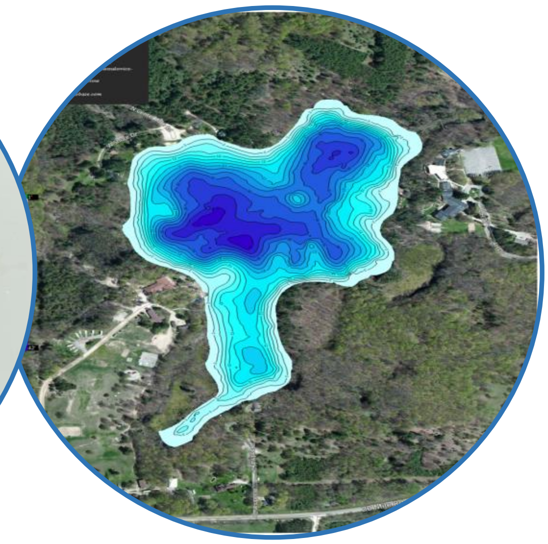
Center Lake Aquatic Vegetation Management Plan
Osceola County, Michigan



Provided for: The Residents of Center Lake, the Sherman Township Board & the Kettunen Center

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November, 2015

1.0 EXECUTIVE SUMMARY & OVERVIEW

Center Lake, comprising 40 acres, is of glacial origin with approximately 1.55 miles of shoreline. A small outlet is located at the northeast corner of the lake and the lake receives most of its water from springs at the bottom of the lake. The lake has been historically stocked with Brown Trout and has excellent water quality due to these springs. Based on the current study, Center Lake contains a high amount of submersed native aquatic plant biodiversity but contains 3 invasive aquatic plants which includes the exotic submersed Eurasian Watermilfoil (3.75 acres) and the macro alga Starry Stonewort (0.70 acres), and the exotic emergent Purple Loosestrife (0.25 acres) which threaten the biodiversity of the submersed and emergent native aquatic plant communities, may impede navigation and recreational activities, and may reduce lakefront property values if not properly managed. There are a total of 22 native aquatic plant species in and around Center Lake that are threatened by the 3 invasive, exotic aquatic plants.

Restorative Lake Sciences recommends an integrative approach for the treatment of these three invasive exotic aquatic plant species since each requires a different aquatic herbicide and approach. Continued surveys and education of the property owners around Center Lake is recommended so that future infestations of other invasive aquatic plants or other exotic creatures does not occur in Center Lake.

Alternatives for the management of the existing invasive are provided in this report along with a listing of existing native aquatic plants for those that live on Center Lake.

