Big Brower Lake

Lake Management Plan Update 2016

Recommendations 2017-2021

Submitted By:

Jaimee Conroy, Environmental Scientist

PLM Lake & Land Management Corp.

PO Box 132 · Caledonia, Michigan 49316
phone 616.891.1294 · fax 616.891.0371
www.plmcorp.net

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Lake Management Plan Update

Introduction

Purpose of Update

This management plan updates and documents management activities during the past several years, examines current conditions in the lake, and provides management recommendations for the future. Eurasian watermilfoil had previously caused the most serious aquatic plant-related problems in the lake. Reducing it to a maintenance (low) level of abundance has allowed native plant species to recover in the lake and allowed the lake to be managed using smaller herbicide treatments and harvesting.

Characteristics of the Lake

Big Brower Lake is an 85-acre lake located in Courtland Township, Kent County, Michigan. Big Brower Lake is within the Rogue River Watershed. The Rogue River is a major tributary of the Grand River. The watershed is 167,625 acres and includes portions of Kent, Montcalm, Muskegon, Newaygo, and Ottawa counties. The Rogue River is fed by wetlands, county drains, lakes, and both warm and cool-cold water tributaries.

Rooted vegetation covers a substantial amount of the littoral zone of the lake.

A majority of the shoreline have been developed for single family year-round homes. The lake has a private boat launch, located on the east shore of the lake. An area of wetlands borders the northern end of the lake near the outlet. A formal lake-use survey was not included in this study, but observations made while working on the lake indicate that the lake is used for fishing, boating and swimming.

PLM's Integrated Plant Management Program

An Integrated Plant Management program should focus on preserving and protecting desirable plant life while controlling unwanted "weed" species through remediation services. In addition, these preventative programs should strive to keep the lake free of unwelcome plants that are known to be pests elsewhere in the region.

The first step of PLM's Integrated Plant Management Program is to *evaluate* and record current lake conditions and lake residents' goals. Next is to *prescribe* a lake specific management plan to control unwanted plant growth. *Implementation* of the agreed upon lake management plan is the final step of the program. After the program has been implemented, PLM will assess the results and use the information to modify and improve priorities, processes and plans – starting the cycle again. The key to a successful Plant Management Program is to minimize the total long term impacts of noxious aquatic vegetation while preventing new infestations and protecting the aquatic environment.

Why Do Aquatic Plants Become a Nuisance?

In moderation, aquatic plants are good for the lake, providing habitat for fish and other organisms and stabilizing bottom

sediments. Plants get to be a problem when their growth becomes excessive and interferes with the use of the lake. At high levels, even native plants can disrupt the balance and be viewed as "invasive". A number of factors can result in excessive growth of aquatic plants. In many, or perhaps most cases, several factors have combined to result in the problem.

Exotic plant species cause many of the most serious weed problems. Exotic plants are plants that are not native to this area, which have been brought to the area and released.

Because they often have few natural enemies (their pests, pathogens, etc. may not have come over with them), they grow out of control. When exotic aquatic plants such as Eurasian watermilfoil and Curlyleaf pondweed invade a lake, they often form extensive dense populations, crowd out native species and reduce the quality of habitat for other organisms.

Human activities also increase the input of nutrients and nutrient-rich sediments to the lake. Nutrients feed the growth of algae in the water and settle on the bottom, where they provide a rich substrate for aquatic plant growth. Nutrient inputs increase the overall growth of all aquatic plants (exotic and native) and algae. Preventing excess nutrients from entering your lake is much less expensive than trying to fix the problems they cause.

Eurasian watermilfoil

EWM, an exotic species, is an extremely aggressive submerged aquatic plant that has the abilities to form a monoculture among vegetation. EWM spreads by fragmentation (every inch of plant can sprout new growth) and has a very strong root system. EWM forms a canopy above native plants, choking out the competition. EWM also has the ability to overwinter underneath the ice, allowing it to be present throughout the winter. This gives the plant a head start in growing during the spring and chokes out native plants very quickly. EWM should be controlled as soon as it is found within a waterbody to prevent further infestation and loss of native plant diversity. NOTE: Once a native plant is lost in a lake, there is no guarantee it will return.

Curlyleaf pondweed

Curlyleaf pondweed, an exotic species, usually emerges early each spring, flowers and sets seed in the late spring and early summer, and then collapses by the first week in July. There are, however, exceptions to this pattern regarding juvenile plants, part of this re-growth community can occasionally be found in the late summer or early autumn. These small plants are capable of over-wintering below ice cover. Curlyleaf can be a severe nuisance during the early part of the peak recreational use season. Early control of this species is recommended so that the plant is not allowed to produce large quantities of biomass that die naturally and decompose in early July when water temperatures and the potential for oxygen stress are high. Early treatment/management is also encouraged to take place prior to seed production therefore, reducing the next generation of early pondweed growth.

