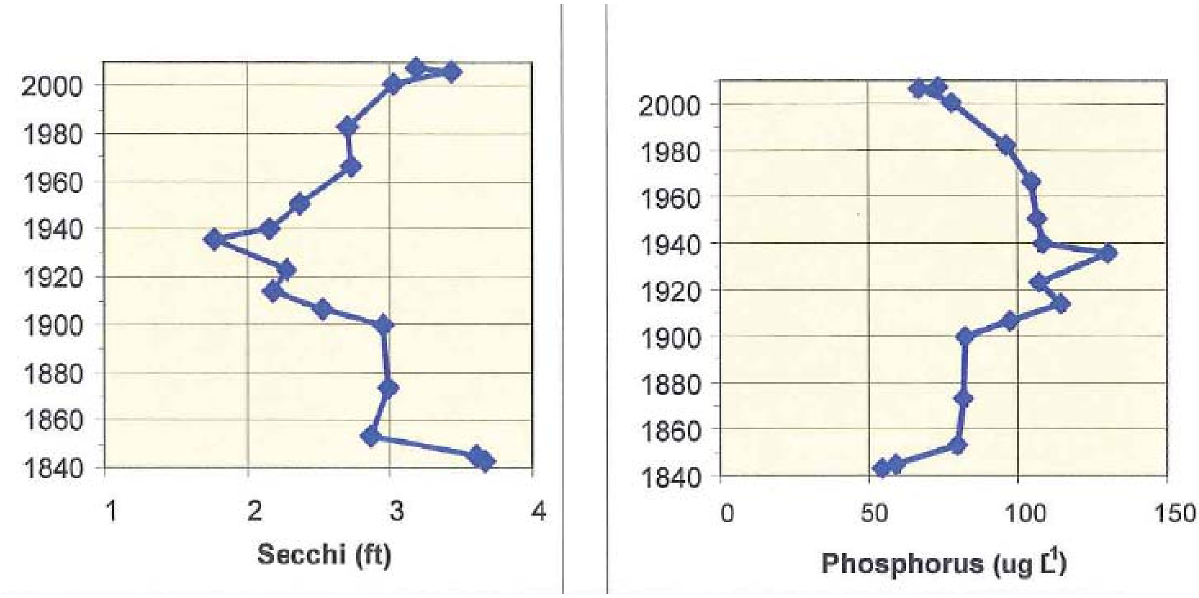


Figure 6 – Estimated Mean Summer Secchi Depth and Summer Phosphorous Concentrations in the Core

These values were inferred from the diatom community using weighted averaging modeling (Garrison & LaLiberte, 2010).

Phosphorous levels in the mid part of the 20th Century were higher than they were back in the 1800's, and higher then they are now (Figure 6), again possibly associated with a period of rapid development on and around the lake. Since the 1980's phosphorous is the most significant element that has increased in deposition. Total phosphorous levels in the summer can exceed 150 µg/L. In this same time period, organic matter and calcium also increased but not as dramatically. Garrison and LaLiberte, 2010 suggest this could be from increased internal recycling of phosphorous existing in the sediments. What caused greater levels of phosphorous in the sediments to be re-introduced into the lake during this time frame is not completely known, but could be related to the introduction and subsequent takeover of the early season plant community by curly-leaf pondweed. While it is not known what level of CLP was in the lake in the 1980's and before, current levels stand at 600 plus acres or approximately 25% of the entire lake surface. CLP completes its life cycle and begins senescence in the early summer.

4.3 What Makes the Lake the Way It Is?

As was discussed in the beginning, the condition of a lake is largely determined by its natural conditions including the type of watershed or catchment it has, the location of the lake in that watershed, its morphometry, and the make-up of its flora and fauna. These natural characteristics are then influenced by human activity to create the current conditions in the lake.

4.3.1 Watershed Information

The Big Chetac Chain is part of the Red Cedar River Basin which drains a 1,893 square-mile area in west central Wisconsin that includes parts of Barron, Chippewa, Dunn, Polk, Rusk, Sawyer, St. Croix and Washburn Counties (Figure 7). The Basin consists of eight smaller watersheds: Red Cedar Lake, Brill & Red Cedar Rivers, Yellow River, Lake Chetek, Pine Creek and Red Cedar River, Hay River, South Fork Hay River, and Wilson Creek.
Big Chetac Lake is located in southwestern Sawyer County, Wisconsin in the Town of Edgewater and is part of the Red Cedar Lake sub-watershed (Figure 8). This sub-watershed is situated in the upper most reaches of the larger Red Cedar River Basin. Overall, this portion of the basin is predominantly forested.

Approximately 54 square miles drained by several tributaries contribute surface water to Big Chetac Lake (Figure 9). This immediate drainage area and the lake itself are considered to be the headwaters of the entire Red Cedar River. Groundcover work done in the watershed in 2008 suggests about 86% of the immediate drainage area of Big Chetac Lake is currently in a forested state.

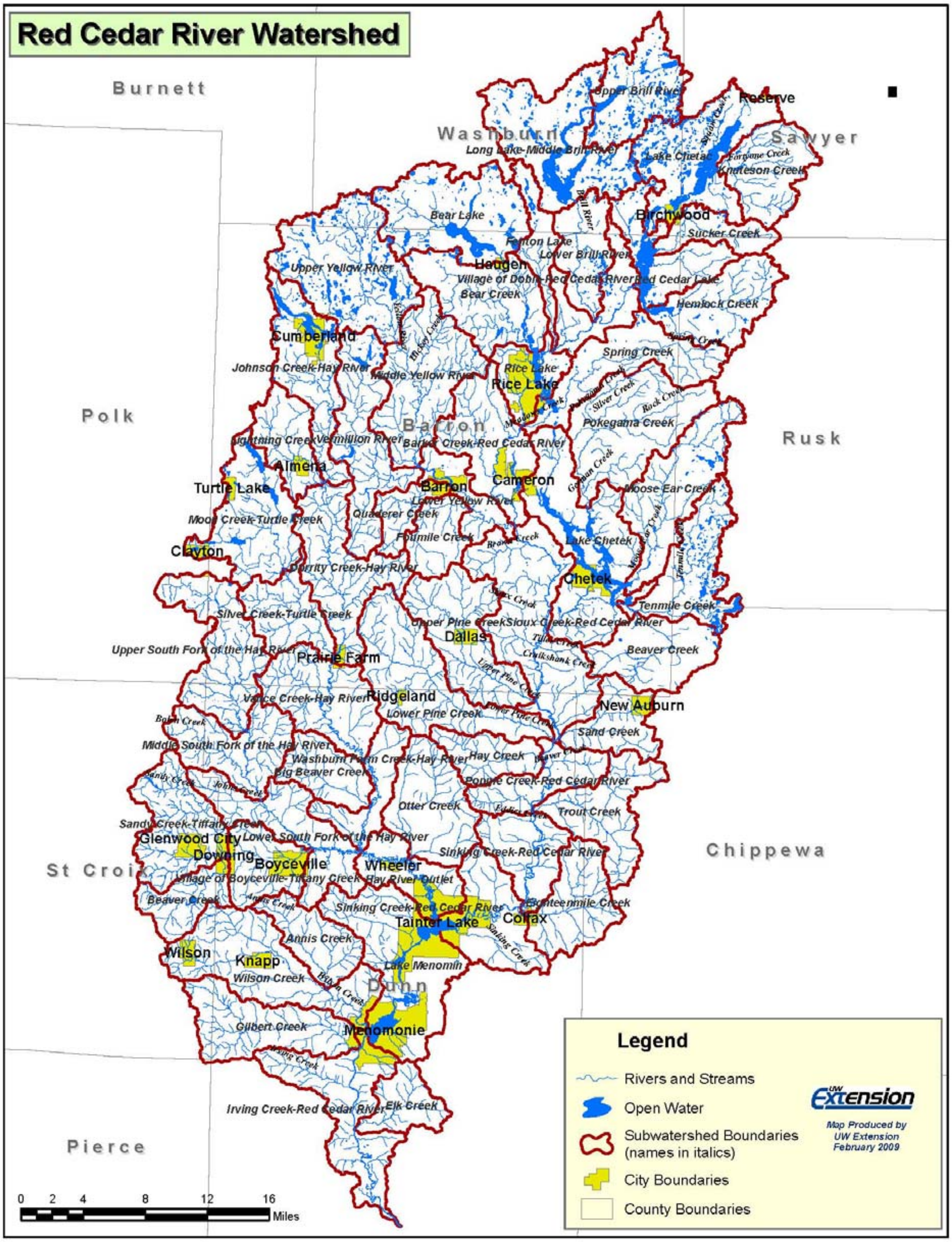


Figure 7 – Red Cedar River Basin

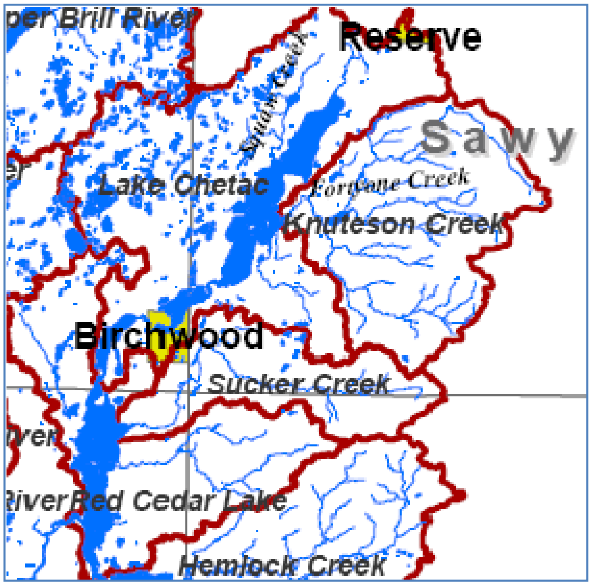


Figure 8 – Red Cedar Lake Sub-watershed

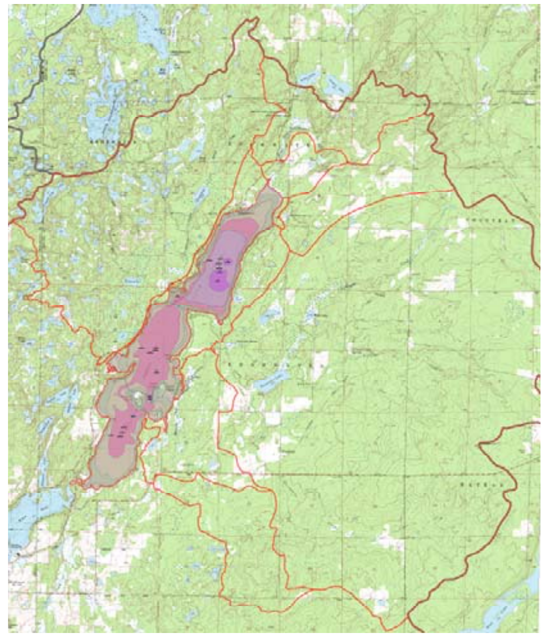


Figure 9 – Big Chetac Immediate Drainage Basin

4.3.2 Soil and Groundwater

Soil or substrate is composed primarily of minerals which are produced from parent material which is weathered or broken into small pieces. Primarily sandy loam and silt loam soil textures surround Big Chetac Lake. Table 1 shows some of the dominant soils surrounding the lake with their texture, drainage class, and hydric rating. It is not known what level of phosphorous is found naturally in the soils around the Big Chetac Chain. Soil testing could be completed within the watershed to help determine if it holds an abnormally high concentration of phosphorous.

Table 1
Soil Types Surrounding Big Chetac Lake

Soil Name	Soil Texture	Drainage Class	Hydric Rating
43C Antigo silt loam	Silt loam	Well drained	Not hydric
412A Rifle and Tacoosh	Mucky peat	Very poorly drained	All hydric
571E Pelissier gravelly sandy loam	Gravelly sandy loam	Excessively drained	Not hydric
615B Cress sandy loam	Sandy loam	Somewhat excessively drained	Not hydric
615D Cress sandy loam	Sandy loam	Somewhat excessively drained	Not hydric
970E Keweenaw, stony-Pence, stony-Greenwood complex	Sandy loam	Well drained	Partially hydric
3403A Loxley, Beseman and Dawson	Peat/muck	Very poorly drained	All hydric

Groundwater flows through the different types of soil substrate on its way into Big Chetac Lake. The volume of groundwater, what it flows through, what it carries with it, and where it goes in and out influences the lake. The amount and direction of groundwater flow for Big Chetac Lake was estimated by installing 12 mini-piezometers around the perimeter of the lake. Areas of inflow and outflow were determined by the difference in head height or hydraulic gradient within each piezometer from the lake level. If the head is greater than the lake level then groundwater is flowing into the lake and if it is less than the lake level it is flowing out of the lake. Different soil types have different permeability rates. Groundwater flows through the different soils of the lake bed at different rates. The soil type and flow rate (hydraulic conductivity) were determined for each of the 12 piezometers installed around the lake. Based on the results recorded, groundwater flows into the lake from the north and west with some inflow from the east, and flows out to the south and east. The daily flow of groundwater into the lake is estimated at just over 2 gallons (2.01) per square foot of lake bed, or nearly five million gallons a day. Phosphorous concentration in the groundwater was about 78 ug/l, one-third to twice as high as the concentrations measured in the all but one of the tributaries. However, groundwater samples were taken from only two of the piezometers installed for this study, and on only one occasion. A study completed on Long Lake just to the west of Big Chetac Lake indicated high phosphorous concentrations in the groundwater. Work completed in an earlier phase of the "Getting Rid of the Green" project estimated 5% of the total phosphorous in the lake was contributed by groundwater.

4.3.3 Lake Morphometry

According to the Surface Water Resources Book for Sawyer County, in 1967 the lake is listed as having a surface area of 2,148.6 acres and 14.4 miles of shoreline. GIS work in 2008 however indicated a surface area of just over 2500 acres with 17.8 miles of shoreline. The lake forms a series of three elongated basins connected by deep channels. Figure 10 shows the hypsographic curve for Big Chetac Lake (1967 Historical Lake Map, WDNR) The hypsographic curve is a graphical representation of the relationship of the surface area of a lake to its depth. The north basin is the deepest of the three basins at 26-ft (Figure 11). The lake is 30 feet deep at its deepest point in the narrows between the islands in the south basin. The average depth is approximately 14 feet deep. Generally, Big Chetac Lake has a gently sloping muck bottom. Bottom sloping is greatest in the north basin west to east. The littoral zone is approximately 800 acres, covering about a third of the lake bottom (Figure 12). Approximately 80% of the littoral zone is organic muck, 15% is rock, and 5% is sand (Figure 13).