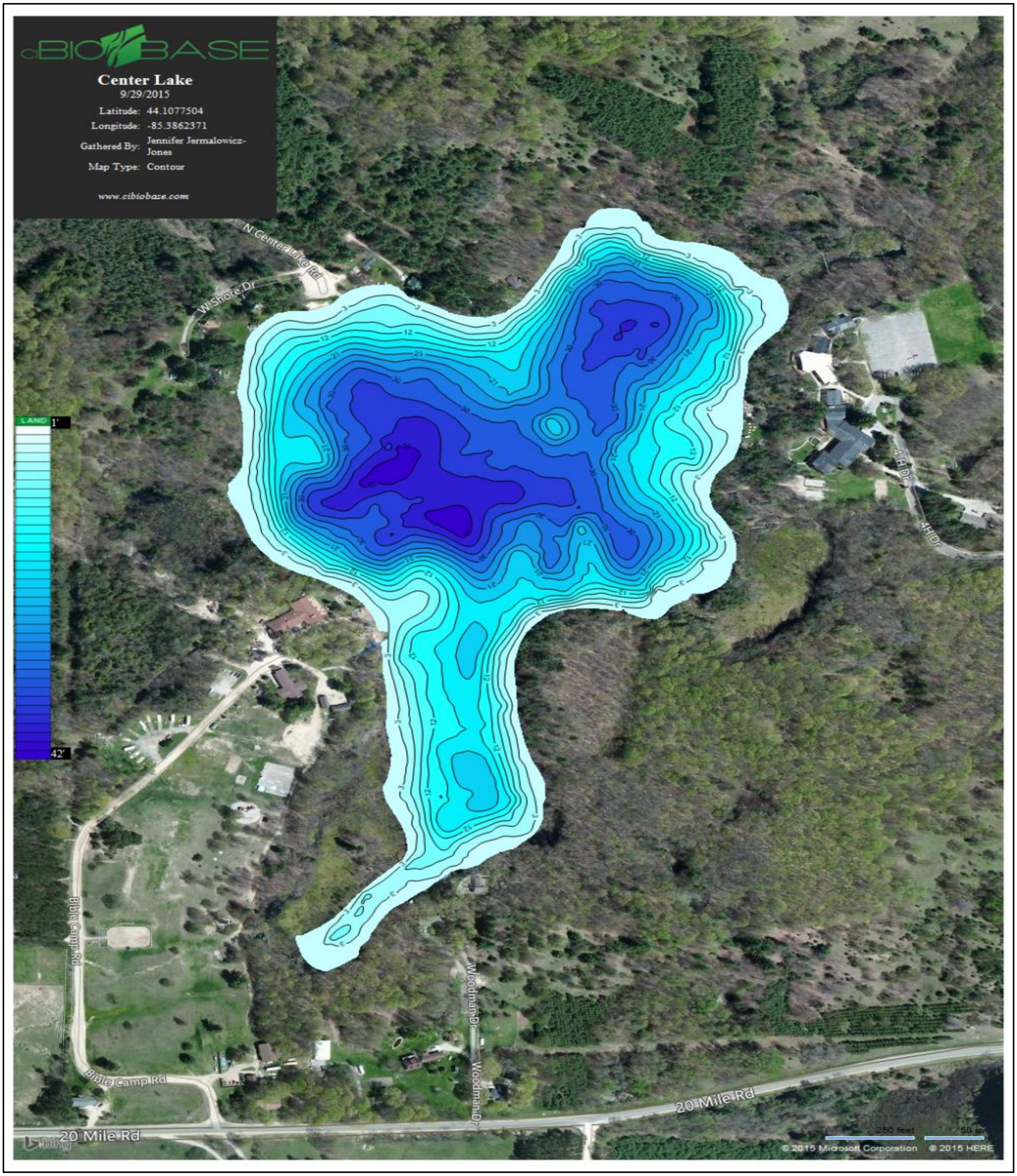

Figure 1. Modernized depth contour map of Center Lake, Osceola County, Michigan (RLS, 2015).

2.0 CENTER LAKE AQUATIC PLANT COMMUNITIES

Aquatic plants (macrophytes) are an essential component in the littoral zones of most lakes in that they serve as suitable habitat and food for macroinvertebrates, contribute oxygen to the surrounding waters through photosynthesis, stabilize bottom sediments (if in the rooted growth form), and contribute to the cycling of nutrients such as phosphorus and nitrogen upon decay. In addition, decaying aquatic plants contribute organic matter to lake sediments which further supports healthy growth of successive aquatic plant communities that are necessary for a balanced aquatic ecosystem. An overabundance of aquatic vegetation may cause organic matter to accumulate on the lake bottom faster than it can break down. Aquatic plants generally consist of rooted submersed, free-floating submersed, floating-leaved, and emergent growth forms. The emergent growth form (i.e. Cattails, Native Loosestrife) is critical for the diversity of insects onshore and for the health of nearby wetlands. Submersed aquatic plants can be rooted in the lake sediment (i.e. Milfoils, Pondweeds), or free-floating in the water column (i.e. Bladderwort). Nonetheless, there is evidence that the diversity of submersed aquatic macrophytes can greatly influence the diversity of macroinvertebrates associated with aquatic plants of different structural morphologies (Parsons and Matthews, 1995). Therefore, it is possible that declines in the biodiversity and abundance of submersed aquatic plant species and associated macroinvertebrates, could negatively impact the fisheries of inland lakes. Alternatively, the overabundance of aquatic vegetation can compromise recreational activities, aesthetics, and property values.

A whole-lake scan of the entire basin of Center Lake revealed that most of the lake remains non-vegetated. Figure 2 below shows the lake areas that are vegetated and those that lack vegetation appear blue in color. Areas of the lake with high-growing aquatic plants are red in color and in this case many of those areas consist of milfoil growth. Areas with green color represent low-growing aquatic vegetation which can be low-growing new milfoil growth or favorable native aquatic plants such as Chara. This is why it is critical to also conduct additional surveys such as an Aquatic Vegetation Assessment Site (AVAS) protocol to also record the individual species present at each site in addition to scanning the lake bottom. More specific detail on the individual species of native plants is given in Section 2.2 below.