Algae

Algae are basically divided into planktonic, filamentous, and macroalgae forms. Planktonic algae are microscopic, free floating plants, often referred to as "water bloom". In large number, the algae can cause water to appear green, brown, yellow, or even red. Filamentous algae, commonly called "pond

scum" can form raft-like masses over the water surface. Since they are vulnerable to winds and currents, they are generally restricted to bays, bayous, and sheltered shorelines. Filamentous algae can grow attached to the lake bottom, weeds and docks. The filamentous algae will frequently detach from the lake bottom and form floating mats. The macroalgae includes three types, chara, starry stonewort and nitella. Chara grows like a carpet on the bottom of the lake. It is nature's water filter and is excellent for fish bedding. Chara grows approximately one inch a week during the summer months.

An overabundance of algae is an indicator that there is an excess amount of nutrients within the water column/lake, causing the waterbody to become overly productive. Algae are very beneficial in a lake ecosystem and can be thought of as the base of the food chain. Therefore, some alga is required.

However, when an alga reaches the point of hindering the use of the lake, control measures are available. Firstly, actions should be taken within the watershed to promote a healthy lake ecosystem and decrease nutrient loading, etc. However, no immediate change will be seen with these actions. Therefore, many lakes opt to include limited algae control within their management program.

History of Management on Big Brower Lake

In 1987 Fishbeck, Thompson, Carr & Huber, Inc. (FTC&H) prepared a "Big Brower Lake Management Study" for the Big Brower Lake Improvement Board. The purpose of this feasibility study was to determine the extent and probable cause of existing aquatic vegetation problems in Big Brower Lake and to recommend a long-term program for lake improvement which would reduce the abundance of aquatic plants and enhance the value of the lake for residents and other users. A copy of that report is available for review at the Office of the Kent County Drain Commissioner. Summarized, the 1987 management recommendations for Big Brower Lake were:

1. *On-going monitoring*: Studies of water quality and nutrient loading are needed to determine levels pollutants and sources of nutrients entering Big Brower Lake. Water quality analyses should be repeated on a regular basis to monitor changes.
2. *Reduce Phosphorus Content*: Reduction of phosphorus in the lake will most effectively limit plant growth. Use of phosphorus-based fertilizers within the watershed should be discontinued and buffer strips established at lake's edge.
3. *Short term control of aquatic vegetation*: Manual harvesting and chemical herbicide applications are recommended for short-term control of aquatic plants.
4. *Long term control of aquatic vegetation*: Removal of the bottom sediments (dredging) in which these plants grow and obtain nutrients is recommended for long-term control of aquatic plants.

Management Goals for Big Brower Lake

- The primary goal of aquatic plant management in Big Brower Lake is the control of exotic aquatic plants, where found. The exotic plant species, Eurasian watermilfoil, Curlyleaf pondweed and Cabomba should be controlled throughout Big Brower Lake, if found. The abundance of these species should be reduced to the maximum extent possible, and efforts should be made to reduce their recovery after treatment.
- Aquatic plant management should preserve species diversity and cover of native plants sufficient to provide habitat for fish and other aquatic organisms. Native plants should be managed to encourage the growth of plants that support the Big Brower Lake fishery (by creating structure and habitat) provided that they do not excessively interfere with recreational uses of the lake (e.g., swimming and fishing) in high-use areas. Where they must be managed, management techniques that reduce

the stature of native plants without killing them (e.g., harvesting, contact herbicides) should be used whenever possible. Specific areas should be set aside where native plants will not be managed, to provide habitat for fish and other aquatic organisms. Muskgrass (*Chara*) should be allowed to grow throughout the lake, except in where it grows so tall as to interfere with boating and swimming.

Starry stonewort

- The species Starry stonewort, if found on the Big Brower Lake should be actively controlled and managed. Starry stonewort is in the same family as Muskgrass (Chara) but is considered to be an exotic invasive species. Starry stonewort, which looks very similar to the beneficial species Chara, is appearing in more and more lakes. Chara is a highly desired plant because it is typically low growing, keeps the water clear and can slow down the invasion of exotic weed species. Starry stonewort also forms dense mats, but unlike chara, it can grow from 5 to 7 feet tall. Starry stonewort can be very detrimental to a lake's ecosystem and has the ability to kill off native plants and have a negative impact on a lake's fisheries.