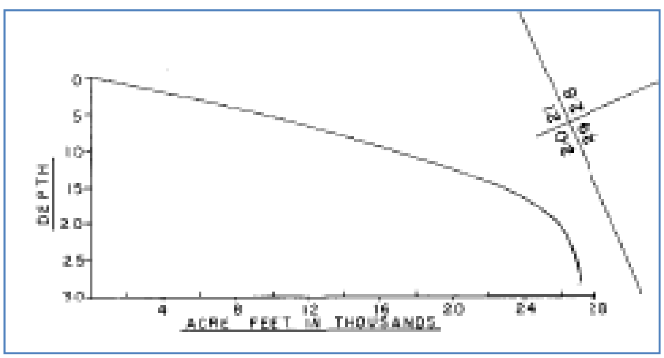


Figure 10 – Hypsographic Curve for Big Chetac Lake

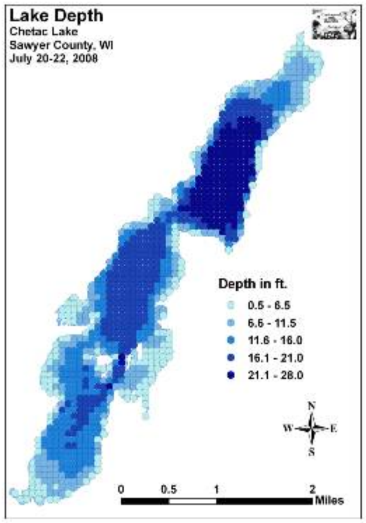


Figure 11 – Lake Depth From 2008 ERS Plant Survey

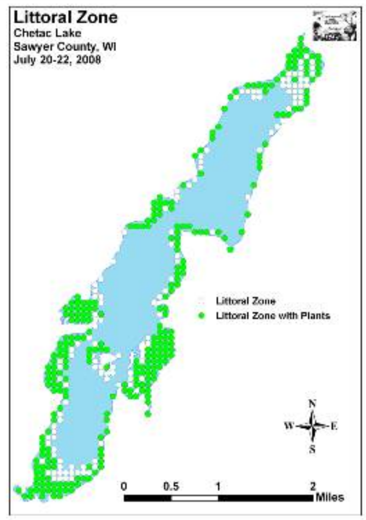


Figure 12 – Littoral Zone From 2008 ERS Plant Survey

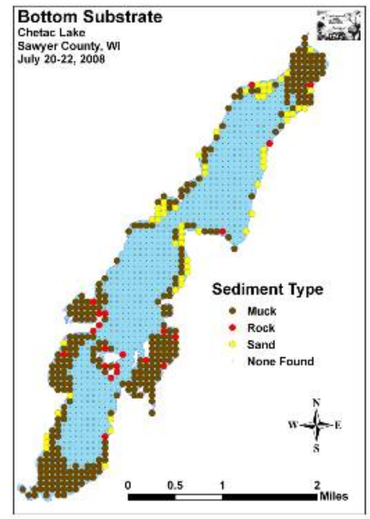


Figure 13 – Bottom Substrate From 2008 ERS Plant Survey

4.3.4 Flora and Fauna

4.3.4.1 Fisheries

Birchwood, Wisconsin situated on the southern tip of Big Chetac Lake, promotes itself as the Bluegill Capital of Wisconsin. The lake receives a great deal open water and ice fishing pressure for bluegills and crappies, as well as larger game fish like walleye, bass and northern pike. According to Frank Pratt, WDNR Fish Biologist for Big Chetac Lake, the lake has a very productive warm water fishery including walleye, largemouth and smallmouth bass, bluegill, and crappie. The lake also contains perch, northern pike, pumpkinseeds, rock bass, and bullheads. The fish stocking summary on the WDNR website states Big Chetac Lake was stocked with walleye between the years 1972-2004. Age classes include fingerling, fry, and small and large fingerlings. The largest amount of fish stocked in a year was in 1980 when 256,000 walleye fry were stocked.

Image taken from Birchwood Area Chamber of Commerce web site at www.birchwoodwi.com

Data from a 1997 WDNR Creel Survey estimates the number of walleyes in the lake to be just over 3,300 or 1.7 walleyes per acre. Of these, 1.2 fish per acre are over a foot in size. The population of walleyes is not naturally producing and depends on stocking. For the twelve stocked lakes listed for Sawyer County in the WDNR Treaty Walleye Population Estimation Report, Big Chetac ranks fourth in adult walleyes per acre. The highest number of stocked walleyes per acre in these twelve lakes is 2.8 walleyes per acre in Sand Lake, the lowest per acre value is 0.4 walleyes on Smith Lake. During the 1997 WDNR Creel Survey which records angler harvest throughout the fishing season, nearly 26,000 northern pike, 12,200 largemouth bass, 5,125 smallmouth bass, and nearly 5,000 walleye were caught. The report did not record panfish caught and harvested. Only about 17% of the fish caught by anglers were kept with an average of 22.5 hours of fishing effort per fish kept by an angler.

4.3.4.2 Natural Heritage Inventory

The Natural Heritage Inventory (NHI) database contains recent and historic element (rare species and plant community) observations. The list was last updated in October, 2009. Each species has a state status ranking with either SC/FL as federally protected as endangered or threatened, but not so designated by state, SC/P as fully protected, SC/N as no laws regulating use, or THR as Threatened. According to the list for Sawyer County in the Big Chetac area, there is one mammal (gray wolf – SC/FL), two bird species (bald eagle – SC/P and osprey – THR), and one fish (weed shriner – SC/N).

4.3.4.3 Wetlands

A wetland is an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions (WDNR). Wetlands have many functions which benefit the ecosystem surrounding the Big Chetac Chain. Wetlands with a higher floral diversity of native species support a greater variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide habitat for feeding, breeding, resting, nesting, escape cover, and travel corridors for mammals and waterfowl, and spawning grounds and nurseries for fish. Wetlands also provide flood protection within the landscape. Due to the dense vegetation and location within the landscape, wetlands are important for retaining runoff from rain and melting snow moving towards surface waters, also decreasing floodwater in area streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes. Wetlands provide shoreline protection because they act as buffers between land and water. They protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This shoreline protection is important in waterways where boat traffic, water current, and wave action cause substantial damage to the shore. Wetlands also provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

Big Chetac Lake has aquatic bed, emergent, shrub scrub, and forested wetlands present all around it (WDNR). Aquatic bed wetlands are wetlands characterized by plants growing entirely on or in a water body no deeper than six feet. Emergent wetlands are wetlands with saturated soil and are dominated by grasses such as redtop and reed canary grass, and by forbs such as giant goldenrod. Shrub scrub wetlands are areas characterized by woody shrubs and small trees such as tag alder, bog birch, willow, and dogwood. Forested wetlands are wetlands dominated by mature conifers and lowland hardwood trees. Forested wetlands are important for stormwater and floodwater retention and provide habitat for various wildlife. Figure 14 shows the location of area wetlands according to the Wisconsin Wetland Inventory.

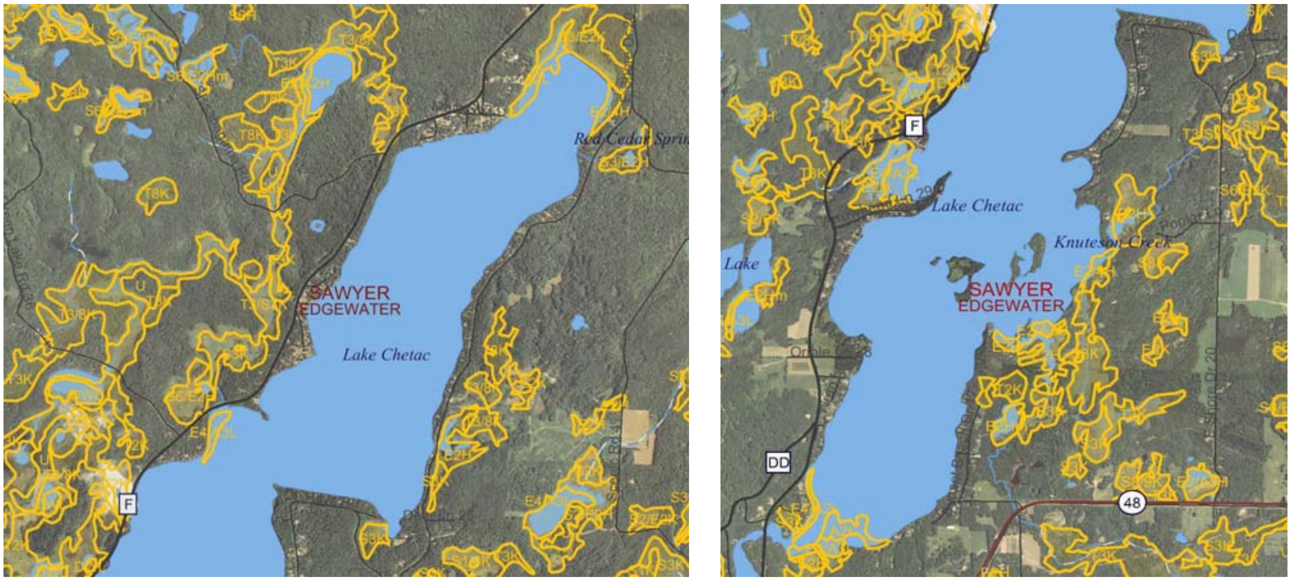
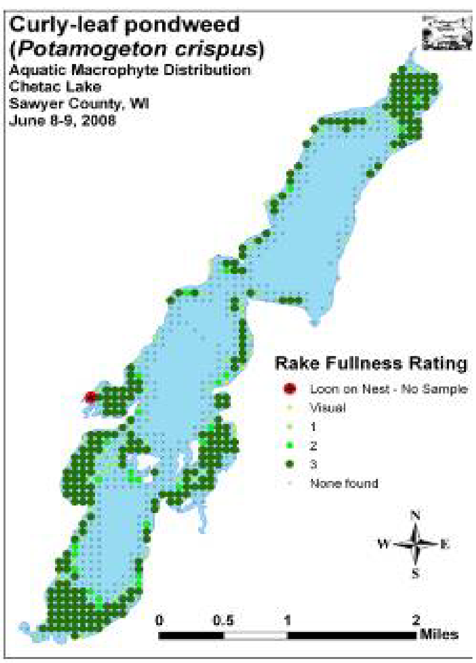


Figure 14 – Wetland complexes around Big Chetac Lake according to the Wisconsin Wetland Inventory

4.3.4.4 Aquatic Plants

In 2008, a point-intercept whole lake aquatic macrophyte (large plant) survey was completed by Endangered Resource Services following WDNR protocol, with data collected in early June and late July (Appendix E). Using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth and total lake acreage, 970 GPS points on a sampling grid were generated for Big Chetac Lake aquatic plant survey. The goals for this survey were to map the abundance and distribution of CLP (an aquatic invasive plant species known to be in the lake in large amounts); determine if Eurasian water milfoil (EWM), another aquatic invasive plant species, had invaded the lake; and to establish initial data on the diversity, abundance and distribution of native aquatic plant populations.



June 2008 CLP Distribution in Big Chetac Lake. ERS 2008

In June, CLP was found at 340 of the 970 survey points, approximately 35% of the lake's total surface. The density of plant material collected from each point by a rake is rated on a 1-3 scale, with 3 being the most dense. Using this ranking system, 30% of the lake's surface had dense growth of CLP. In late July, CLP was found at 269 of the survey points, or approximately 28% of the lake. Many sites which had dense monotypic CLP growth in June did not have any native species growing at them in July after the CLP had died out.

EWM was not found in Big Chetac Lake in the 2008 survey. CLP, small pondweed, and coontail were the most common macrophyte species found during the July survey at approximately 49%, 48%, and 42% of survey points with vegetation respectively (Figure 15). All three species were widely distributed throughout the lake over organic muck. Although many other species were also widely distributed, only CLP, small pondweed, and coontail had a relative frequency (a value that shows an individual species' frequency relative to all other species) over 14%.

Together, these three species combined for over 47% of the total relative frequency of plants in the lake. No other plant species had a relative frequency over 10%.

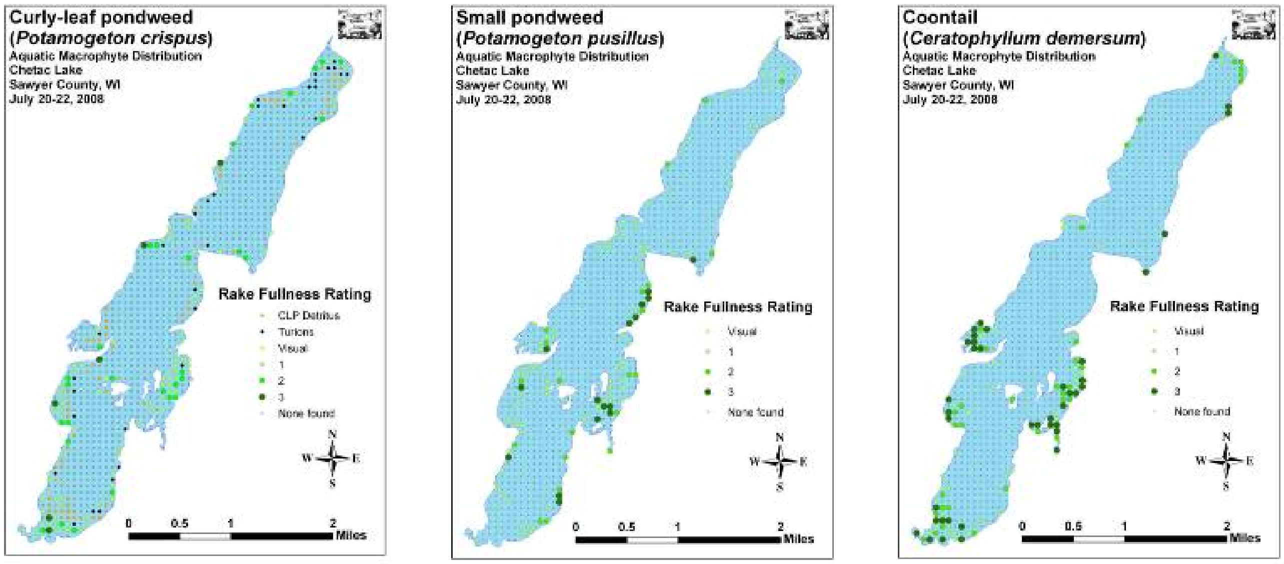


Figure 15 – CLP, Small Pondweed, and Coontail Distribution in Big Chetac Lake

The lakes topography resulted in expansive plant beds in the north basin around the Benson Creek inlet, the eastern bay near the Knuteson and Malviney Creek inlets, the bays west and northwest of the islands, and the south bay near the outlet to Birch Lake. The shallow water and thick organic muck in these areas promoted both plant density and species richness. A total of 44 native plants to species were identified in and immediately adjacent to Big Chetac Lake. They produced a mean Coefficient of Conservatism of 6.5 and a Floristic Quality Index of 43.1. This index measures the impact of human development on a lake’s aquatic plants. Species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and often exploit these changes to the point where they may crowd out other species. The most abundant species’ in Big Chetac Lake, coontail and small pondweed have C’s of 3 and 7 respectively. CLP is not given a C because it is considered an invasive species. Nichols (1999) reported an Average Mean C of 5.6 for the North Central Hardwood Forests Region putting Big Chetac Lake well above average for this part of the state. The FQI was also more than double the mean FQI of 20.9 for the North Central Hardwood Forests Region (Nichols, 1999). This exceptionally high FQI is likely a result of Big Chetac Lake's large size, variable substrate, mixed clarity and diverse water flow conditions. All of these factors create numerous microhabitats which offer suitable growing conditions for a wide variety of aquatic plants. Other than curly-leaf pondweed, reed canary grass was the only other non-native plant species found during the plant survey.