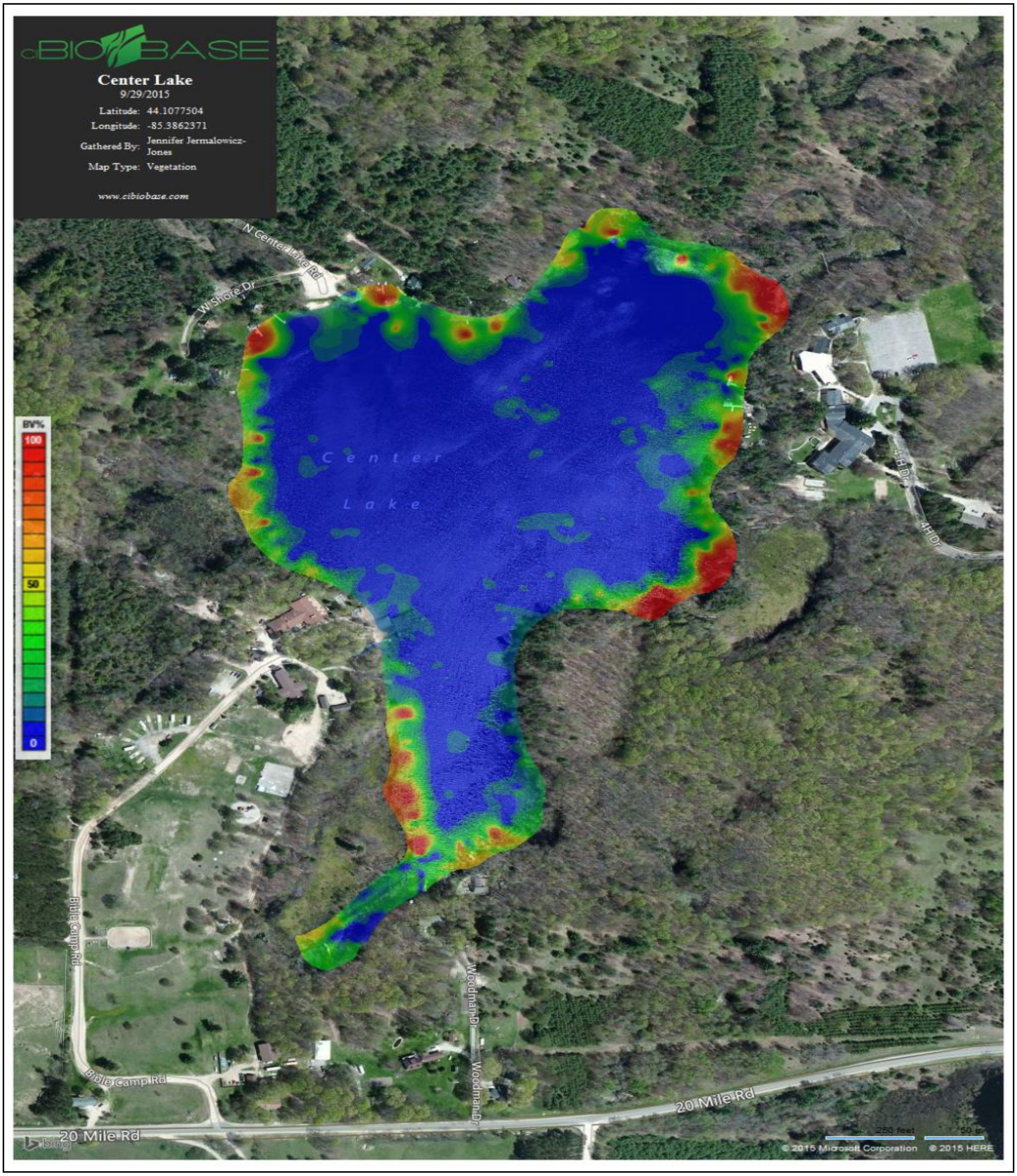

Figure 2. Aquatic vegetation biovolume map of Center Lake, Osceola County, Michigan (RLS, 2015).

2.1 Center Lake Exotic Aquatic Macrophytes

Exotic aquatic plants (macrophytes) are not native to a particular site, but are introduced by some biotic (living) or abiotic (non-living) vector. Such vectors include the transfer of aquatic plant seeds and fragments by boats and trailers (especially if the lake has public access sites), waterfowl, or by wind dispersal. In addition, exotic species may be introduced into aquatic systems through the release of aquarium or water garden plants into a water body. An aquatic exotic species may have profound impacts on the aquatic ecosystem. Exotic aquatic plant species in Center Lake are shown in Table 1 below.