Phragmites

- The invasive terrestrial plants, Purple loosestrife and Phragmities should be controlled along the shoreline and adjacent wetlands where present. Both species are exotic and have the ability to displace beneficial native vegetation. Purple loosestrife grows 2 -4 feet tall and is a vibrant magenta color. It is very aggressive and can quickly become the dominant wetland vegetaion. Phragmites (common reed) is a wetland grass that ranges in height from 6 to 15 feet tall. "Phrag" quickly becomes the dominant feature in aquatic ecosystems, aggressively invading shorelines, wetlands, and ditches. This plant creates dense "strands" - walls of weeds crowding out beneficial native wetland vegetation and indigenous waterfowl habitats. Spreading by fragmentation and an extensive root system, Phragmites ultimately out-competes native plant life for sun, water and nutrients.
- Conditions in Big Brower Lake should not be allowed to deteriorate below present levels. Expansion of aquatic plant problems should trigger an adjustment in the aquatic vegetation management strategy. To support such responses, an annual record of vegetation and management should be maintained.
- Preventative measures that protect the lake from further nutrient enrichment should be identified and implemented.

Vegetation Survey Results

Planning/Evaluation

Vegetation surveys determine the locations of target and non-target plant species. The results of the surveys are used to determine the most appropriate management strategy. The vegetation surveys also document the success of the prescribed management program. An AVAS survey is the State of Michigan's method for conducting a complete aquatic vegetation survey. The Aquatic Vegetation Assessment Site (AVAS) survey divides the parts of the lake capable of growing plants (littoral zone) into subareas and records the cover of each aquatic plant found in each "site". This method of surveying takes into account not only the types of plant species present in the lake but also the densities of those species. AVAS surveys are also an excellent way to track plant species trends over time. A goal of invasive plant management is to have native plants increase while exotic plants decrease over time. The success of this goal can be illustrated through the use of the AVAS data collected over several years.

Table 1: Plant Species Found in Big Brower Lake – August 2016

AVAS Code	Common Name	Scientific Name	% Cumulative Cover
	Submerged- Exotic		
1	Eurasian watermilfoil	Myriophyllum spicatum	1.31
	Submerged- Native		
3	Muskgrass	Chara	13.58
4	Thinleaf pondweed	Potomageton spp.	.12
5	Flatstem pondweed	Potomageton zosteriformis	.12
10	Illinois pondweed	Potomageton illoensis	.85
11	Largeleaf pondweed	Potomageton ampifolious	.85
15	Wild Celery	Vallisneria americana	12.15
21	Elodea	Elodea canadensis	.08
25	Naiad	Najas flexilis	5.13
	Emergent- Native		
30	Water lily	Nymphaea odorata	8.69
39	Cattail	Typha spp.	3.04
40	Bulrush	Scirpus spp.	1.08
	Emergent- Exotic		
43	Purple Loosestrife	Lythrum salicaria	.04
	TOTAL		**47.04%**

Aquatic Vegetation

A complete AVAS survey of Big Brower Lake to determine plant types, populations and aquatic problems was conducted in August 2016. Big Brower Lake supports a fairly diverse community of aquatic plants. Several species of aquatic plants were encountered in the August 2016 survey of the lake (Table 1). Rooted plant growth is moderate almost everywhere in the littoral zone (0 to 10 feet deep of the lake).

All of the plants listed in Table 1 are native North American species, except for Eurasian watermilfoil, and Purple loosestrife. Although both Curlyleaf pondweed and Cabomba were found on the lake this season, neither were actively growing at the time of the survey. Common exotic plants found on Michigan lakes are Eurasian watermilfoil, Curlyleaf pondweed, Phragmites and Purple loosestrife. These plants are non-indigenous aquatic nuisance species, i.e., plants from other places. These exotic plants cause considerably more problems than most native species. Eurasian watermilfoil can attain nuisance levels of growth at almost any time of year, whereas curly leaf pondweed completes its lifecycle and drops out of the water column by approximately the Fourth of July.