Wild rice (*Zizania palustris L.*) is an aquatic grass which grows in shallow water in lakes and slow flowing streams. This grass produces a seed which tastes good and is a nutritious source of food for wildlife and people. It is highly protected in Wisconsin and has significant cultural implications for the Native American community. The seed matures in August and September with the ripe seed dropping into the sediment, unless harvested by wildlife or people. According to the 2008 aquatic macrophyte survey, wild rice is located in Big Chetac Lake and is common to abundant in the bay east of the islands on the southeast portion of the lake.

Complete summary statistics from the 2008 Big Chetac Lake Aquatic Macrophyte Survey completed in July of that year are provided in Table 2.

Table 2
July 2008 Summary Statistics for Big Chetac Lake Aquatic Plant Survey

Total number of points sampled	970
Total number of sites with vegetation	269
Total number of sites shallower than the maximum depth of plants	392
Frequency of occurrence at sites shallower than maximum depth of plants	68.6
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	12.5
Number of sites sampled using rope rake (R)	0
Number of sites sampled using pole rake (P)	396
Average number of all species per site (shallower than max depth)	2.04
Average number of all species per site (veg. sites only)	2.97
Average number of native species per site (shallower than max depth)	1.55
Average number of native species per site (veg. site only)	2.67
Species Richness	37
Species Richness (including visuals)	42
Species Richness (including visuals and boat survey)	48
Mean depth of plants (ft)	5.9
Median depth of plants (ft)	6.0

4.3.4.5 Algae

While no sampling was completed during this study to specifically identify different algal species in the water, anecdotal observations and results from the 2008 paleoecology core indicated that blue-green and other species of algae are present. During recent summers, the lake has been experiencing severe blue-green algae blooms and during the summer of 2005, the bloom was so bad it caused the Sawyer County Land and Water Conservation Department to place environmental hazard warning signs on the lake due to the high blue-green algae concentrations. During the analysis of the 2008 paleoecological sediment core taken from the north basin of Big Chetac Lake algal remains were examined. Three blue-green algae species, Aphanizomenon, Anabaena, and Microcytis most frequently dominate algae blooms in a lake. In a sediment core, the first two can be identified as they leave fossil remains. Microcytis does not. Fossil remains of the first two were found back in the 1800's, but their numbers decreased and remain low after the installation of the dam in the early 1900's. Microcytis is more competitive under high phosphorous conditions than either of the other two. Garrison and LaLiberte, 2010 suggest that Microcytis has become the dominant blue-green algae in Big Chetac Lake since the early 1900's and since it does not leave fossil remains, levels can only be guessed.

Gloetrichia, another blue-green algae that can reach bloom proportions, was found in relatively high numbers throughout the Big Chetac Lake core. Pediastrum, a green algae that is common in lakes under a variety of nutrient levels, had high levels from the mid-1800's until about 1950. After that, low levels were recorded indicating poor water clarity in the lake because this large algae typically grows on the lake bottom, and needs adequate light penetration to do well (Garrison & LaLiberte, 2010).

4.3.5 Water and Nutrient Budgeting

Determining a budget for a lake, be it a water budget or a nutrient budget, involves determining how much is coming into the lake and how much is going out. During this study, water inputs to Big Chetac Lake included local tributaries, precipitation, and groundwater flow. Water going out included that which goes out through Birch Lake and over the dam, ground water exiting the lake, and evaporation. Residence time is a measure of how long water coming into a lake remains before going out again. Residence time for Big Chetac Lake is estimated to be about four years. In-lake phosphorus mass for the entire lake was calculated at approximately 9,624 lbs based on water sampling at various depths throughout the 2007 summer season.

Phosphorous loading from the following sources were quantified; atmospheric deposition, groundwater flow, tributary loading, near shore contributions, septic systems, curly-leaf pondweed decay, and internal recycling. Figure 16 shows the breakdown for phosphorous loading from these sources.

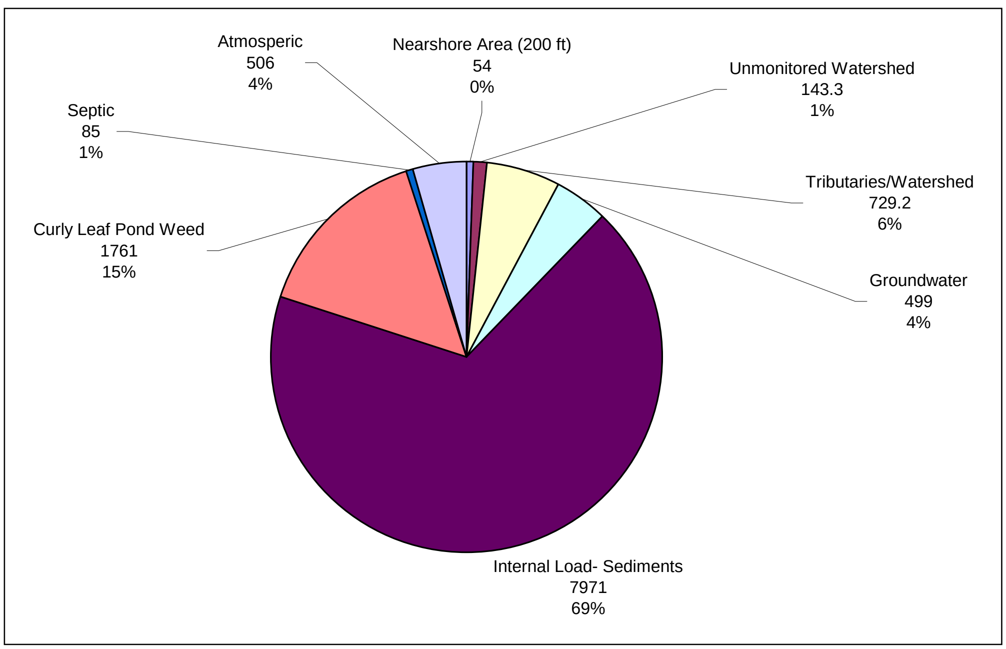


Figure 16 – Total Phosphorus Loading to Big Chetac Lake From Various Sources

Recycling of existing phosphorous from the sediments at the bottom of the lake accounts for approximately 69% of the total phosphorous loading to the lake. A lack of oxygen caused by decaying plant and animal material in the bottom of the lake and high pH levels in the water column lead to an internal release of phosphorous stored in the bottom sediments. A long lake residence time (3 to 4 years for Big Chetac Lake) increases the amount of phosphorous that settles into the bottom sediments instead of being flushed from the system. The phosphorus from the sediment is then distributed or re-suspended throughout the lake by natural processes including turnover, chemical reactions facilitated by a lack of oxygen and high pH values, and waves caused by the wind; and human induced disturbances including waves and disturbances to the bottom by boat traffic. Phosphorous release rates from the sediments calculated in 2007 by the US Army Corp of Engineers (Appendix F) were as high as 19.1 mg/m^2/day under high pH and anoxic conditions. Total days without oxygen in the bottom waters ranged from 5 days a year in the south basin to as much as 90 days a year in the north basin.

Phosphorous contributed by senescence of CLP was the next largest source of phosphorous to Big Chetac Lake at 15%. According to data reported on in the 2008 Paleoecology sediment core, since the 1980's phosphorous is the most significant element that has increased in deposition. In this same time period, organic matter and calcium also increased but not as dramatically. Garrison and LaLiberte, 2010 suggest this could be from increased internal recycling of phosphorous existing in the sediments. What caused greater levels of phosphorous in the sediments to be re-introduced into the lake during this time frame is not completely known, but could be related to the introduction and subsequent takeover of the early season plant community by curly-leaf pondweed. While it is not known what level of CLP was in the lake in the 1980's and before, current levels stand at 600 plus acres or approximately 25% of the entire lake surface each year. Increased levels of CLP since the 1980's could also explain the increased levels of calcium and organic matter noted in the paleoecological report. Curly-leaf pondweed will often have $CaCO_3$ encrustations on it. Waisel et al, 1990 reported encrustations reaching up to 80% of the total CLP leaf dry weight. These encrustations were also reported to contain large amounts of phosphorous (Allenby, 1981). CLP completes its life cycle and begins senescence in the early summer at the same time that bottom waters in Big Chetac Lake start becoming anoxic. Whether this new decay causes the rapid decline in oxygen, or merely aggravates it is unclear. As was stated before, 15% or more of the total annual phosphorous load in Big Chetac Lake could be coming from CLP.

4.3.6 Nitrogen to Phosphorous Ratio

The nitrogen to phosphorous ratio in the lake is an important indicator as to which nutrient controls the abundance of algae found every year in Big Chetac Lake. There is general agreement among limnologists that if the nitrogen to phosphorous ratio in the lake is greater than 10 to 1, than phosphorous is likely to be the limiting nutrient leading to algal growth. If the ratio is less than 10 to 1, it is likely that nitrogen is the limiting nutrient. A limiting nutrient means that the algal growth is dependent on the amount of that nutrient freely available in the water column. The nitrogen to phosphorous ratio for Big Chetac Lake for the most part indicates that it is phosphorous limited with ratios greater than 10 to 1 (Figure 17).

This means that algal growth in Big Chetac Lake is mostly dependant on the amount of phosphorous available in the water column. If the amount of phosphorous goes up the algal growth is likely to go up as well. If it goes down, algal growth will likely go down. There are a couple of times during the open water season where nitrogen may be limiting. In mid May and late September the nitrogen to phosphorous ratio dips below 10 to 1 particularly in the Central and South basins. Chlorophyll *a* values, an indicator of the amount of algae in the system, also go down at these points, though not a great deal.

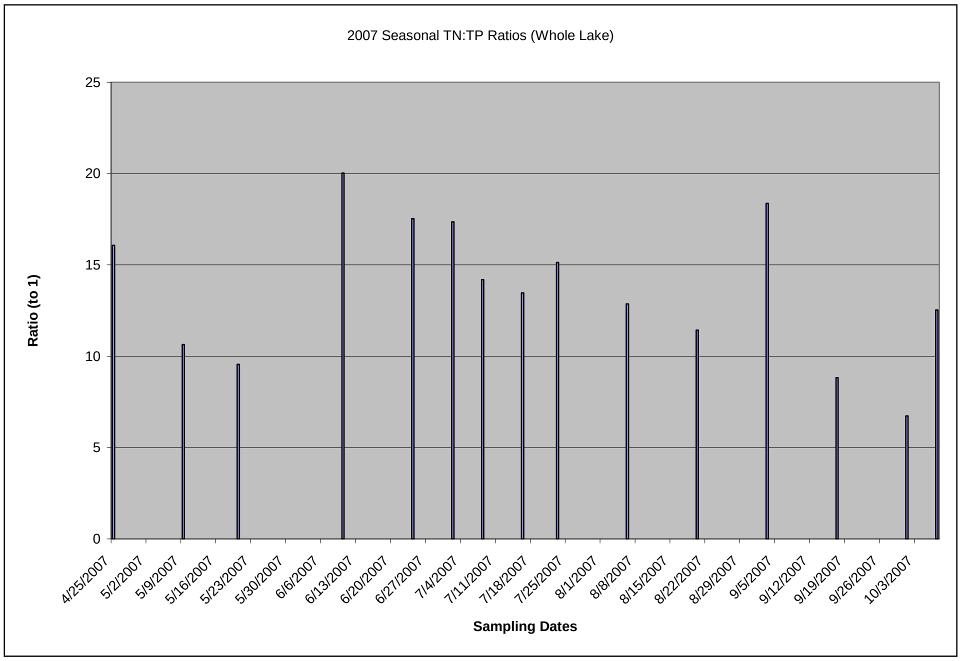


Figure 17 – Seasonal Total Nitrogen to Total Phosphorous Ratios for Big Chetac Lake

4.3.7 Summary

The Big Chetac Chain, and specifically Big Chetac Lake is a naturally eutrophic lake in an overall watershed that is largely still in a natural state. Historical data suggests that nutrients particularly phosphorous and nitrogen have always been available in excess. The excess phosphorous has maintained high concentrations of algae growth in the lake making it very fertile. Water clarity has always been low, limiting the amount of native plant growth that can do well. It has a long lake residence time meaning that phosphorus carried into the system from outside sources has ample time to settle out of the water column and into the sediment at the bottom of the lake before being flushed through and out of the system. Internal recycling of these nutrients is facilitated by long periods of oxygen depletion in the bottom waters of the lake, particularly in the north basin. Early season plant growth is dominated by CLP, an invasive species that senesces early in the summer aggravating already high internal release rates of phosphorous. Spring dominance of CLP also limits more beneficial early season native plant growth in the littoral zone through shading and direct competition. Later season native plant growth is inhibited by reduced water clarity as algae dominance replaces CLP dominance in late June and early July.