Eurasian Watermilfoil (*Myriophyllum spicatum*; Figure 3) is an exotic aquatic plant first documented in the United States in the 1880's (Reed 1997), although other reports (Couch and Nelson 1985) suggest it was first found in the 1940's. In recent years, this species has hybridized with native milfoil species to form hybrid species. Eurasian Watermilfoil has since spread to thousands of inland lakes in various states through the use of boats and trailers, waterfowl, seed dispersal, and intentional introduction for fish habitat. Eurasian Watermilfoil is a major threat to the ecological balance of an aquatic ecosystem through causation of significant declines in favorable native vegetation within lakes (Madsen et *al*. 1991), in that it forms dense canopies (Figure 4) and may limit light from reaching native aquatic plant species (Newroth 1985; Aiken et *al*. 1979). Additionally, Eurasian Watermilfoil can alter the macroinvertebrate populations associated with particular native plants of certain structural architecture (Newroth 1985). Approximately 3.75 acres of Eurasian Watermilfoil was found in Center Lake during the September 29, 2015 aquatic vegetation survey by RLS scientists.

Approximately 0.25 acres of Purple Loosestrife (*Lythrum salicaria*; Figure 5), an invasive (i.e. exotic) emergent aquatic plant that inhabits wetlands and shoreline areas was found along some areas of the southwest, southeast, and northeast shorelines of Center Lake. *L. salicaria* has showy magenta-colored flowers that bloom in mid-July and terminate in late September. The seeds are highly resistant to tough environmental conditions and may reside in the ground for extended periods of time. It exhibits rigorous growth and may out-compete other favorable native emergents such as Cattails (*Typha latifolia*) and thus reduce the biological diversity of localized ecosystems. The plant is spreading rapidly across the United States and is converting diverse wetland habitats to monocultures with substantially lower biological diversity. Lake residents should be educated about its invasiveness and threat to the health of the Center Lake ecosystem. It should be removed promptly (i.e. by hand pulling or using a shovel to remove the roots and then discarding the plant into the garbage) if it is discovered to avoid further infestation. If the plant is not promptly removed by hand, it could dominate in wetland areas and require larger-scale systemic herbicide treatments.

Starry stonewort (*Nitellopsis obtusa*; Figure 6) is an invasive macro alga that has invaded many inland lakes of Michigan and was originally discovered in the St. Lawrence River. Approximately 0.70 acres of this invasive alga was found in Center Lake. The "leaves" appear as long, smooth, angular branches of differing lengths. In clear lakes, the alga has been observed in dense beds at depths beyond several meters and can grow to heights in excess of a few meters. It prefers clear alkaline waters and has been shown to cause significant declines in water quality and fishery spawning habitat.

A map showing the distribution of all invasives in and around Center Lake is shown in Figure 7 below.

Figure 3. Eurasian Watermilfoil ©RLS

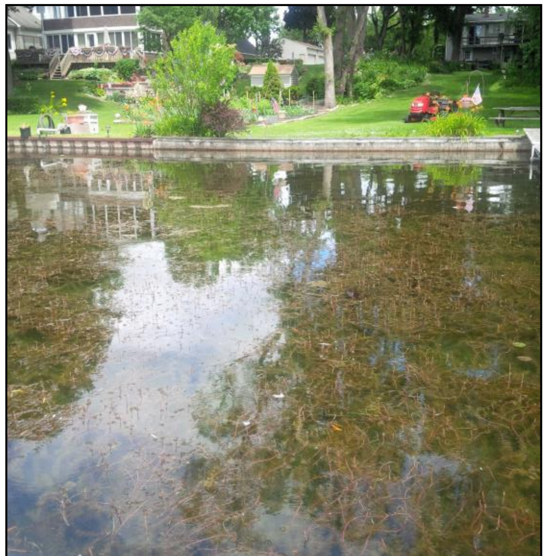

Figure 4. Eurasian Watermilfoil canopy ©RLS

Figure 5. Purple Loosestrife ©RLS

Figure 6. Starry Stonewort

Exotic Aquatic Plant Species	Common Name	Growth Habit	# Acres in Center Lake
Myriophyllum spicatum	Eurasian Watermilfoil	Submersed; Rooted	3.75
Lythrum salicaria	Purple Loosestrife	Emergent	0.25
Nitellopsis obtusa	Starry Stonewort	Submersed; Rooted	0.7

Table 1. Center Lake exotic aquatic plant species (September 29, 2015).