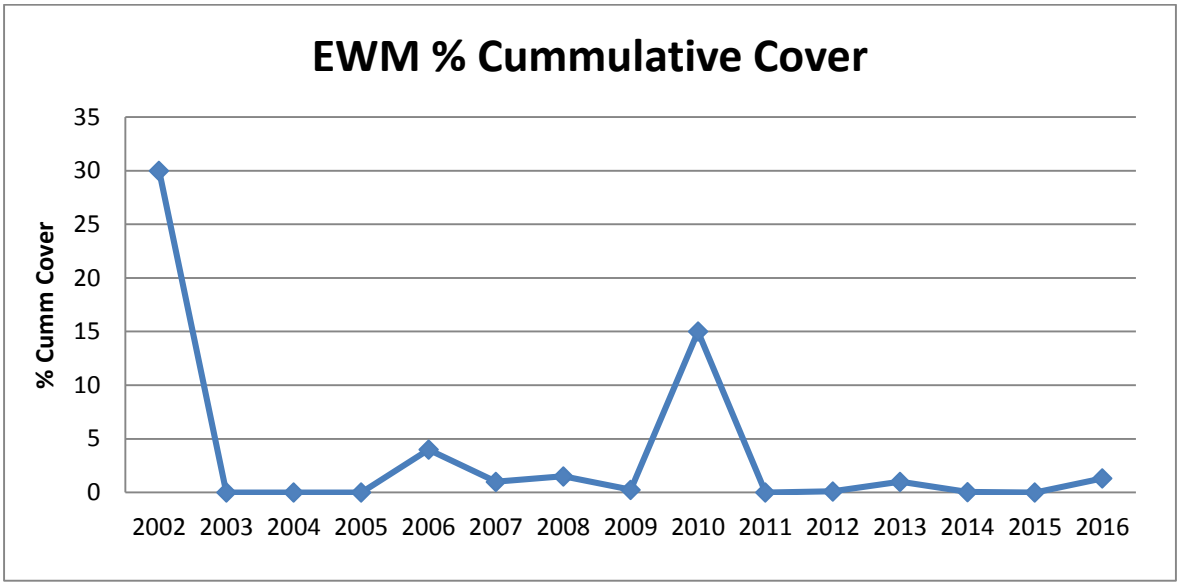
Chara

Water Lily

Wild Celery

The native plant species in Big Brower Lake benefit the lake, performing such functions as stabilizing sediments and providing habitat for fish and other aquatic organisms.

Below is a graph illustrating the success of the EWM management program over the last 10+ years.



Water Quality Program

Water quality in the lake has been evaluated by PLM in the spring and late summer every year dating back to 2001. On each occasion, a depth profile of water temperature and dissolved oxygen concentrations were measured at one-meter (approximately three foot) intervals and the Secchi disk depth was measured in the deepest part of the lake (Deep Hole Site). Samples for LakeCheck analysis were collected from the deep part of the lake (surface and bottom water) and the inlets have been sampled periodically throughout the years. LakeCheck measures conductivity, total dissolved solids, pH, alkalinity, total phosphorus, and nitrates. The water quality of the lake was tested in 2016.

Temperature and Dissolved Oxygen Profiles

Depth profiles of temperature and dissolved oxygen are taken at the Deep Hole Site twice a year, spring and late summer.

Throughout the years the dissolved oxygen has been adequate and capable of supporting an active fishery. However, many times during peak summer months, the dissolved oxygen below the thermocline, declines sharply to levels that can be unsuitable for fish life. When the cooler, bottom water is de-oxygenated it prevents fish from living there. This may cause problems such as natural fish die offs if the de-oxygenated waters reach higher levels approaching the waters surface.

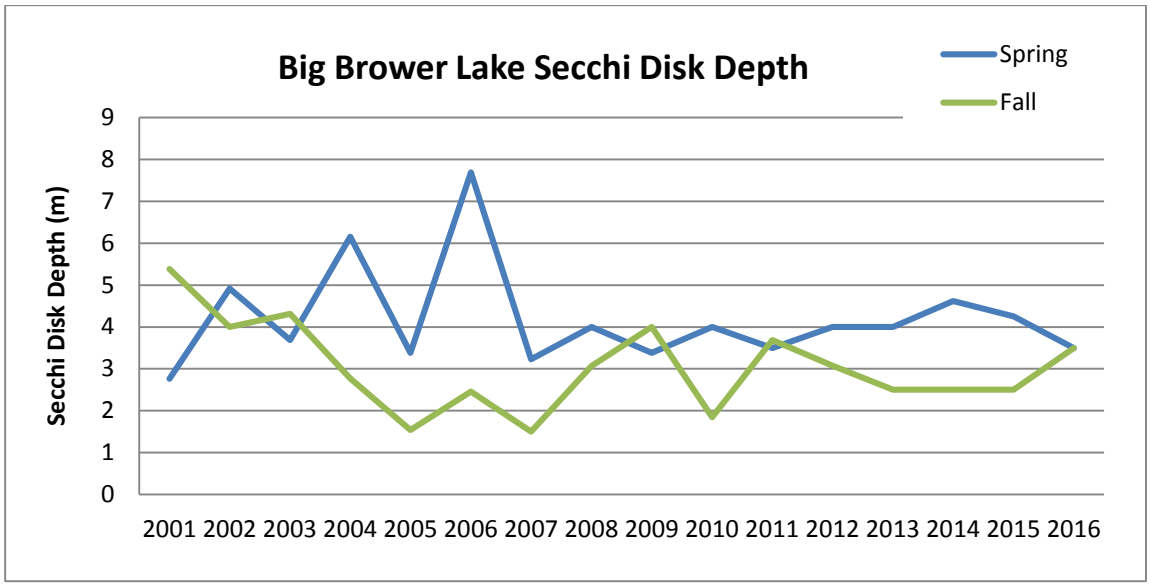
Conductivity Total Dissolved Solids, pH and Alkalinity

Conductivity and Total Dissolved Solids (TDS) measure the total concentration of dissolved salts in the water. Values for Big Brower Lake indicate low concentrations of dissolved materials. Alkalinity and pH measure the amount of dissolved bases and the balance of acids and bases in the water. Alkalinity and pH values were within normal ranges for a moderately hard water lake.