4.4 Should Anything be Done to Improve Conditions in the Lake?

Changing Big Chetac Lake from a nutrient rich, algae dominated system to a clear water plant dominated system is not a reasonable goal, given the history and characteristics of it. Setting appropriate goals for lake improvement based on what is desirable and what is politically and economically feasible, is reasonable. Under the assumption that current overall conditions in the lake can be improved, but not significantly changed; that previously unidentified aquatic invasive species like EWM are not desirable in the lake; that the existing fishery is desirable; that the majority of lake users would like to see improvements in water quality that will decrease the number of days where lake use is impaired; and that greater lake understanding will help facilitate these things; the answer to the question above is yes. If something can be done, something should be done. The following goals are reasonable outcomes for management completed in Big Chetac Lake:

- reduce the number of days the lake experiences severe algae blooms (chlorophyll concentrations >30 µg/L) that impact lake use
- reduce the impact of the non-native invasive plant species curly-leaf pondweed
- protect and enhance the native plant population in the lake
- prevent new, undesirable non-native invasive species from entering the lake
- maintain the current fishery
- educate lake residents and users as to how the lake "works" and what they can do to help protect, maintain, or improve the lake

4.5 What Alternatives Exist for Meeting Lake Improvement Goals?

The following section discusses alternatives for meeting each of the goals stated above. Not all of these alternatives are feasible for Big Chetac Lake. Where this is the case an explanation is provided.

4.5.1 Goal 1 – Reduce the Number of Days the Lake Experiences Severe Algae Blooms That Impact Lake Use

To reduce the number of days the lake experiences severe algae blooms, the amount of available phosphorous in the system has to be reduced. There are two main ways to do this, control or reduce external sources of phosphorous and control or reduce internal sources of phosphorous. In most cases, both are needed to improve conditions.

4.5.1.1 Controlling or Reducing External Inputs

External inputs of phosphorous to the Big Chetac Chain include sources that can and cannot be readily managed. Overall, only 16% of the total phosphorous is coming from external sources, the rest is coming from internal loading and from CLP as it decays in the system. External sources measured include the atmosphere, groundwater, near shore contributions (including septic systems), and contributions through surface water runoff from the larger watershed. Little can be done to reduce the amount of phosphorous carried in by groundwater or blown over and carried into the lake by wind and precipitation. These sources contribute approximately half of the phosphorous attributable to external sources. Of the remaining 8%, 7% is coming from the larger watershed through tributary streams and over-land runoff. Only 1% is attributed to the near shore developed area around the lake.

4.5.1.1.1. Promote Best Management Practices (BMP's) in the Watershed That Reduce Phosphorous Loading

The immediate watershed around Big Chetac Lake is mostly in a natural state. Seasonal (May-September) phosphorous loading per acre is approximately 0.038 lbs/acre, extremely low. Agricultural practices in a watershed are often a significant source for phosphorous in a lake. However, only 2% of the total watershed acreage is currently being used for agricultural purposes. Even so, best management practices including no till crop farming, grassed buffers along Big Chetac tributaries, and livestock feeding and manure management strategies to reduce overland runoff could help to reduce phosphorous loading from this area.

More than 75% of the watershed is still in a forested state, much of this is Sawyer County Forestry land. A conscious effort should be made to preserve, protect, and enhance these properties and to preserve additional property through conservation easements, environmental land trusts, and the Wisconsin Stewardship Program. When logging is done in the watershed, the BCCLA should be actively working with the county to insure logging practices minimize disturbance and protect near shore buffers along lakes and streams.

4.5.1.1.2. Promote BMP's in the Developed Near Shore Area That Reduce Phosphorous Loading

Total inputs from the near shore area, the developed portion of the Big Chetac shoreline as compared to the other sources of phosphorous including the overall watershed is very low at less than one percent of the total amount, including contributions from septic systems. However the amount of phosphorous contributed per acre of the near shore area is 0.37 lbs/acre, nearly 15 times greater than the phosphorus contributed per acre in the rest of the watershed. By restoring disturbed shorelines, leaving "no mow" or more substantial buffer strips along the lake's edge, using no fertilizer or phosphorous free fertilizers, diverting runoff form hard surfaces and rooftops, preventing shoreland erosion, and maintaining septic systems in properly working order, the total phosphorous per acre of the near shore area can be reduced. Most of these best management practices can easily be implemented at relatively low costs. The BCCLA should be actively promoting these activities.

4.5.1.2 <u>Controlling or Reducing Internal Inputs</u>

Internal loading of phosphorous from the bottom sediments and from the decay of CLP contribute an estimated 84% of the total phosphorous to the lake. Unfortunately controlling internal sources of phosphorous is not an easy or inexpensive activity. The following management activities have been used, but not all are feasible or practical for the Big Chetac Chain.

4.5.1.2.1. Increasing the Flushing Rate

The flushing rate of a lake is related to its retention time. The longer water stays in a system, the more opportunity there is for the phosphorous in that water to settle out into the bottom sediments or to be utilized for growing algae. One researcher suggested that blue-green algal dominance is never observed in lakes where hydraulic retention time is shorter than five days, even though such lakes can have very high nutrient concentrations (Scheffer, 1998). Flushing a lake with relatively clean water can decrease nutrient levels and even wash out certain slow-growing algal groups. Often there is a noticeable reduction in algae following a large rain event as the retention time in the lake is shortened by the added runoff. US Army Corp of Engineer work completed in Rice Lake, Barron County, Wisconsin showed that lake retention time under normal conditions was in the range of one month, but decreased to only a few days after a significant rain event. Of course Rice Lake is an impoundment on the Red Cedar River, not in the headwaters, therefore the river serves as the single largest source of water to the lake. It should be noted that the flushing in this sense can also add a great deal of phosphorus laden sediment to a body of water, adding phosphorous at the same time it is removing it.

There is no single source of water to Big Chetac Lake that is comparable to the Red Cedar River. Even if there was a source for low nutrient water that could be diverted into Big Chetac Lake to increase flushing, there would be major concerns about what sending increased levels of nutrient rich water downstream would do to Balsam, and Red Cedar Lakes. This management alternative is not feasible for Big Chetac Lake

4.5.1.2.2. *Hypolimnetic Withdrawal*

Increasing the flushing rate in the lake affects the surface waters coming in and going out of the lake. Removing nutrient rich bottom water from deeper, stratified basins in the lake during long periods of oxygen depletion with the use of large capacity pumps and hoses is another way to approach the removal of nutrient rich water. Called hypolimnetic withdrawal, it is an in-lake restoration technique based on the selective discharge of bottom water to enhance the removal of nutrients that build up when the bottom waters becomes anoxic (Nurnberg, 2007). Comparison of water quality variables before and during treatment in about 40 European and 8 North American lakes indicates that hypolimnetic withdrawal is an efficient restoration technique in stratified lakes (Nurnberg, 2007), but it does have some negative consequences.

In order to be effective, surface water outlets have to be blocked to compensate for the additional water removed from the deeper basins. It would be difficult to block the outlet from Big Chetac Lake to Birch Lake in order to take water from just Big Chetac Lake. Birch Lake is deeper and suffers the same problems that Big Chetac experiences. While it may be possible to block the flow of water over the Birch Lake dam and remove it instead from the deeper Birch Lake basin, the benefits of doing so would be very limited. In addition, consideration needs to be given for where to divert the pumped water and its impact on downstream waters, including eutrophication, temperature increase, oxygen depletion, and odor development. One factor deemed critical to the success of this technique is avoiding extreme temperature changes in the water column (Nurnberg, 2007). This may be of little consequence in Big Chetac Lake, but in the smaller and much deeper Birch Lake it could be.

4.5.1.2.3. *Prevent Oxygen Depletion in the Bottom Waters*

Techniques employed to solve or reduce oxygen depletion in bottom waters of a lake can be broadly grouped into three categories: artificial de-stratification, hypolimnetic aeration, and hypolimnetic oxygenation (Beutel, 2002).

The simplest method is artificial de-stratification where compressed air is injected through perforated pipes or course diffusers located at the bottom of the water column. Induced mixing from rising air bubbles produces vertical mixing, thereby inhibiting the formation of thermal stratification. De-stratification increases bottom water dissolved oxygen (DO) by redistributing photosynthetically produced oxygen from surface to bottom waters, as well as increasing contact time between water and the atmosphere. The main drawback of artificial de-stratification is increased summer temperatures in bottom water. Higher temperatures degrade cold-water fishery habitat, and warm discharges from de-stratified reservoirs may impair downstream biota (Beutel, 2002).

Hypolimnetic aeration is another common management strategy used to maintain oxygen levels in the bottom waters while preserving thermal stratification. The technique uses a confined air-lift system where air bubbles are injected at the bottom of an air-lift tube, and oxygen is transferred to the water as the air-water mixture travels up the tube. Aerated water is then redistributed into the bottom waters. Lake managers have utilized both full-lift systems that raise the water to the surface and partial-lift system that raise water up to around the point of stratification known as the thermocline. This method may eliminate the warming of bottom waters, but has a number of potential problems associated with it. Oxygen transfer rates are low for most hypolimnetic aeration techniques. Thus, aeration units may need to operate at high recirculation rates and/or multiple units may be required. This leads to elevated levels of turbulence within the bottom waters which can increase sediment oxygen demand or result in accidental de-stratification. A number of aeration systems have been unable to maintain even low levels of DO in the bottom waters. The introduction of compressed air which predominantly consists of nitrogen may also lead to elevated levels of dissolved nitrogen gas in the bottom waters and the formation of gas bubble disease in fish (Beutal, 2002).

Hypolimnetic oxygenation is a relatively new aeration technique used to prevent depletion of oxygen in bottom waters. Lake oxygenation systems generally consist of a liquid oxygen storage facility on shore. Evaporators transform the liquid oxygen to gas, and the gas is dissolved into lake water through an on-shore contact chamber, a system of diffusers located under water, or a contact chamber submerged in the lake. Like hypolimnetic aeration, it preserves thermal stratification, however pure oxygen rather than air is used. As a result of higher oxygen solubility and higher system transfer efficiencies, the size of the mechanical devices and recirculation rates needed to deliver an equivalent amount of oxygen using pure oxygen rather than air are greatly reduced. This avoids a number of the disadvantages associated with traditional aeration systems. Lower recirculation rates minimize turbulence introduced into the bottom waters, thereby minimizing induced oxygen demand and the chance of accidental de-stratification. High oxygen delivery rates and low induced oxygen demand allow for the maintenance of high levels of DO in oxygenated bottom waters throughout the stratified period. Additional advantages of hypolimnetic oxygenation include avoidance of hypolimnetic dissolved nitrogen supersaturation in the bottom waters that can cause gas bubble disease in fish, low energy use, and low commercial oxygen costs (Beutel, 2002).

Not all researchers agree that hypolimnetic aeration or de-stratification works. More research into the costs and benefits from pursuing one of these techniques needs to be done before deciding to use one of these in Big Chetac Lake.

4.5.1.2.4. Sediment Sealing

Sediment sealing means the physical or chemical isolation of the sediment and the nutrients bound by it from the water (Moss et al, 1996). Physically separating the sediment from the water can be done by placing plastic sheeting or by providing for a thick layer of some other barrier forming material like fly ash (the solid waste product from coal burning facilities). This technique is inappropriate when improving habitat for native plants and creatures is also a goal of lake improvement.

Chemical sealing means introducing a nontoxic material to the sediment to facilitate the binding of excess phosphorous in the sediment in a form that cannot be recycled back into the water column. One nontoxic material that has been used with some success is aluminum sulfate or “alum”. On contact with water, aluminum sulfate is broken down into another chemical compound that forms a fluffy precipitate called “floc”. As the floc slowly settles it removes some phosphorous from the water and collects suspended particles in the water and carries them down to the bottom of the lake. Once on the bottom the floc forms a layer that acts as a phosphorous barrier by combining with the phosphorous as it is released from the sediment (WDNR, 2003).

Under proper use guidelines, alum has not been shown to cause any long-term negative impacts to aquatic life or human life. The biggest problem is determining how much alum to use, and trying to establish how long the alum treatment may be effective. Research suggests that if proper amounts are applied and other external sources of phosphorous have been removed or minimized then it is possible to achieve an average of 8 years of controlled phosphorous in both shallow and stratified lakes. The biggest factor in unsuccessful projects was failing to control external sources of phosphorous to the treated lake.

Costs associated with alum treatments range from $280 to $700 an acre depending on the dosage requirements and costs to mobilize equipment (WDNR, 2003).

4.5.1.2.5. Sediment Removal

Sediment removal or dredging can be an effective tool for reducing internal phosphorous loading in lakes. All the previously mentioned techniques for reducing phosphorous levels in a lake come with a great deal of risk of failure. Removing the phosphorous enriched surface layers of sediment can permanently reduce the total available phosphorus in a lake system. It could also remove a great deal of the CLP turions that have built up in the system. However, it is a very expensive management technique and one that is not readily supported by the WDNR for a number of reasons.

4.5.1.2.6. Biological Manipulation

Biological manipulation or biomanipulation means any adjustment of the biological community in an ecosystem to achieve a desired end. For lakes, it principally means altering the fish community to increase the numbers of grazer zooplankton (tiny water creatures that feed on algae), particularly Daphnia species in the water. The goal is to reduce the amount of algae in a system by increasing the number of zooplankton that feed on it. The primary way to increase zooplankton is by decreasing the number of planktivorous fishes that feed on the zooplankton. To decrease the number of planktivorous fishes, the number of piscivorous fishes that feed on planktivorous fishes must be increased. This goal can be achieved by stocking piscivorous fish or by removing planktivorous fish. Fish populations in Big Chetac Lake are already manipulated by walleye stocking and fish size and bag restrictions. However, there is also a general acceptance and satisfaction with the current fishery in the lake, which includes a substantial pan fish fishery. Bluegills, sunfish, and crappies are considered planktivorous fish species, particularly when they are small.

Many factors can influence the success of biomanipulation. Certain algae species, including some of the blue-greens, are not fed on by zooplankton grazers. Once planktivorous fish species have been removed there may be an increase in other predators of the desired zooplankton. Wind and wave induced turbidity can negatively affect the desired population of zooplankton, as can the presence of non-native species, disease, and parasites (Moss et al, 1996).

No official work has been completed to identify the current make-up, distribution, and size structure of the zooplankton population in the Big Chetac Lake Chain. If biomanipulation is to be considered in the future, a study of this nature needs to be completed. Another potential issue is that the algal species that is most prevalent in Big Chetac Lake, according to the 2008 paleocore work, is not one that daphnia feed on. Furthermore, a great deal of discussion would need to be had before attempting to manipulate what is already considered to be a tremendous warm water fishery.