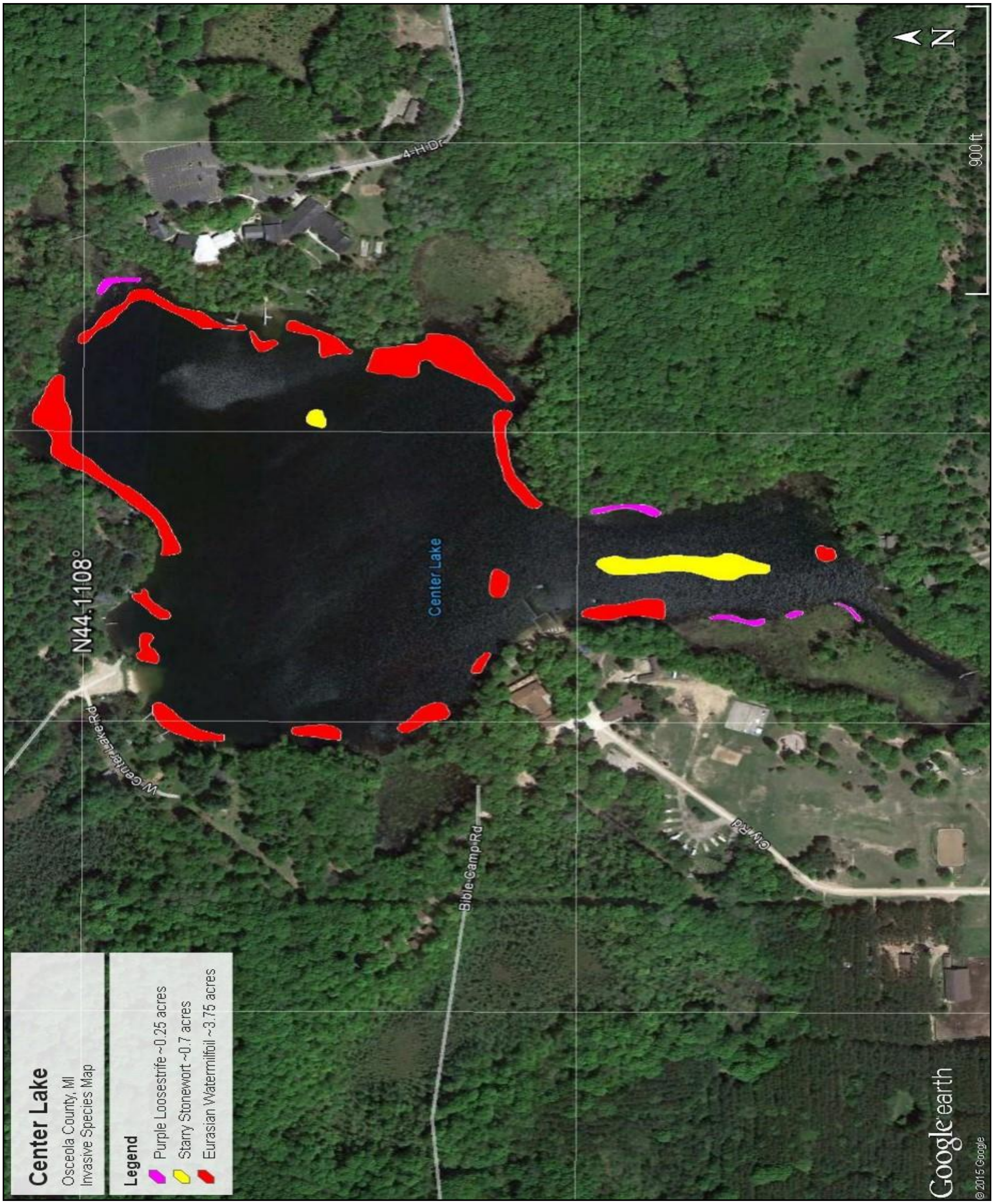

Figure 7. Distribution of Invasive Aquatic Plants in Center Lake (September 29, 2015).