Secchi Disk Depths

The Secchi disk depth is a measure of water clarity, determined by measuring the depth to which a black and white disk can be seen from the surface. (Larger numbers represent greater water clarity). Historically, the water clarity on the lake is better in the spring and degrades as the season progresses. This is most likely due to an increase in algae along with turbidity from runoff and recreational use. The average secchi disk readings over the last five years are 4 meters for the spring sampling and 2.7 meters

during the late summer. These values are slightly higher than the averages observed in the 2013 Lake Management Plan Report.

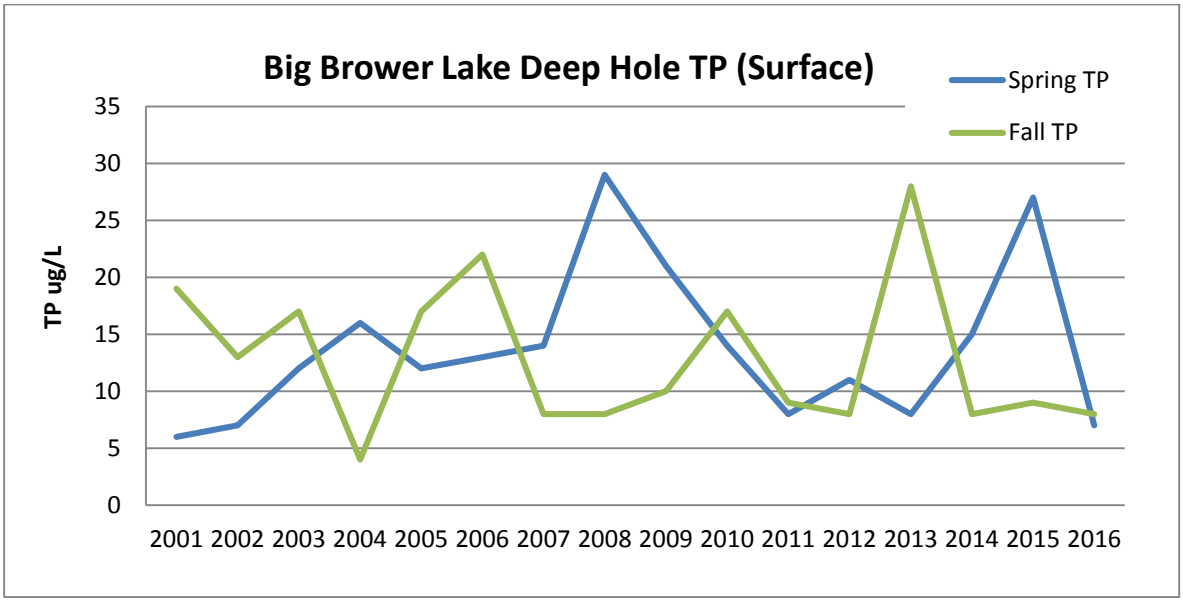


Total Phosphorus

Total phosphorus measures the total amount of phosphorus in the water. Phosphorus is an important plant nutrient (i.e., fertilizer) and the nutrient most likely to promote algal growth. Elevated phosphorus inputs to lakes caused by human activities are a major cause of cultural eutrophication.

The concentration of phosphorus encountered in Big Brower Lake over the past 5 years indicates minor phosphorus enrichment of the lake. The average concentration in the spring was 13.6 ug/L, which is considered slightly enriched. The average concentration for the late summer sampling, which is a deep water sample below the thermocline, is slightly lower, 12.2 ug/L, but still considered to be only slightly enriched.

The *Big Brower Lake Study* completed by FTC&H in 1987 showed the lake to have a phosphorus concentration of 10 ug/L at the surface in the deep hole. Based on this past data it appears that the lake is only slightly more enriched than it was 25 years ago.



Nitrates

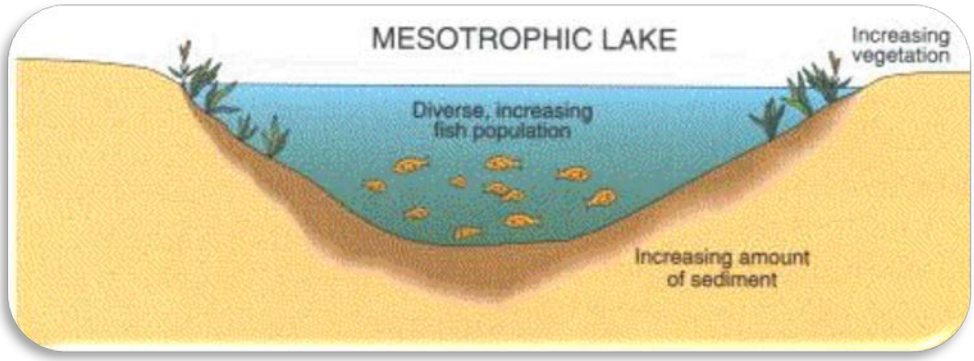
Nitrates measure the total amount of in-organic nitrogen in the water. Nitrogen is an important plant nutrient (i.e., fertilizer) and the nutrient most likely to promote the growth of rooted plants. Overall, nitrate concentrations in the lake are slightly enriched.