Another form of biomanipulation is to introduce barley straw to a lake or pond. While there is little dissent that barley straw can in fact reduce algae biomass, there is great discussion as to how much is needed and its overall effectiveness. There are several theories for why barley straw, at least in small scale applications works. One suggests that decomposing straw uses up nutrients in the water so they are not available for algae growth. Another suggests that decomposing straw gives off compounds toxic to algae (Scheffer, 1998). In order to be successful in Big Chetac Lake, huge amounts of barley straw would have to be placed in the water all around the lake.

4.5.2 Goal 2 – Aquatic Plant Management to Reduce the Impact of Curly-leaf Pondweed

While there is no evidence to support it, at 600 acres, early season CLP growth is likely one variable that has changed significantly in the last 30 years. It is impossible to know when CLP was first introduced to the system, but it is easy to tell that it has had a negative impact on water quality and more desirable native plant growth. At the same time, it may have positively impacted the fishery from the pan fish angler’s point of view. Removing all CLP from the lake is likely not possible, nor entirely beneficial, however, reducing its current level of growth whereby some of the negative consequences are minimized may be one of the best ways to improve the lake, short term. This consultant is not aware of any past plant management other than land owner removal and the occasional use of aquatic herbicides on an individual land owner basis.

4.5.2.1 Aquatic Plant Management Alternatives

When addressing non-native invasive plants like EWM and curly-leaf pondweed management often includes an attempt at complete removal. Eradication is generally not a feasible goal, but large-scale removal is. Both of these plants negatively impact native plant species that provide many benefits to the lake. Early season removal can minimize some of these impacts by opening up the lake canopy to allow for the greater light penetration needed for native plant growth.

While protection of native plants should be a primary focus of plant management, certain native plants can cause lake use and navigation issues of their own. Submersed aquatic plants like coontail, northern watermilfoil, Canadian waterweed, and certain floating leaf plants like watershield and water lilies can cause problems. Emergent plants like pickerel weed, arrowhead, various bulrushes, and wild rice may be considered a nuisance by some riparian owners, but in general are extremely beneficial to a lake and removal should be minimized. In the case of wild rice, it is a highly protected emergent aquatic plant species and basically untouchable. If native plants are to be targeted for management (i.e. removal), clear documentation of the navigational and nuisance level growth issues is necessary.

Regardless of the target plant species, native or non-native, sometimes no management is the best management alternative. Areas considered critical habitat for fish and wildlife may best be left alone. Only if management of non-native plant species in critical habitat areas is expected to benefit that area, should it be considered.

Control methods for nuisance aquatic plants can be grouped into four broad categories: aquatic plant habitat manipulation; biological control; chemical control; and mechanical/physical control. Examples of plant habitat manipulation include dredging, flooding and drawdown. Biological control methods include organisms that use the plants for a food source or parasitic organisms that use the plants as hosts. Biological control may also include the use of species that compete successfully with the nuisance species for resources. Chemical control is typified by the use of herbicides. Mechanical and physical control methods include pulling, cutting, raking and harvesting. In many cases, an integrated approach to aquatic plant management is necessary.

Not all plant management alternatives can be used in a particular lake. What other states accept for aquatic plant management may not be acceptable in Wisconsin. What is acceptable and appropriate in southern Wisconsin lakes may not be acceptable and appropriate in northern Wisconsin lakes. The WDNR has a Northern Region Aquatic Plant Management Strategy (Appendix G) that went into effect in 2007. All aquatic plant management plans developed for northern Wisconsin lakes are evaluated according to the goals of this strategy which are as follows:

- Preserve native species diversity which, in turn, fosters natural habitat for fish and other aquatic species, from frogs to birds.
- Prevent openings for invasive species to become established in the absence of the native species.
- Concentrate on a" whole-lake approach" for control of aquatic plants, thereby fostering systematic documentation of conditions and specific targeting of invasive species as they exist.
- Prohibit removal of wild rice. WDNR – Northern Region will not issue permits to remove wild rice unless a request is subjected to the full consultation process via the Voigt Tribal Task Force. We intend to discourage applications for removal of this ecologically and culturally important native plant.

4.5.2.1.1. Manual Control and Management

Except for wild rice, physical removal of aquatic plants via human power (hand-pulling, raking, or cutting) is allowable in Wisconsin under guidelines provided for in NR 109 (Appendix H). Removal of native plants must be confined to an area not more than 30 ft wide measured along the shoreline including that area which contains boat access to a pier or dock, swimming area, or other recreational use area and not adjacent to an area where plants have been removed by another method. Removal of dislodged aquatic plants that drift on-shore and accumulate is allowed, as is the removal of any amount of EWM, CLP, or purple loosestrife, if it is done in a manner that does not negatively impact other native plant species. Removal of aquatic invasive species by snorkeling or scuba diving is also allowable without a permit. Any plants that are cut or dislodged must be removed from the water so as not to infringe upon the rights of other riparian owners.

Lake User Survey results suggest about 42% of the lake shore owners have tried to remove vegetation by their property. Lake riparian owners should be actively involved in the physical removal of aquatic plants near shore that are considered non-native or reaching nuisance level growth. The physical demands of this type of removal limits the extent to which it can be successfully be done. Shallow, hard-bottom areas near shore are best suited for this type of control and the impacts to the vegetation in the larger lake are minimal. Mulching of the plants removed can provide excellent compost. Pulling, cutting, and/or raking are important physical plant control measures but not always easy to complete and very time consuming on the part of the riparian owner.

4.5.2.1.2. *Large-Scale Mechanical Control and Management*

Mechanical removal of aquatic plants involves the use of motorized accessories to assist in vegetation removal. The most common form of this is the use of large-scale mechanical weed harvesters on the lake. Harvesting assumes that vegetation is cut and removed from the system after cutting. Harvesters are driven by modified paddle wheels and include a cutter that can be raised and lowered, a conveyor system to capture and store cut plants, and the ability to off-load the cut plants. The depth at which these harvesters cut generally ranges from skimming the surface to as much as five-feet deep. Harvesters can remove thousands of pounds of vegetation in a relatively short time period. They are not, however, species specific. Everything in the path of the harvester will be removed including the target species, other plants, macro-invertebrates, semi-aquatic vertebrates, forage fishes, young-of-the-year fishes, and even adult game fish found in the littoral zone (Booms, 1999). While relatively maneuverable in open water, the sheer size of the machines limits the area they can operate. They are most effective in larger lakes with ample littoral zone depth and where the target species is almost mono-typical.

While large-scale harvesting can remove large amounts of vegetation, re-cutting several times a season is often required to provide adequate annual control (Madsen, 2000). Large-scale plant harvesting in a lake is similar to mowing the lawn. Plants are cut at a designated depth, but the root of the plant is often not disturbed. Cut plants will usually grow back after time, just like the lawn grass. Harvesters can be effective at removing large masses of floating vegetation including CLP near the end of its life cycle. When considering a large-scale harvesting operation, much consideration needs to be given to the timing of harvesting. CLP has a 2-4 week window where harvesting can be most effective. Removing plants when they have reached peak growing mass, yet not begun to produce turions, provides the most benefit for long-term relief.

Large-scale harvesting often leaves large amounts of floating fragmented vegetation to move about the lake and wash up onto shorelines. Removing washed in fragments from beaches and lake fronts can be an arduous task for riparian owners. Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (Madsen, 2000).

Part of the effect of harvesting is the alteration of underwater habitat. Some research indicates that after cutting, reduction in available plant cover causes declines in fish growth and zooplankton densities. Other research found that creating deep lake channels by harvesting increased the growth rates of some age classes of bluegill and largemouth bass (Greenfield et al, 2004).

When considering large-scale mechanical harvesting as a control measure considerable thought must go into the transfer and disposal of plant material. This plant material is generally more than 90% water and not suitable for feed, and often cannot be sold or made into anything useful. It does make good mulch or compost provided all the dead fish material is removed. Off loading sites for the lake must be approved by the WDNR as does the disposal site. Transporting harvested vegetation from the lake to an appropriate disposal site and the equipment necessary to do it must be included in costs associated with large-scale harvesting.

Large-scale harvesting can be accomplished in two ways. Harvesting operations can be contracted, or harvesting equipment can be purchased by the Lake Association, who then must provide maintenance and storage, driver operation and training, and harvesting documentation. Without the cost associated with the purchase of equipment included, a 2009 comparison between costs associated with contracted vs. ownership harvesting was completed by Freshwater Science Inc, LLC in Minnesota. Contracted costs averaged $390.00 per acre. Ownership costs averaged $480.00 per acre. Costs associated with the purchase of harvesting equipment depends on size and number of harvesters needed, whether they are purchased new or used, and what type of support equipment including trailers, storage sheds, weed conveyance systems, trucks for hauling, etc are needed, but could range in the tens of thousands to hundreds of thousands of dollars. Ownership of the necessary equipment enables the cost of that equipment to be spread out over the life of the machine. Contracted harvesting creates additional risks and inconveniences including introduction of other unwanted invasive species and not having full control over when and how the harvesting is completed.

While it would be difficult to remove 600 acres of CLP from the lake without multiple harvesters, a single harvester used to open up navigational channels and fish lanes in certain parts of the lake including the narrows leading into Birch Lake, would be beneficial.

4.5.2.1.3. Other Mechanical Management and Control Alternatives

Cutting without plant removal, grinding and returning the vegetation to the water body, and rotovating are other methods employed to control nuisance plant growth in some lakes. Cutting is just like harvesting except the plants are left in the waterbody. Grinding incorporates cutting and then grinding to minimize the biomass returned to the lake. Rotovating works up bottom sediments dislodging and destroying plant root crowns and bottom growth. All three of these alternatives have major drawbacks in Wisconsin lakes. Cutting and grinding leave behind a tremendous mess and do nothing to minimize phosphorous input from large mats of decaying plants. Rotovating disrupts the bottom dwelling benthic community in a lake, disturbs the sediment/lake water interface increasing turbidity and re-suspension of sediments, and facilitates nutrient release from those sediments. Without removal, cut fragments freely distribute to other areas of the lake through wind, wave, animal, and boat action.

Small-scale mechanical devices including bottom rollers and surface sweepers are available and are usually attached to the end of a dock or pier and sweep through an area adjacent to the dock. Bottom rollers are usually driven by electric motors and run at least once a week. Continued disruption of the bottom area usually causes plants to disappear and light sediments to be swept out. The use of rollers may disturb bottom dwelling organisms and spawning fish. Plant fragmentation of nuisance weeds may also occur. Furthermore, in soft bottom areas, sediment disturbance can be significant.

A lake sweeper is an automatic weed control device that may be attached at one end to a dock or other fixed location and consists of a 24'-42' metal pole that moves forward and reverse in a 270-degree arc. A pump provides the force to move the floating pole back and forth. Instead of rolling along the sediment, the Lake Sweeper floats along the lake surface, with a series of lightweight rakes dragging behind it.

Another form of mechanical harvesting is using diver operated suction harvesting (also referred to as suction dredging) to remove aquatic plants. Plants are removed directly from the sediments by divers operating a vacuum like device. The technique can be very selective with divers choosing what plants to individually remove. It can be an excellent method for removal of small beds of plants or areas of scattered clumps of plants to large for hand harvesting (Madsen, 2000). However, this system is very slow and labor intensive, and expensive. Associated costs can range from $1,000 to $25,000 per acre, exclusive of the equipment costs (NYSDEC, 2005).

Currently the WDNR does not support the use of bottom rollers or surface sweepers. Limited suction harvesting is being permitted on a trial basis. Bedsprings and four-wheelers and similar set-ups are generally not permitted by the WDNR. Plant loss and sediment disturbance caused by routine boating between a riparian owners dock and open water is not subject to any regulation.

4.5.2.1.4. Chemical Control and Management

Chemical management techniques have changed dramatically in the past 20 years. Increased concern about the safety of pesticide use in the 1960's and 1970's changed the review process for all pesticides, particularly for products used in water. 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 (Madsen, 2000). In 1976, 20 active ingredients were available for aquatic plant control, as of 1995, only six are available with one additional compound (triclopyr) currently undergoing the registration process in many states. These compounds have undergone rigorous testing to enable them to be approved by the Environmental Protection Agency (EPA) for use in aquatic settings.

The six or seven active ingredients that have been approved by the EPA, not only are ensured safe for aquatic use but also have manufacturers committed to the aquatic market. It is important to remember, however, that these products are only considered safe when used according to the label accompanying the product. The EPA approved label provides guidelines for protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. In most states, there exists additional permitting or regulatory restrictions on the use of these herbicides. A typical state restriction requires that these herbicides be only applied by licensed applicators. Annual updates from state regulatory and environmental agencies are necessary to check for changes in label restrictions and application policies or permit requirements, before developing or implementing any plans for applying herbicides (Madsen, 2000).

Herbicides labeled for aquatic use can be classified as either contact or systemic. Contact herbicides act immediately on the tissues contacted, typically causing extensive cellular damage at the point of uptake but not affecting areas untouched by the herbicide. Typically, these herbicides are faster acting, but they do not have a sustained effect, in many cases not killing root crowns, roots, or rhizomes. In contrast, systemic herbicides are translocated throughout the plant. They are slower acting but often result in mortality of the entire plant (Madsen, 2000).

Herbicides are applied in either liquid or granular form. In most cases, the chemicals are applied to the water directly overlying the problem area. Most granular herbicides are activated through photodegradation of the granular structure, releasing the active chemical. These chemicals either elicit direct toxicity reactions or affect the photosynthetic ability of the target plant. The plants die and degrade within the lake. Some herbicide residuals sink to the lake sediment, providing some additional temporary control of vegetation.

When properly applied, certain herbicides can control aquatic vegetation without harming the fish and other wildlife. In some instances, herbicides can be used selectively to control certain plant species without killing others. Aquatic herbicides can be part of an integrated management plan where some areas are treated and others are left with vegetation or treated with another method. They can be particularly effective for controlling aggressive weed species such as EWM. Aquatic herbicides offer temporary solutions. Plants will reappear, and re-treatment or application of another control method will usually be necessary.

Correct timing of the chemical application is important, since seeds can germinate and roots can sprout even when the parent plants are killed off. The specific time for the application will depend on the specific target weed, required dosage rate, water temperature, water chemistry characteristics of the lake, weather conditions, water movement and retention time, and recreational use of the lake. Curly-leaf pondweed has a growing season from mid-fall through early summer, while EWM usually grows from early spring through the end of the summer. Herbicide applications must consider the timing of the growing season relative to the algae levels (since photodegradation of herbicides may be slower when algae reduces lake clarity), ice cover, and the effect the chemical application will have on the recreational use of the lake. Most herbicides have restrictions on the use of the water body immediately after treatment, lasting up to 30 days, depending on the dose rate or use of the lake (NYSDEC, 2005).