2.2 Center Lake Native Aquatic Macrophytes

There are hundreds of native aquatic plant species in the waters of the United States. The most diverse native genera include the Potamogetonaceae (Pondweeds) and the Haloragaceae (Milfoils). Native aquatic plants may grow to nuisance levels in lakes with abundant nutrients (both water column and sediment) such as phosphorus, and in sites with high water transparency. The diversity of native aquatic plants is essential for the balance of aquatic ecosystems, because each plant harbors different macroinvertebrate communities and varies in fish habitat structure.

Center Lake contained 13 native submersed, 2 floating-leaved, and 7 emergent aquatic plant species, for a total of 22 native aquatic macrophyte species (Table 2). Photos of all native aquatic plants are shown below in Figures 8-29. The majority of the emergent macrophytes may be found along the shoreline of the lake. Additionally, the majority of the floating-leaved macrophyte species can be found near the shoreline. This is likely due to enriched sediments and shallower water depth with reduced wave energy, which facilitates the growth of aquatic plants with various morphological forms.

The dominant aquatic plants in the main part of the lake included the Floating-leaf Pondweed (16.6% of the littoral zone), Chara (11.2% of the littoral zone), and the emergent Burr Reed and Leatherleaf (both occupying 6.6% of the shoreline). The Pondweeds grow tall in the water column and serve as excellent fish cover. In dense quantities, they can be a nuisance for swimming and boating and can be controlled with selective herbicide management. Chara grows low to the bottom and serves as excellent fish spawning habitat and also helps to keep the sediments from being suspended in the water column which helps to keep the water clear. The emergent plants around the shoreline, especially Burr Reed and Leatherleaf are characteristic of bog and acidic habitats which are usually high in species diversity of bryophytes and other small non-vascular plants.

The abundance of emergent plants are critical for shoreline stabilization as well as for wildlife and fish spawning habitat. The presence of Purple Loosestrife around the Center Lake shoreline is an imminent threat to the emergent aquatic plan populations, which could be displaced if left untreated or removed.

Native Aquatic Plant Species Name	***Aquatic Plant Common Name***	***Abundance in/around Center Lake***	***Aquatic Plant Growth Habit***
Chara vulgaris	Muskgrass	11.2	Submersed, Rooted
Potamogeton pectinatus	Thin-leaf Pondweed	0.2	Submersed, Rooted
Potamogeton zosteriformis	Flat-stem Pondweed	0.2	Submersed, Rooted
Potamogeton amplifolius	Large-leaf Pondweed	1.6	Submersed, Rooted
Potamogeton gramineus	Variable-leaf Pondweed	0.4	Submersed, Rooted
Potamogeton robbinsii	Fern-leaf Pondweed	1.3	Submersed, Rooted
Potamogeton natans	Floating-leaf Pondweed	16.6	Submersed, Rooted
Potamogeton nodosus	American Pondweed	0.1	Submersed, Rooted
Elodea canadensis	Common Waterweed	0.1	Submersed, Rooted
Potamogeton pusillus	Small-leaf Pondweed	0.1	Submersed, Rooted
Utricularia vulgaris	Bladderwort	0.1	Submersed, Non-Rooted
Najas flexilis	Slender Naiad	0.1	Submersed, Rooted
Myriophyllum tenellum	Leafless Watermilfoil	3.5	Submersed, Rooted
Nymphaea odorata	White Waterlily	3.0	Floating-Leaved, Rooted
Brasenia schreberi	Watershield	2.1	Floating-Leaved, Rooted
Typha latifolia	Cattails	0.1	Emergent
Scirpus acutus	Bulrushes	0.1	Emergent
Arrow Arum	Arrowhead	0.1	Emergent
Sparganium americanum	Burr Reed	6.6	Emergent
Pontedaria cordata	Pickerelweed	4.0	Emergent
Chamaedaphne calyculata	Leatherleaf	6.6	Emergent
Decodon verticillatus	Swamp Loosestrife	0.5	Emergent

Table 2. Center Lake native aquatic plants (September 29, 2015).