Evaluation of Trophic Status

Trophic status is a measure of nutrient richness and productivity (i.e. the ability to grow plants and animals). Trophic Status Index (TSI) values are used to describe the trophic status of lakes. Indices typically rank lakes from 1 to 100, based on such parameters as Sechhi disk depth and total phosphorus. The table shows the TSI average values of Big Brower over the past 5 years. Overall the TSI values for Big Brower Lake would categorize it as being Mesotrophic.

Deep Hole Site	TSI Secchi Depth	TSI Total Phosphorus
2012	42	32
2013	44	39
2014	42	35
2015	43	39
2016	44	31

Mesotrophic lakes have moderate nutrient levels, clear water and moderate productivity. Rooted plants are commonly abundant and moderate dissolved oxygen in cooler waters allow for the survival of cold water fish.



E.Coli Monitoring

E. Coli bacteria monitoring was also conducted over the last five years. Coliform bacteria (E. Coli) are invisible. Contamination of surface water by *E. coli* and other bacteria poses a hazard to swimmers and to pets that drink the water. Contamination by fecal bacteria also indicates the potential for contamination by even more dangerous pathogens from animal digestive systems, including bacteria, protozoans (such as *Giardia* or *Cryptosporidium*) or viruses. Contamination can potentially be derived from a number of sources, including failed septic systems, agricultural runoff, or waterfowl or wildlife droppings. Big Brower lake was sampled along the residential shoreline areas during the peak summer month of July. Sampling is best done in mid-summer when the water temperature is at its warmest and the bacteria have a perfect environment to populate. All sites sampled have always had very low levels of E.Coli and have always been below safe swimming standards.

The correct balance of an aquatic ecosystem will result in great water quality, thriving fisheries, and a diverse native plant population. With the help of a proper lake management program, the benefits of a balanced ecosystem are evident in Big Brower Lake.

Strategies for Achieving Lake Management Goals

Aquatic Plant Control Techniques

Areas of the lake that support vegetation will grow plants, despite intense efforts to remove them. Aquatic vegetation provides important benefits to a lake, including stabilizing sediments, providing

habitat for fish and other aquatic organisms, and slowing the spread of exotic plant species. In general, native plants interfere less with recreation and other human activities than exotic species. The non-native plant species, Eurasian watermilfoil and curly leaf pondweed concentrate their biomass at the water surface where it strongly interferes with boating, swimming and other human activities. This growth form also allows exotic plants to displace native plants and form a monospecific (i.e., single species) plant community. The dense surface canopies of Eurasian watermilfoil and Curly leaf pondweed provide a lower quality habitat than that provided by a diverse community of native plants. Control of exotic plant species minimizes interference of plant growth with human activities and protects the native vegetation of the lake. The goal of environmentally responsible aquatic plant management, therefore, is not to remove all vegetation, but to control the types of plants that grow in the lake and the height of plants, to minimize interference with human activities.

It is important that control techniques meet the needs and expectations of lake users. Each technique has advantages and disadvantages. Many aquatic plants are relatively susceptible to some control measures but resistant to others. Too often, lake groups select a control technique before determining what their needs are.

Chemical control, or use of aquatic herbicides, is the most common strategy for controlling exotic plant species. Aquatic herbicides provide predictable results and there is a great deal of research and data regarding theses products. Many of the aquatic herbicides available can be used to selectively control exotic species with minimal or no impact on native species.

Mechanical harvesting is best suited for native plant species. Most native plant species have a higher tolerance to aquatic herbicides and require higher dosage rates (higher cost and reduced selectivity). Mechanical harvesting can be used to provide relief from native plant species if they are causing a recreational nuisance. Harvesting does not kill the plants, but simply reduces it's stature, leaving lower growth for fish habitat and sedimnet stabilization. Mechanical harvesting of Eurasain watermilfoil is **not** recommended as it will expedite its spread throughout a lake through fragmentation.

Biological control options for nuisance aquatic vegetation are limited. Grass carp, which indiscriminately devour aquatic vegetation, have been restricted in many states because of their nonselective grazing and fear they may escape into nonintended waters. The use of the milfoil weevil (Euhrychipsis lecontei) to control Eurasian watermilfoil has been implemented in many Michigan lakes. PLM Lake & Land Management Corp has many years of experience paticapating in weevil stocking, evaluations and longterm observations related to their performance and sustainability. Although the milfoil weevils may impact EWM populations in certain situations, the use of this tool remains unpredictable.