Chemically-treated lakes may experience some significant side effects. Because herbicides kill plants primarily through toxic response, the toxicity of the herbicide to non-target plants and animals can be of great concern. Non-target plants may not be resistant to the herbicide. If a wide variety of plant species are eradicated by herbicide treatment, the fast-growing ("opportunistic") exotic species that were the original target plants may re-colonize the treatment area and grow to levels greater than before treatment (NYSDEC, 2005).

Short-term impacts of aquatic herbicides have been fairly well studied for most of the inhabitants of lakes and the surrounding environment. If a herbicide is applied according to proper guidelines, the potential for harm to other organism is deemed to be an “acceptable risk”. In general, humans and most animals have high tolerance to the toxic effects of herbicides presently approved for use in lakes.

Herbicide costs will vary with the chemical brand and form (liquid or granular), required dose rate, applicator fees, frequency of application, and the amount of pre and post treatment monitoring and assessment that is done. Typical costs for using herbicides are approximately $400-700 per acre of treated area with the majority of these costs associated with the raw materials.

4.5.2.1.5. EPA Approved Aquatic Herbicides Appropriate for Use in Big Chetac Lake

Endothall is contact herbicide. Its common trade name is Aquathall K or Super K, or Hydrothall. Endothall is a broad spectrum herbicide most commonly used to kill pondweeds like curly-leaf. It is also used to kill EWM, coontail, wild celery, and some species of algae. It is not effective on roots, rhizomes, or tubers. Unlike Diquat, another contact herbicide, it is not affected by particulates or dissolved organic material. It should not be used in tank mixtures with copper, as it can have an antagonistic reaction with chelated copper compounds. Combined early season treatments using 2,4-D and Endothall have been used with some success to control both EWM and CLP when present in the same area (Skogerboe & Getsinger, 2006).

Fluridone is another aquatic herbicide used to control problem EWM and CLP growth. Fluridone is applied to the entire body of water in a liquid form at very low doses. Contact time with the target species may need to be maintained for three months or more. Initial treatments may begin as early as April with additional treatments to maintain the desired concentration. While there are no swimming, fishing, or drinking water restrictions when fluridone is in the water, the label warns against using the water for irrigation for seven to thirty days after treatment. Even at the low fluridone concentrations used to treat milfoil, some terrestrial plants may be sensitive to fluridone if they are watered with treated lake water.

Complexed copper compounds include a variety of formulations from different companies, under different names and labels. It is very effective for algal control and somewhat effective for several vascular plants (particularly hydrilla), and can be used in combination with some other herbicides to increase its effectiveness.

Glyphosate is not effective on submersed plants. It is used for control of emergent or floating leaf plants like purple loosestrife, cattails, phragmites, and lily pads. Glysophate is the herbicide found in the Round-Up (trade name) that is available over the counter for terrestrial weed control. A water-safe version of it called Rodeo is commercially available, but not from the average retail store. The Rodeo form of glysophate must be used when on or near water. It is not legal to use Round-Up on or near water. A surfactant and dye are usually added to it to make it stick to the target vegetation better and to make it more visible after application. Glysophate can be applied in a foliar spray or painted or dabbed onto a cut stem or stems. It is a systemic herbicide drawn into the plant and to the roots, so it will kill all parts of the target plant if applied correctly.

Follow-up monitoring should track the fate of any applied chemical, changes in plant communities, water quality conditions, and impaired uses. The effectiveness for any given herbicide treatment varies with the treatment design, and the conditions of the lake and treatment site. There are other aquatic herbicides that are approved for use in Wisconsin, however they not necessarily appropriate for use in Big Chetac Lake at this time (Appendix I).

4.5.2.1.6. Aquatic Plant Habitat Disruption

Aquatic plant habitat disruption involves management activities that alter the environment in which aquatic plants are growing which in turn acts upon the plants. Several techniques are commonly used: drawdown or flooding, dredging, benthic barriers, shading or light attenuation, and nutrient inactivation. While not prohibited in Wisconsin, these plant management alternatives will undergo much greater scrutiny by the WDNR, and in most cases will not be permitted.

Drawdown is an effective aquatic plant management technique that alters the plant's environment. Essentially, the water body has all of the water removed to a given depth. It is best if this depth includes the entire depth range of the target species. Drawdown, to be effective, needs to be at least 1 month long to ensure thorough drying. In northern areas, a drawdown in the winter that will ensure freezing of sediments is also effective. Drawdown requires that there be a mechanism to lower water levels. Although it 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. Drawdown may provide an opportunity for the spread of highly weedy or adventitious species, particularly annuals (Madsen, 2000).

Drawdown can be very economical as it does not require any large expenditure of money for the actual lowering of the water, assuming there is a dam outlet structure that will allow for the desired level of drawdown. Based on this consultants observations, the Birch Lake dam structure within the Village of Birchwood does have the capability of substantially lowering the water level of the Big Chetac Chain of Lakes (personal observations 5/27/2010). As earlier stated, it is desirable to lower the lake level far enough to impact a substantial portion of the target species habitat. The target species would be curly-leaf pondweed. The average depth of CLP growth for all sites is approximately 8.25 ft. The optimal growth range is 3-11 ft with plants identified in as much as 15 ft of water. If a drawdown were to occur it would have to be substantial enough to negatively affect turion growth. A drawdown of 8.5 ft would impact 71% of the sites with CLP in 2008. A drawdown of 6.5 ft would impact about 35% of all sites with CLP in 2008.

The water level in the Big Chetac Chain of Lakes is drawn down each fall. In 2009, drawdown began on October 9 (personal observation May 2010). At this time, it is not known by how much the lake level was or is lowered. Some preliminary calculations were made by this consultant to determine how much water would have to be removed from the Big Chetac Chain of Lakes to lower the lake level by 6.5 ft. The total volume of water removed from the Chain would be in the neighborhood of 2.3 billion cubic feet. This volume includes the lowering of Birch and Big Chetac Lakes by 6.5 ft and allowing nearly 38,500,000 cubic ft/day of water coming in from the tributaries to pass through. The dam structure could potentially release water through a 65 square foot opening given the dam chute is 10-ft wide. If the opening could be created instantaneously, then approximately 50,500,000 cubic ft of water would have to pass through it each day for 60 days to lower the lake level by 6.5 ft. The velocity going through the dam gate would be approximately 9.0 ft/second. A longer time period to complete the drawdown could be considered, but then the level of nutrients in the water being removed from the Big Chetac Chain and passed downstream would be much higher than it is in the fall.

The environmental impacts caused by such a withdrawal could be many. There are two more dam structures on the Red Cedar River within 25 miles of the Birch Lake dam. Water from the Big Chetac Chain would have to pass through Balsam, Red Cedar, and Rice Lake before gaining the open water of the river, unaffected by dams, until it reaches Lake Menomin in Menomonie, WI. It is very likely that the dam in Mikana on Red Cedar Lake, and the dam on Rice Lake would have to be opened at the same time to accommodate the additional flow through. Erosion along the river could increase substantially with the amount of water and velocity that would be necessary to make the drawdown work. At 6.5 ft, 48, 59, and 68 % of the total volume of water in the North, Central, and South basins respectively would be drained. Approximately 25% of the total Birch Lake volume would be drained. Filling the lake back up again in the spring would also take a great deal of time.

Once the drawdown is completed, there is no guarantee that it would successfully kill the desired amount of CLP. Early snow cover could prevent the exposed sediment from freezing for a long enough period of time to impact turions embedded in the mud. In some cases, drawdown has actually increased the amount of CLP growth in the following year (J. Johnson May 2010 personal communication). A drawdown would also impact the few remaining native species in the lake as most are present in shallow bays that would be drained by a 6.5 ft drawdown.

Combining a drawdown with herbicide application and/or harvesting may be a possibility. One concern would be the amount of herbicide that would be needed to account for the fact that the lake would be refilling during the timeframe where chemical treatment of CLP would be most effective. In Wisconsin, the use of a drawdown of this scale to control aquatic plants would likely not be approved without completing an Environmental Assessment to determine all the possible impacts a drawdown could have.

Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, have inadequate pelagic and hypolimnetic zones, need deepening, or require removal of toxic substances. This method is effective in that dredging typically forms an area of the lake too deep for plants to grow, thus opening an area for riparian use. By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community. Results of dredging can be very long term. Biomass of Potamogeton crispus in Collins Lake, New York remained significantly lower than pre-dredging levels 10 years after dredging. 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 multi-purpose lake remediation technique (Madsen, 2000).

Raising the water level, although not very common, can have a similar effect to dredging as the water depth can be made too great for aquatic plants to grow.

Benthic barriers or other bottom-covering approaches are another physical management technique that has been in use for a substantial period of time. 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. The problem with using sediments is that new plants establish on top of the added layer. The problem with synthetic sheeting is that the gasses evolved from decomposition of plants and normal decomposition activities of the sediments underneath the barrier collect under the barrier, lifting it.

Benthic barriers will typically kill plants under them within 1 to 2 months, after which they may be removed. Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively. Sites from which barriers are removed will be rapidly re-colonized. In addition, synthetic barriers may be left in place for multi-year control but will eventually become sediment-covered and will allow colonization by plants. Benthic barriers, effective and fairly low-cost control techniques for limited areas (e.g., <1 acre), may be best suited to high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily effect benthic communities (Madsen, 2000).

A basic environmental manipulation for plant control is light reduction or attenuation. Shading has been achieved by fertilization to produce algal growth, application of natural or synthetic dyes, shading fabric, or covers, and establishing shade trees. During natural or cultural eutrophication, phytoplankton growth alone can shade out other plant growth. Although light manipulation techniques may be useful for narrow streams or small ponds, in general these techniques are of only limited applicability in lakes (Madsen, 2000)

4.5.2.1.7. Biological Control Measures

Biological control (bio-control) involves using animals, fish, fungi, insects, other plants, or pathogens as a means to control another in the same environment. Competition between native and non-native plants is one form of biological control. Another is to use a biological control agent that could be insect or other creature to control a target species. The goal of biological control is to weaken, reduce the spread, or eliminate the unwanted target species so that native or more desirable species can make a comeback. Care must be taken however, to insure that the control species does not become as big a problem as the one that is being controlled. Not all biological controls are introduced for a purpose. Many are introduced accidentally or get here on their own. As effective as they can be, great care and long-term planning for impacts needs to be considered before implementing their use. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

Using native plants to out-compete non-native plants, either by encouraging their growth if they already exist or by introducing or re-introducing them into a system is a desirable management technique. Providing a more healthy and diverse native plant community is almost always an end goal in aquatic plant management. Lakes currently lacking a native plant community can have these communities reestablished. In communities that have only recently been invaded by non-native species, a seed bank probably exists that will restore the native community after successful management of the non-native plant. In communities that have had single species non-native plant dominance for a long period of time (e.g., greater than 10 years), native plants may have to be reintroduced as a part of or after successful management. A healthy native plant community may slow invasion or reinvasion by non-native species and generally provides more of the environmental and habitat needs desired in an aquatic littoral zone.

Biological control using other animals, insects, pathogens, or fungi for reduction of nuisance plants in aquatic systems has both positive and negative attributes. One positive is that a biological control agent can often be found that is host specific, so effects to non-target species may be reduced. Biological control agents may also be able to reproduce in response to increases in target species density often without reapplication of the agent. Development and registration (where necessary) of biological control agents is generally less expensive than chemical agents. Additionally, the ecosystem impacts under biological control can be more gradual, thereby allowing the system to adjust to loss of a species good or bad (Greenfield et al, 2004).

Biological controls can have many potential disadvantages. Substantial risk is involved when new species are introduced as biological control agents. To be considered successful, these species are expected to persist indefinitely in the environment where they are used, and may spread to new locations. Therefore, if there are any adverse effects resulting from the biological control agent, these effects may be difficult or impossible to control. Other drawbacks include unpredictable success and rates of control that are slower than with chemical or mechanical methods. Resistance in host species is unlikely to develop but can occur. Finally, agents that work in one area may not be suitable in all ecosystems. Climate, interference from herbicidal application, hydrological conditions, and water quality conditions in the system can influence the effectiveness of biological control agents. The growth of undesirable weeds can be suppressed by the use of biological control agents, but rarely eliminated (Greenfield et al, 2004).

Many herbivorous insects have been and continue to be studied for their impacts on unwanted aquatic plant species. An herbivorous aquatic moth, two native herbivorous weevils, and a chironomid species have been associated with the decline of EWM in a waterbody. Several species of insect are being used to control purple loosestrife infestations very effectively. To date, this researcher is not aware of any insect controls being studied specifically for the control of curly-leaf pondweed. However, research into establishing bio-controls is on-going. Studying naturalized and native herbivores and pathogens that impact nuisance aquatic and wetland plants increases the number of potential bio-control agents that could be incorporated into invasive plant management programs. The groundwork has been laid for conducting future bio-control research and experimentation. Although not all of the native and naturalized organisms researched can be successful, the information and expertise is now available for potential insects and pathogens to be collected, analyzed, and studied. A continuation of the work that has been started is needed to make available for the future more successful native bio-control agents (Freedman et al, 2007).

Grass carp, also known as the white amur (Ctenopharyngodon idella), feed on aquatic plants and have been used as a biological tool to control nuisance aquatic plant growth in other states. Grass carp are more effective at removing some plant species than others. As with any large-scale ecosystem manipulation, grass carp introduction can cause significant environmental impacts to a water body. Elimination of submerged plants by grass carp foraging could result in increased turbidity, water column nutrients, and algae production. If all aquatic vegetation is removed, waterfowl, amphibians and aquatic mammals may also be adversely impacted. In light of the fact that grass carp, once introduced, are extremely difficult to remove from a water body, caution should be exercised when considering new waters for grass carp introduction (Greenfield et al, 2004). In addition to grass carp, common carp and tilapia have been added to ecosystems to reduce aquatic vegetation. However, these fish species are not perceived to be successful and are not generally recommended for use as biological control agents.

Plant fungi and pathogens are currently still in the research phase. Certain species for control of hydrilla and EWM have shown promise but so far, only laboratory tests in aquariums and small ponds have been conducted. Methods are not available for widespread application. Whether these agents will be successful in flowing waters or large-scale applications remains to be tested (Greenfield et al, 2004).

Organic and inorganic materials, such as peat, barley straw, lime, clay, and iron filings have been used to attempt control of rooted aquatic plants and algae. Control may be achieved by reducing nutrient availability to the nuisance species or by causing natural chemicals that impede growth to be released. The success of these management alternatives is mixed, and while research continues into their use, large-scale applications such that would be necessary in Big Chetac Lake are not considered feasible at the present time.