Figure 8. Chara (Muskgrass)

Figure 9. Thin-leaf Pondweed

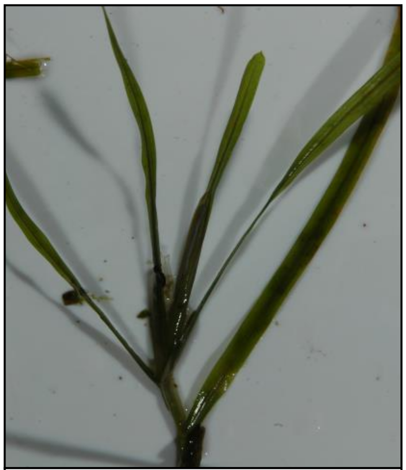

Figure 10. Flat-stem Pondweed ©RLS

Figure 11. Large-leaf Pondweed ©RLS

Figure 12. Variable-leaf Pondweed ©RLS

Figure 13. Fern-leaf Pondweed ©RLS

Figure 14. Floating-leaf Pondweed

Figure 15. American Pondweed

Figure 16. Elodea Common Waterweed ©RLS

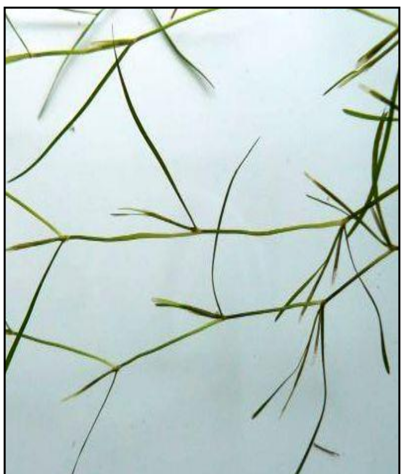

Figure 17. Small-leaf Pondweed ©RLS

Figure 18. Bladderwort ©RLS

Figure 19. Slender Naiad ©RLS

Figure 20. Leafless Watermilfoil ©RLS

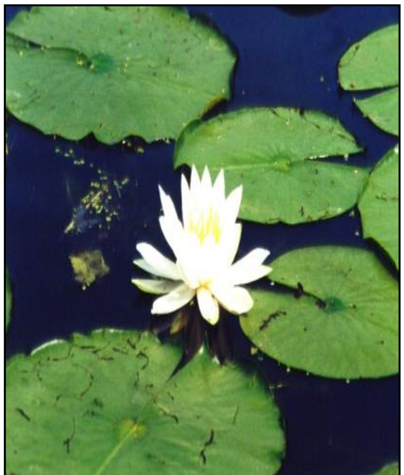

Figure 21. White Waterlily ©RLS

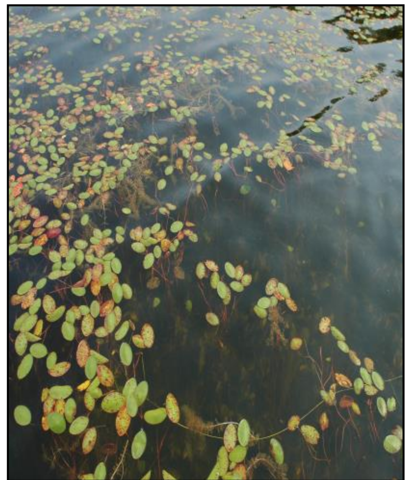

Figure 22. Watershield ©RLS

Figure 23. Cattails ©RLS

Figure 24. Bulrushes ©RLS

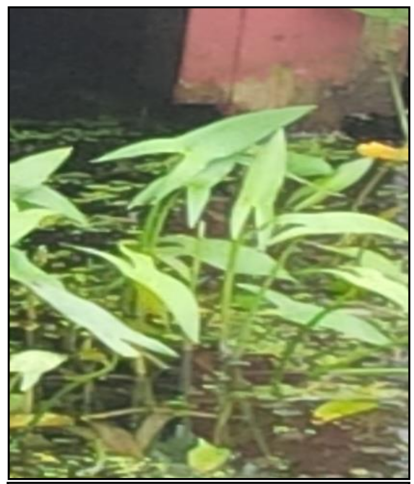

Figure 25. Arrowhead ©RLS

Figure 26. Burr Reed

Figure 27. Pickerelweed ©RLS

Figure 28. Leatherleaf

Figure 29. Swamp Loosestrife

3.0 CENTER LAKE MANAGEMENT AQUATIC PLANT IMPROVEMENT ALTERNATIVES

3.1 Center Lake Aquatic Plant Management

Improvement strategies, including the management of exotic aquatic plants, control of land and shoreline erosion, and further nutrient loading from external sources, are available for the various problematic issues facing Center Lake. The lake management components involve both within-lake (basin) and around-lake (watershed) solutions to protect and restore complex aquatic ecosystems. The goals of a Lake Management Plan (LMP) are to increase water quality, favorable wildlife habitat, aquatic plant and animal biodiversity, recreational use, and protect property values. Regardless of the management goals, all management decisions must be site-specific and should consider the socio-economic, scientific, and environmental components of the LMP (Madsen 1997).