Bacteria product formulations and application techiques has greatly improved in recent years. Granular bacteria products can be applied to specific shoreline areas to reduce organic muck that has acumulated over the years. As waterbodies age, organic sediment can build up due to excessive plant and algae growth. This process is called eutrohpication. Increasing native populations of bacteria can slow this process down. Reductions in the depth of muck may depend on many variables. Most importantly, the percent of sediment that is organic. The more organics in the sediment, the greater the potential for muck reduction via bacteria augmentation.

Aeration can be a beneficial tool to sustain ecological balance within an aquatic ecosystem. By maintaining sufficient oxygen levels throughout a waterbody, the entire eutrophication process can be slowed down, the health of the fishery can be maintained and overall water quality can be improved. The implementation of an aeration system to control rooted aquatic plant growth is not recommended. Rooted plants, such as Eurasian watermilfoil, will not be affected by aeration. Similar to the use of biological control, the impact of aeration on improving water quality and reducing organic sediment will vary greatly from site to site. Therefore, it is extremely important to thoroughly evaluate each site's conditions and expectations before implementing an aeration system.

Integrated Pest Management (IPM) approaches to aquatic plant control IPM emphasize spending more effort evaluating the problem, so that exactly the right control can be applied at just the right time to control the pest. IPM approaches minimize treatment costs and the use of chemicals. Lake management planning ensures the most appropriate, cost-effective treatment for your lake. Planning is an essential phase of Integrated Pest Management and includes lake vegetation surveys, water quality evaluation and a detailed, written lake management plan. Having the plan in place helps lake users know what to expect from lake management. Survey results provide a permanent record of conditions in the lake and the impact of management practices.

Exotic Plant Management

Aquatic herbicides currently represent the most reliable, effective, selective means for controlling Eurasian watermilfoil. There are currently five systemic herbicides, 2,4-D (Navigate), 2,4-D amine (Sculpin G), triclopyr (Renovate 3 & OTF), 2,4-D/Triclopyr combination (Renovate Max G) and fluridone (Sonar or Avast), which can be used to achieve long-term, selective control of Eurasian watermilfoil. Systemic herbicides are capable of killing the entire plant.

Several contact herbicides, including diquat & flumioxian can also provide short-term control of Eurasian watermilfoil, Curlyleaf pondweed & Cabomab. These herbicides kill only the shoots of the plant, and plants regrow relatively quickly from their unaffected below ground parts.

Systemic herbicides control Eurasian watermilfoil with little or no impact on most native plant species. Under ideal conditions, several consecutive annual applications of these herbicides can reduce Eurasian watermilfoil to maintenance (low) abundance, such that only relatively small spot treatments are required to keep it under control. For this strategy to succeed, it is necessary to treat most of the Eurasian watermilfoil in the lake each time.

Harvesting of Eurasian watermilfoil is **not** recommended. This plant spreads by fragmentation and regrows significantly more rapidly than most native plant species; thus continued harvesting of mixed plant beds typically leads to nearly complete domination of the aquatic vegetation by Eurasian watermilfoil.

Purple loosestrife can be selectively controlled through the use of triclopyr (Renovate). Purple loosestrife is an exotic species, which can out compete native vegetation, destroying valuable wetlands and animal habitat. In past years our options to manage this nuisance weed has been extremely limited to prevention, manual removal or broad spectrum herbicide treatments, which not only killed the Purple Loosestrife but also the native vegetation remaining in the treatment areas.

Phragmites, if found on Big Brower Lake, can be selectively controlled through the use of glyphosate or imazapyr (Habitat) herbicides. Phragmites is an exotic species, which can out compete native vegetation, destroying valuable wetlands and animal habitat.

Native Plant Management

Native plants should be controlled primarily by harvesting offshore and contact herbicides near shore, between docks and within swim areas (if required). Unlike Eurasian watermilfoil, most native plants do not regrow rapidly after harvesting, and a single harvest is often sufficient to control them for the entire summer. Normally low-growing species should not be controlled unless unusually fertile growing conditions allow them to grow tall in areas of high recreational use. Contact herbicides applied at higher rates can be effective at controlling native plants that are causing a nuisance close to shore, in between docks.

Algae Management

Areas of excessive filamentous algal growth or muskgrass (*Chara*) growth can be controlled using copper-based algaecides. Treatments should be confined to shallow areas where these algae cause a serious interference with recreation. Muskgrass should only be controlled where it grows up to the surface. Even in these areas, muskgrass treatments should be designed to take off the top layers of growth without exposing bare sediments, so as to preserve the beneficial functions of this species.