4.5.3 Goal 3 – Protect and Enhance the Native Plant Diversity and Distribution

The diversity and distribution of native plants is a good indicator of overall health of a lake. The right mix of shoreland, emergent, floating leaf, and submerged plants helps provide a wide variety of habitat for fish and wildlife, protects shoreland from erosion, provides privacy for lake residents, improves aesthetics, and uses up some of the available phosphorous before it is used for growing algae. As a lake becomes more nutrient rich, water clarity often declines which leads to a decline in the type, abundance, and location of native plants in that lake.

In July of 2008, 269 points of the 392 points previously identified in the in the littoral zone had an average of only 2.67 different native plants species present per point. The remaining 123 points in the littoral zone had no plant growth. Of the 46 total plant species identified in Big Chetac Lake during this survey, only 36 were actually collected from rake samples taken from the 269 points. The remaining ten were only visually identified. Of the 36 species, only two (coontail and small pondweed) were found in 100 or more of the 296 points. Twelve other species were found at 11-60 points out of the total 296. Twenty-two other plant species were present only at 10 (3%) or less of the 296 points, with two-thirds of these found at 3 or less (1%) of the 296 points. While the diversity or type of aquatic plants in Big Chetac Lake is above average when compared to other lakes, plant abundance and distribution is very poor.

This lack of abundant native vegetation can be tied to the early season dominance of CLP. CLP out-competes native plant species for light and habitat in the spring and early summer at a time when lake water would otherwise be clear enough to support native plant growth. By the time CLP has disappeared from the lake’s surface, the water clarity in the lake has become too low to support abundant native plant growth except in the shallowest of bays. Several strategies can be defined for protecting and enhancing the existing native plant community in the lake. The first strategy strives to minimize native plant competition with CLP in the early season. The second strives to improve water clarity by reducing phosphorous loading to the system. These two strategies depend on existing plant populations to expand on their own once competition and water clarity are brought under control. Both of these strategies are combined and re-establishing native plant communities by planting is added in the third strategy.

4.5.3.1 <u>Minimize Native Plant Competition with CLP</u>

Large-scale harvesting of CLP opens up areas of a lakes surface increasing light penetration that is needed to support late season native plant growth, but does little to minimize competition. Any native plants that are present when the CLP is harvested also gets harvested. Early season native plant growth is triggered by appropriately warm lake water. CLP does best under cold water conditions. By the time the lake water is warm enough to trigger native plant growth, CLP has already established its dominance. The only way to minimize CLP competition is to remove CLP before it has a chance to dominate. The best way to do this is by using early season cool water herbicides to minimize early season CLP growth. Endothall is an herbicide that does best when water temperatures are still below 60 degrees F. It can be used in very low concentrations to kill CLP in strategic areas before it becomes dominant. Endothall is considered fairly selective at this time. If CLP is removed at this early stage, then native plants may have less early season competition as the lake water warms up. In addition, since CLP treated in this fashion does not have a chance to mature, the number of new turions left in the sediment to grow new CLP each year is also reduced.

4.5.3.2 Improve Water Clarity

Aquatic plants need sunlight to grow. Figure 18 shows the average monthly water clarity measurements as recorded since 1995 by Citizen Lake Monitoring Network volunteers using a Secchi disk. Water clarity in Big Chetac Lake is deep enough in May and June to support a littoral zone that extends to around 12.5 ft. Unfortunately excessive CLP growth in the spring and early summer prevents many native plants from growing at this time. By the time CLP has completed its life cycle near the end of June into early July, and dropped to the bottom of the lake, the lake water has warmed up, oxygen depletion is common in the bottom waters, and excess phosphorous is being used to grow algae, and light penetration plummets.

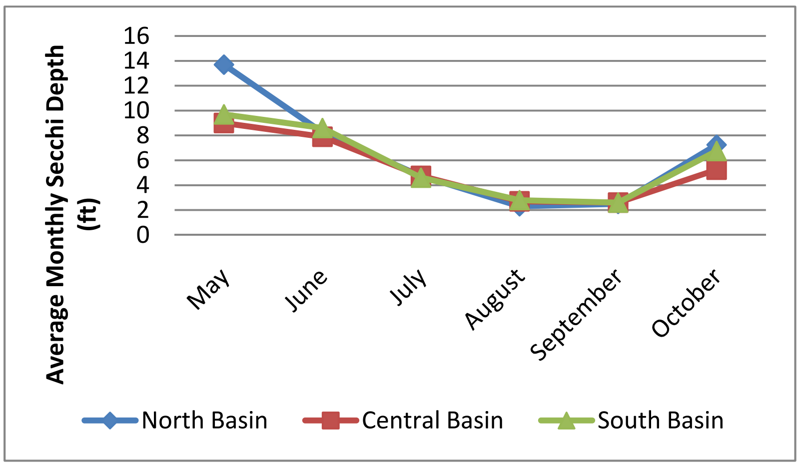


Figure 18 – Average Monthly Secchi Depths in the Three Big Chetac Lake Basins as Recorded by CLMN Volunteers from 1995-2009

In July, water clarity drops markedly from May and June and then in August and September, it bottoms out. The littoral zone in August and September likely only extends to 3 or 4 ft of water. At this time, algae is the dominant form of vegetation in the lake. The strategies discussed in Goal 1 are applicable here. If substantial reductions can be made in the total external and internal phosphorous loading occurring in the lake over time, it is conceivable that improvements in water clarity could be seen as well.

4.5.3.3 Re-establishing Native Plant Communities by Planting and Restoration

As was mentioned in a previous section, using native plants to out-compete non-native plants, either by encouraging their growth if they already exist or by introducing or re-introducing them into a system is a desirable management technique. Re-establishment may happen naturally if waters only recently became turbid or switched from plant to algae dominance and seeds and other propagules are still present. In a system like the Big Chetac Chain, where CLP dominance in the spring and early summer and algal dominance in the summer, seeds and other propagules may have long died or been too deeply buried to come back on their own and deliberate introductions must be made. Making the decision to re-introduce aquatic vegetation is not an easy one, because once it is decided that desired pants have disappeared completely and have to be artificially introduced the costs are high. A source for fairly large quantities of new plants will be needed, physical protection from fish and birds will likely be needed, stabilization and protection of sediment in the planting area from wind and waves will likely be needed, and substantial labor needs for collection of stock, planting and maintenance will be required.

Langlade County, Wisconsin "Buffer Blocker" System

Determining what plants to re-introduce and where is another substantial undertaking. There are essentially three types of aquatic plants: emergent, floating leaf, and submergent. Emergent plants include reed, bulrush, cattail, grasses (like wild rice), sedges, and tall herbs. Floating leaf plants include water lilies, floating leaf pondweeds, and common waterweed. These plants generally grow in shallow water down to 2 or 3 meters. Submerged plants are usually rooted to the bottom of a lake (but not always) and completely under water except for certain parts like flowers, at certain times during the year. By inventorying existing plants in a body of water, even just remnant populations, a list of species to re-introduce can be established. If no plants exist, then vegetation in surrounding lakes could provide a place to start, and general lake structure can help further define the species to reintroduce. Once decided, plants may be able to be collected from other areas of the same lake, collected from other lakes, or purchased from commercial vendors. Collecting plants from the same or other water bodies may require a permit. If commercial plants are purchased care should be taken to not introduce unwanted vegetation at the same time.

A good rule of thumb is to plant as many submerged or floating leaf plants as possible given resource constraints, as these plants are likely the most susceptible to failure. It may not be as important to do this for emergent plant species (Moss et al, 1996). There are many sources for more information. Smart et al, 1998 discuss many techniques for establishing native aquatic plants in reservoirs with an absence of vegetation or low species diversity. The Langlade County, Wisconsin Land Records and Regulations Department has a Shoreland Restoration Web Site which provide a great deal of information for re-establishing native plants (Langlade County Land Records and Regulations Department, 2007). A complete review of these techniques and others would be necessary before undertaking a planting project.

4.5.4 Aquatic Invasive Species Early Detection and Response Planning

The Big Chetac Chain is not known to have Eurasian Water Milfoil (EWM) or other aquatic invasive species. It is desirable to keep it this way. Watercraft inspection at all lake access points during periods of high use will help reduce the chance that a new AIS is introduced to the lake. Regular monitoring for EWM and other AIS in the lake is also important. A plan for what to do if a new aquatic invasive species is identified in the lake has been included in Appendix J. This plan identifies the procedures to follow to collect and voucher a suspect plant or animal sample, designate where and to whom that sample should go to, and outlines what should happen if a positive identification is made.

4.5.4.1 Watercraft Inspection

The Big Chetac Chain is not known to have Eurasian water milfoil and other AIS at the present time. It is desirable to keep it this way as long as possible. One of the best things that can be done is to set up a regular watercraft inspection program at the public access points around the lake. Watercraft inspection involves placing people at the boat landings during busy times to talk to boaters using the lake about aquatic invasive species and what they can do to prevent their spread. Watercraft inspectors also check boats for incoming or out-going material attached to boats or in live wells to help boaters stay within the laws in Wisconsin that make it illegal to launch a boat with foreign material attached to it, or to drive down a public hi-way with aquatic invasive species material attached to a boat or trailer. Watercraft inspectors also collect general lake use information from boaters that helps determine statewide actions related to AIS.

The University of Wisconsin Lakes (UW-Extension-Lakes) program offers training and materials for watercraft inspection through the Clean Boats Clean Waters (CBCW) program. During a CBCW workshop, people are trained to set up and operate watercraft inspection programs. After completion, they are recognized as trainers themselves, able to take what they know to others.

Some lakes have been installing boat landing monitoring cameras at their public access points. Called I-lids by one company, the camera films activity at the boat landing and streams it to a local computer for viewing. The purpose is to provide additional incentive for boaters to do what is necessary to comply with the illegal to launch law when a watercraft inspector is not present at the landing to remind them. The cameras have not been wholly determined to be effective, and only a few individuals have received citations for disobeying the law based on being caught on camera. Also, even if a person is caught bringing EWM or another invasive species into a body of water, once in the lake, the damage has already been done. Camera monitoring is not a substitute for actual watercraft inspectors, but may be used to support an overall watercraft inspection program.

4.5.4.2 In-Lake Aquatic Invasive Species Monitoring

Providing regular in-lake monitoring for EWM and other AIS could identify a new AIS introduction before it has a chance to become a significant problem in the Chain. Early identification can lead to early intervention, offering more management options at a lower cost. It is conceivable to think that if CLP had been identified when it first became a part of the vegetation in Big Chetac Lake, and prevented from becoming the dominant plant that it is now, that conditions in the lake might be different. Other species, particularly EWM could have the same impact over time if it were to get into the chain. There is of course, no certainty of this, but the risk is there.

Regular monitoring of the Big Chetac Chain for EWM and other AIS should be completed. Public access points should be monitored every couple of weeks during the open water season, and the entire plant growing zone of the lake should be monitored for AIS at least once a month during the open water season. The Citizen Lake Monitoring Network offers volunteer training and support for aquatic invasive species identification and monitoring. As with the CBCW program, a training session is offered by CLMN AIS Monitoring personnel that helps organizations set up and operate an in-lake AIS monitoring program. Teaching skills necessary for identification of the species of concern, material support, and guidance for how to make the program successful are included. After completion, attendees are recognized as trainers themselves, able to take what they know to others.

An official AIS In-Lake Monitoring Program should be designed or implemented as soon as possible. Officially recognized monitors should be trained in AIS identification and monitoring procedures. These monitors could be volunteer or paid and should be given the necessary equipment and materials to complete this monitoring on regular basis and be required to submit the information they collect to the appropriate people and places.

In addition, all lake users and riparian owners should be given the opportunity to learn in-lake AIS monitoring techniques to be used in their daily use of the lake.

4.5.5 Maintain the Current Fishery

As has been mentioned several times in this report, there seems to be a general satisfaction with fishery in Big Chetac Lake. Management alternatives chosen for Big Chetac Lake should have this in mind. Increasing native plant diversity, reducing CLP, and reducing phosphorous loading should have little negative impact to the current fishery given that there will likely be no "rapid" shifts in the lake's condition as a result of this plan.

4.5.6 Community, Lake User, and Lake Riparian Owner Education

The success of any lake or aquatic plant management plan depends on involvement of stakeholders throughout the process of data collection, planning, implementation and maintenance. Without buy-in from the general public who use and benefit from the lake, management will likely fall short of expectations. For users and benefactors of the Big Chetac Chain, one of the most important things to learn is what limitations exist for making substantial changes in the overall quality of the lake. As was said before, one of the most valuable characteristics of Big Chetac Lake is its fishery. Part of the reason it has such a tremendous fishery is because it is a highly eutrophic, nutrient rich system. Another thing to understand is that the lake has likely always been a nutrient rich system with lots of green water and turning it into a clear water lake is likely impossible and probably undesirable.

Improving the system is not undesirable, and there are things that can be done to attempt that. Lake users, riparian owners, and the local community need to be educated and informed as to what these things are and how they can help make them happen. Some management activities will be inexpensive and can be implemented by the general public. Others will be very expensive and only implementable under very strict guidelines. All management activities come with limited guarantees that they will accomplish the goals set for them. Stakeholders need to be involved in decisions made to spend what could be thousands of dollars a year to improve the system, and help decide if the costs to do so are reasonable under the assumed risk.

4.5.6.1 Lake Stewardship

Lake Stewardship is defined as an attitude that recognizes the vulnerability of lakes and the need for citizens, both individually and collectively, to assume responsibility for their care. A good lake steward will learn what they can about how to protect and enhance the body of water entrusted to their care, and show this by way of the activities they participate in. The Big Chetac Lake Chain Association, while not the only entity to be charged with "taking care of" the lake is in a position to provide education and information to its members and others about the activities considered good lake stewardship. It has and continues to attempt to involve the public in activities related to the lake.

Membership in an association like the BCCLA is voluntary and the number of people who choose to become members is likely determined by what it is perceived that the association accomplishes on behalf of the lake and lake users. Showcasing what it does, assuming that practicing good lake stewardship is part of its mission, is important.

One way of doing this is to set a date and time every year when all lake residents and users in the community are invited to attend a Lake Fair sponsored by the Lake Association. A Lake Fair provides a forum for many different topics to be discussed, put on display, or made available for hands on learning. It is much less formal than a lake meeting, and could provide activities for many different age groups and interests to get involved. Every year, the Wisconsin Lakes Partnership sponsors the annual Lakes Convention in March. A smaller version of the Lakes Convention is held every year in some location in northwest Wisconsin. Both of these events and many other resources could provide ideas and contacts for setting up a local lake fair event.

4.5.6.2 Citizen Lake Monitoring Network Volunteer Water Quality Monitoring

Volunteers in the Citizen Lake Monitoring Network (CLMN) from Big Chetac Lake already collect some water quality data. There are three CLMN data sites on Big Chetac Lake and one on Birch Lake. All four should have the full complement of expanded water quality testing offered by the program including total phosphorous and chlorophyll May-August, and water clarity, temperature and dissolved oxygen ice out to ice on. Additional water quality testing could be added, funded either by a grant or the Lake Association to include fall sampling for total phosphorous and chlorophyll, and potentially other parameters including total nitrogen and the dissolved states of both phosphorous and nitrogen.

Water clarity, temperature and dissolved oxygen (DO) testing should be completed on a more regular basis. Purchasing a digital meter to test for DO and temperature would make this easier.

4.5.6.3 Public Information and Involvement

Providing multiple sources to get informational and education materials is important for getting and keeping the general public involved. The BCCLA should offer newsletters both in print and digital, provide a web site for getting and disseminating information about the Chain and the activities occurring there. Individual mailings to all lake residents could also be incorporated as a means to share information. The Association already offers open meetings and social events as a part of their operation. Public access sites are another place to make sure the message of good lake stewardship is heard. All access points should be evaluated for the signage already in place and a plan developed for what should be included, and then that plan should be implemented. A consistent message at all landings regarding AIS and other important lake functions can help accomplish the goals in this plan.

4.5.6.4 Forming a Lake District

Membership in the current BCCLA is a voluntary. Under most scenarios this is a good thing. Dues paid by members provide a funding source for the Lake Association to use to support its activities. Assuming the Lake Association is doing things that lake users and riparian owners approve of or that they can justify, and there is not a perceived notion that a given body of water is in great shape and does not need a local management body, membership is usually high, or at least adequate to do what the Association does. However, when management needs that affect all lake users begin to increase, it is often difficult to generate enough financial support through voluntary dues. Fund-raising can be done, donations can be sought, and state lake grant programs can be tapped into, but none of these activities provide a stable and consistent source of funding.

While there are management activities to improve the condition of the Chain over time that do not have high costs associated with them, these are limited and will take many years to show any impact, and may be difficult to get lake users to participate in freely. The majority of the management activities that may be employed to help improve the Chain will have substantial costs associated with them, if implemented.

A Lake District is a special purpose unit of government. whose purpose is to maintain, protect, and improve the quality of a lake and its watershed for the mutual good of the members and the lake environment. The boundaries usually include the property of all riparian owners and can include off-lake property that benefits from the lake or affects the lake's watershed. The district may include all or part of a lake or more than one lake. A city or village must give its approval to be included in a district. Within a lake district, all property owners share in the cost of management activities undertaken by the district. A lake district is a true example of participatory democracy. Residents who live in the district and are eligible voters and all property owners have a vote in the affairs of the district. This is accomplished at an annual meeting which must be held between May 22 and September 8 each year. Property owners living within the boundaries of a lake district are required by law to pay fees. The amount of those fees is voted on by the members at the annual meeting. This fee is usually a part of your property tax bill and may come in the form of a mill levy (it can be no more than 2.5 mill and is often much less (some districts have no fees of any sort), a special assessment, or user charge. Borrowing or grant programs can also be used to raise money if approved at the annual meeting (UW-Extension Lakes).

Normally, a lake district's day-to-day activities are carried out by a board of from 5 to 7 commissioners. One is appointed by the county and one by the town. The remaining commissioners are elected by the membership. One elected commissioner must be a resident unless no resident is willing to serve, and the others must be either residents or property owners in the district. At all times, the powers of the commissioners are subject to the decisions of the membership at the annual meeting. The commissioners must meet quarterly, and open meeting laws apply.

A lake district can be formed in one of four ways:

- by 51% of the landowners in the proposed district petitioning the county or town board;
- by owners of 51% of the land in the proposed district petitioning the county or town board;
- by resolution of a village board or city council; or
- by conversion of a town sanitary district.

An existing district may be dissolved by a 2/3 vote of the members at an annual meeting. In the 2009 Lake User Survey, respondents were asked if they would support the formation of a Lake District. Approximately 30% said yes or probably yes, 23% were unsure, and 47% said they would not.

A description of the institutional framework affecting management of the lake including local government jurisdictional boundaries, plans, existing ordinances, and an analysis of the need for adoption of local ordinances for lake protection should be completed before implementing any large-scale, or long-term management activities.

5.0 Cost-Benefit Analysis for Nutrient Management Alternatives

A cost benefit analysis finds, quantifies, and adds all the positive factors of a planned action. These are the benefits. Then it identifies, quantifies, and subtracts all the negatives of the planned action, the costs. The difference between the two indicates whether the planned action is advisable. Many of the larger management alternatives that could be undertaken to facilitate improvements in the Big Chetac Chain will cost a lot of money and come with some risk of failure. Before embarking on any improvement action, a cost-benefit analysis should be completed, the results of which should be presented to the general public. The addition of alum, hypolimnetic aeration, de-stratification, dredging for nutrient control and choosing between contracted vs. ownership CLP harvesting and whether or not to move forward with chemical treatment should undergo greater cost-benefit analysis then has already been completed.

6.0 Lake and Aquatic Plant Management Recommendations

The following is a list of the objectives and associated actions for each of the Management Goals set forth in this Plan.

6.1 Goal 1 – Reduce the Number of Days the Lake Experiences Severe Algae Blooms (>30 μg/L) That Impact Lake Use

- Objective 1 – Explore variation in phosphorous loading caused by reducing CLP in the lake and by managing internal release
  - Action 1 – Complete Lake Nutrient Modeling to explore algal response to phosphorous loading variations in Big Chetac Lake

- Objective 2 – Measure changes in seasonal phosphorous and chlorophyll a concentrations in all three basins and Birch Lake (described later)

  - Objective 3 – Reduce external inputs of phosphorousAction 1– Identify and promote potential Best Management Practices (BMPs) in the watershed
  - Action 2 – Implement BMPs in the watershed
  - Action 3 – Identify and promote potential BMPs in the near shore area
  - Action 4 – Implement BMPs in the near shore area

- Objective 4 – Reduce internal loading of phosphorous in the north basin
  - Action 1 – Complete cost-benefit analysis and feasibility study for alum treatment, de-stratification, and hypolimnetic oxygenation
  - Action 2 – Implement internal loading reduction strategy

6.2 Goal 2 – Reduce the Impact of CLP Through Aquatic Plant Management

- Objective 1 – Complete 1-3 years of contracted large-scale harvesting for CLP removal
  - Action 1 – Determine availability and cost of contracted harvesters, identify off-loading and disposal sites
  - Action 2 – Determine strategy (navigation vs. large area removal) and locations for CLP harvesting
  - Action 3 – Implement CLP harvesting strategy of CLP in 2011

- Objective 2 – Explore the potential for the Big Chetac Chain Association to purchase and operate their own harvesting equipment
  - Action 1 – Complete cost-benefit analysis for contracted vs. owner operated CLP harvesting program
  - Action 2 – Purchase harvesting equipment if warranted

- Objective 3 – Complete large-scale (at least 40 acres) early season chemical treatment of CLP using Endothall for at least 3-5 years to determine potential for native plant restoration
  - Action 1 – Identify a location and treat at least 20 acres without artificial native plant re-introduction
  - Action 2 – Identify a location and treat at least 20 acres with artificial native plant restoration after year three
  - Action 3 – Complete pre and post treatment plant surveying
  - Action 4 – Complete annual turion density sampling in treated areas

- Objective 4 – Complete the necessary environmental assessment to determine the feasibility of a large-scale drawdown of 6-8 ft for CLP control
- Objective 5 – Evaluate the use of fluridone as a whole lake, low dose, early season chemical treatment for CLP
- Objective 6 – Evaluate new biological controls that may be suggested for control of CLP over the next 5 years
  - Action 1 – BCCLA membership in the Aquatic Plant Management Society or other plant management related publication

6.3 Goal 3 – Protect and Enhance the Native Plant Diversity and Distribution

- Objective 1 – Increase protection measures in those areas of the lake that currently have healthy communities of native plants
  - Action 1 – Work with the WDNR to designate critical habitat areas in the Big Chetac Chain

- Objective 2 – Identify a list of emerged, submerged and floating leaf plants that could be artificially re-introduced into the lake
  - Action 1 – Identify a list of aquatic plants that are native to the Big Chetac and that have proven success rate when artificially re-introduced
  - Action 2 – Identify sources sites for the plant list in Action 1, either as a purchased commodity or in-lake transfer.

- Objective 3 – Floating leaf and submerged species re-introduction in chemically treated areas
  - Action 1 – Implement and monitor floating leaf and submerged species re-introduction in treated areas after third year

- Objective 4 – Emergent species restoration along the shoreline
  - Action 1 – Determine areas of the shoreline that would benefit from restoration and contact landowners to garner and gauge interest
  - Action 2 – Implement emergent species restoration if feasible
  - Action 3 – Complete a habitat assessment for wild rice to determine if restoration is feasible
  - Action 4 – Work with GLIFWC to restore wild rice beds if feasible

- Objective 5 – Determine restoration guidelines and methods that will be used to implement in-lake restoration of emergent, submergent, and floating-leaf species

- Objective 6 - Preserve, protect, and enhance undisturbed watershed and shoreline properties through conservation easements, environmental land trusts, and the Wisconsin Stewardship Program

6.4 Goal 4 – Aquatic invasive species monitoring and rapid response planning

- Objective 1 – Watercraft inspection at all public access points during high use periods
  - Action 1 – Set up a Clean Boats Clean Waters watercraft inspection program with trained volunteer and paid inspectors

- Objective 2 – In-lake AIS monitoring during the entire open water season
  - Action 1 – Set up a Citizen Lake Monitoring Network (CLMN) AIS Monitoring program with trained volunteer and paid monitors
  - Action 2 – Provide informal AIS identification training to all interested lake users

6.5 Goal 5 – Maintain and Enhance the Current Fishery

- Objective 1 – Work with WDNR and other fisheries management resource personnel protect and preserve the existing fishery in the Big Chetac Chain

6.6 Goal 6 – Community, lake user, and lake riparian owner education

- Objective 1 – Promote good lake stewardship activities for lake users and lake riparian owners
  - Action 1 – Identify, highlight, showcase, and reward examples of new and existing good lake stewardship activities being completed by lake users and riparian owner throughout the Chain
  - Action 2 – Sponsor an annual Lake Fair for all lake users and the surrounding community as a means to accomplish activities in Action 1, and to serve as a venue to promote more good lake stewardship

- Objective 2 – Water quality monitoring
  - Action 1 – Include all three basins and Birch Lake in expanded CLMN surface water quality testing (Secchi, total phosphorous, chlorophyll a, temperature and dissolved oxygen)
  - Action 2 – Purchase a digital dissolved oxygen/temperature meter to allow faster and more frequent temperature and dissolved oxygen profiling in all three basins and Birch Lake
  - Action 3 – Complete fall surface water sampling in all three basins and Birch Lake

- Objective 3 – Public Information and Involvement
  - Action 1 – Develop and provide multiple sources for public informational and educational materials related to management activities in the Big Chetac Chain including newsletters, web page, individual mailings, open organization meetings, and social gatherings
  - Action 2 – Develop and design signage for all public access points that promote a consistent message to aquatic invasive species, lake use and stewardship
  - Action 3 – Build and install signage at all public access points

- Objective 4 – Explore formation of a Lake District in place of or in addition to the existing BCCLA
  - Action 1 – Create a BCCLA committee to study the formation of a Lake District
  - Action 2 – Form a Lake District

- Objective 5 – Complete a description of the institutional framework affecting management of the lake including local government jurisdictional boundaries, plans, existing ordinances
  - Analyze of the need for adoption of local ordinances for lake protection
  - Make recommendations for local ordinances for lake protection

7.0 Implementation Plan

The lake and aquatic plant management activities recommended in this plan are to be implemented over the course of the next five years and will far exceed the current financial resources of the BCCLA. A time line for the implementation of individual actions within this plan, and possible funding sources is provided in Appendix K. Over the course of the next five years applications for an AIS Established Infestation Control grant, a large-scale lake management planning grant, four small-scale lake management grants, a Lake Protection grant, and at least one Recreational Boating Facilities grant are suggested. These applications are for well-known, well-funded State of Wisconsin grant programs. There may be other sources of grant money. Each of the grant programs listed here require some level of match that the BCCLA or one of its partners would be responsible for making.

A portion of the match required for these various grant programs could be covered by volunteer and donated services. Water craft inspection, AIS monitoring, water quality sampling, Lake Fair organization and participation, project activity administration time, donated materials, donated professional services, county services, and services provided by schools, businesses, other organizations, Army Corp, NRCS, and others are all potential match. However, it is strongly recommended that the BCCLA pursue the formation of a Lake District to aide in funding these and future lake and aquatic plant management activities.

8.0 Partnerships

The BCCLA should pursue partnerships with various departments within the Sawyer County Government including Land Conservation and Forestry, the Great Lakes Indian Fish and Wildlife Commission, the Village of Birchwood, Sawyer County Lakes Forum, Town of Edgewater, local, state, and national fishing clubs, and others to help fund activities aimed at improving water quality conditions in the Chain. All management activities should be well publicized and open for public debate. The Wisconsin Lakes Partnership which includes the WDNR, UW-Extension Lakes Program, and the Wisconsin Association of Lakes, should be considered operating partners in all lake management activities. Greater attempts to address the needs of all Big Chetac Chain property owners and lake users should be made.

Management Activities need to based on three things if outcomes are expected to be positive; sound lake science, stakeholder involvement, and compatibility with State of Wisconsin rules and guidelines. It is believed that this comprehensive lake management plan and the recommendations in it meet this expectation.

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Appendix A

2009 Big Chetac Chain User Survey

Appendix B

User Survey Responses

Appendix C

2009 Nutrient Budget and Management Data Analysis Report

Appendix D

Paleoecological Study of Lake Chetac, Sawyer County

Appendix E

Aquatic Macrophyte Survey for Chetac Lake, Sawyer County

Appendix F

Internal Phosphorous Loading and Water Chemistry Letter Report

Appendix G

WDNR NOR APM Strategy

Appendix H

NR 109

Appendix I

Other Aquatic Herbicides Approved for Use in Wisconsin

Appendix J

AIS Early Detection and Response Plan

Appendix K

Events and Grant Application Implementation Schedule