Monitoring

It is important to maintain a record of lake conditions and management activities. Vegetation surveys monitor types and locations of plants in the lake, providing information that is essential to the administration of efficient, cost-effective control measures. Vegetation surveys also document the success or failure of management actions and the amount of native vegetation being maintained in the lake. Water quality monitoring can identify trends in water quality before conditions deteriorate to the point where remediation is prohibitively expensive or impossible. Records of past conditions and management activities also help to keep management consistent despite changes in the membership of the Lake Association. Records should include (at a minimum):

- Temperature, dissolved oxygen and Secchi disk depth should be measured in the lake. Temperature and dissolved oxygen profiles should be obtained in the deep hole, so as to monitor the timing and extent of oxygen depletion in the hypolimnion (i.e., bottom water).
- Total phosphorus and nitrates should be measured in the surface and bottom water at least two times per season (spring and late summer) to monitor nutrient accumulation in the hypolimnion.
- Lake vegetation should be surveyed on an annual basis (late-spring and/or late summer/early fall) to document the results of plant management efforts and provide information necessary for planning future management.

Nutrient Loading Abatement

Lakeshore property owners should be encouraged to use phosphorus-free fertilizers on lawns and other areas that drain into Big Brower Lake or the adjacent wetlands. Lakeshore residents should also be encouraged to manage their waterside landscapes according to the recommendations outlined in publications on this topic available from the MSU Extension.

It is also important to remember that rooted plants derive most of their key nutrients from the sediments; thus they respond slowly, if at all, to reductions in nutrient loading. In fact, if reductions in nutrient loading lead to improved water clarity, the growth of rooted plants will probably increase.

If organic material (muck) accumulates to undesirable levels in shoreline areas, bacterial treatments should be considered as a way to alleviate the buildup. PLM MD (Muck Digestion) Pellets are a combination of natural beneficial bacteria, enzymes, and vitamins that stimulate the biological activity of the lake bottom. This stimulation allows the bacteria to feed on the organic sediment, therefore reducing the muck levels over time.

Prevention

Eurasian watermilfoil and curly leaf pondweed were most likely introduced to Big Brower Lake by plant fragments carried on boats and/or boat trailers. A variety of other troublesome exotic plants and animals that can be introduced to Big Brower Lake are also transported this way. Preventing their inadvertent introduction to Big Brower Lake can significantly lower the cost of future lake management. Education can be an effective preventative measure. Newsletter articles should alert lake residents to the threat from exotic nuisance plants and animals. Warning signs should be erected at any boat access sites, if applicable, that encourage boaters to clean boats and trailers when launching or removing watercraft from the lake.

Big Brower Lake Management Recommendations for 2017-2021

Management options are dependent on many factors, including but not limited to, species abundance (density), species richness, species location and many lake characteristics. Whenever an exotic species is found within an aquatic environment, action needs to be taken to prevent long term ecological damage as well as recreational and aesthetic loss that will take place.

Submersed Aquatic Plants

Conventional Herbicide treatments

Treatments with the herbicide, Triclopyr (Renovate OTF) in localized treatment areas to slow the spread of Eurasian watermilfoil should be conducted. The treatment should take place once the plants are actively growing but before they are a recreational nuisance.

Curlyleaf pondweed should be treated in early summer, once the plant is actively growing. Curlyleaf pondweed is effectively controlled using diquat, flumioxian or endothall products. Cabomba should be treated immediately after identifying any growth. This plant is a late season plant, therefore treatment will most likely not be required until late summer.

Native plant treatments with contact herbicides and algaecides in residential shoreline areas will minimize nuisance native vegetation and algae. The initial treatment should be scheduled in late June to allow for control prior to the Fourth of July holiday, depending upon growing conditions. Follow up treatments in August may be required to address re-growth.

Sonar A.S. (fluridone treatments)

A lake wide treatment utilizing the herbicide Sonar A.S. may be required if EWM reaches densities that warrant its use. Many advances in new Sonar formulations and treatment protocols are currently being researched. Therefore, a different approach than the standard Sonar treatment protocol may be conducted on Big Brower Lake in the future.

Emergent Vegetation Management

Purple loosestrife should also be addressed around the perimeter of the lake to prevent the further spread of this exotic species. The systemic herbicide, Renovate 3, is effective at selectively controlling Purple loosestrife. Since Renovate 3 is a systemic herbicide, the root system of the plant will be killed not just the foliage

Monitoring and Water Quality Testing

Aquatic vegetation will be monitored to document the condition of the lake and to provide warning of any changes in the condition of the lake that need to be addressed by additional lake management activities. Current water quality testing should continue to document overall health of the waterbody.

The recommended management program for Big Brower consists of:

- A spring vegetation survey (to evaluate conditions in the lake and direct management efforts)
- Early summer herbicide treatment (to control any Eurasian watermilfoil and/or curly leaf pondweed areas that are found)
- Algaecide treatments as needed
- Harvesting of native plants in late summer, if needed
- Late summer native pondweed and/or Eel grass treatment, if needed
- Late summer herbicide treatment (to control any Eurasian watermilfoil and/or Cabomba areas that are found)
- Water quality evaluations throughout season
- A fall vegetation survey