The management of submersed nuisance invasive and native aquatic plants is necessary in Center Lake due to accelerated growth and distribution. Management options should be environmentally and ecologically sound and financially feasible. Options for control of aquatic plants are limited yet are capable of achieving strong results when used properly. Implementation of more growth of favorable native aquatic plants (especially the low growing native plants) in Center Lake to provide for a healthier lake is recommended. However, exotic aquatic plant species and nuisance-level native aquatic vegetation should be managed with solutions that will yield long-term results.

3.1.1 Aquatic Herbicides and Applications

The use of aquatic chemical herbicides is regulated by the MDEQ under Part 33 (Aquatic Nuisance) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, and requires a permit. The permit contains a list of approved herbicides for a particular body of water, as well as dosage rates, treatment areas, and water use restrictions. Contact and systemic aquatic herbicides are the two primary categories used in aquatic systems.

Contact herbicides such as diquat, flumioxazin, and hydrothol cause damage to leaf and stem structures; whereas systemic herbicides are assimilated by the plant roots and are lethal to the entire plant. Wherever possible, it is preferred to use a systemic herbicide for longer-lasting aquatic plant control. There are often restrictions with usage of some systemic herbicides around shoreline areas that contain shallow drinking wells. In Center Lake, the use of contact herbicides (such as diquat and flumioxazin) would be recommended only for the exotic Starry Stonewort since no systemic herbicide exits for the treatment of this macro alga.

Systemic herbicides such as 2, 4-D and Triclopyr are the two primary systemic herbicides used to treat milfoil that occurs in a scattered distribution such as that noted in Center Lake. Fluridone (trade name, SONAR®) is a systemic whole-lake herbicide treatment that is applied to the entire lake volume in the spring and is used for extensive infestations. The objective of a fluridone treatment is to selectively control the growth of milfoil in order to allow other native aquatic plants to germinate and create a more diverse aquatic plant community. Due to the low amount of milfoil in Center Lake, the use of fluridone is not recommended at this time. Recommended herbicides for the current milfoil infestation in Center Lake include liquid or granular Triclopyr. The majority of the milfoil is too close to shore to use 2,4-D since that herbicide cannot be used in near shore areas with shallow well (< 30 feet deep) restrictions.

3.1.2 Mechanical Harvesting

Mechanical harvesting involves the physical removal of nuisance aquatic vegetation with the use of a mechanical harvesting machine (Figure 30). The mechanical harvester collects numerous loads of aquatic plants as they are cut near the lake bottom. The plants are off-loaded onto a conveyor and then into a dump truck. Harvested plants are then taken to an offsite landfill or farm where they can be used as fertilizer. Mechanical harvesting is preferred over chemical herbicides when primarily native aquatic plants exist, or when excessive amounts of plant biomass need to be removed. Mechanical harvesting is usually not recommended for the removal of Eurasian Watermilfoil since the plant may fragment when cut and re-grow on the lake bottom. Due to the threat of milfoil fragmentation, the use of mechanical harvesting for the removal of the milfoil in Center Lake is not recommended. Mechanical harvesting does not require a permit from the Michigan Department of Environmental Quality (MDEQ); however, some counties require a launch site use permit from the Michigan Department of Natural Resources (MDNR) if a public access site is present.

Figure 30. A mechanical harvester

3.1.3 Benthic Barriers and Nearshore Management Methods

The use of benthic barrier mats (Figure 31) or Weed Rollers (Figure 32) have been used to reduce weed growth in small areas such as in beach areas and around docks. The benthic mats are placed on the lake bottom in early spring prior to the germination of aquatic vegetation. They act to reduce germination of all aquatic plants and lead to a local area free of most aquatic vegetation. Benthic barriers may come in various sizes between 100-400 feet in length.

Weed Rollers are electrical devices which utilize a rolling arm that rolls along the lake bottom in small areas (usually not more than 50 feet) and pulverizes the lake bottom to reduce germination of any aquatic vegetation in that area.

Both methods are useful in recreational lakes such as Center Lake and work best in beach areas and near docks to reduce nuisance aquatic vegetation growth.

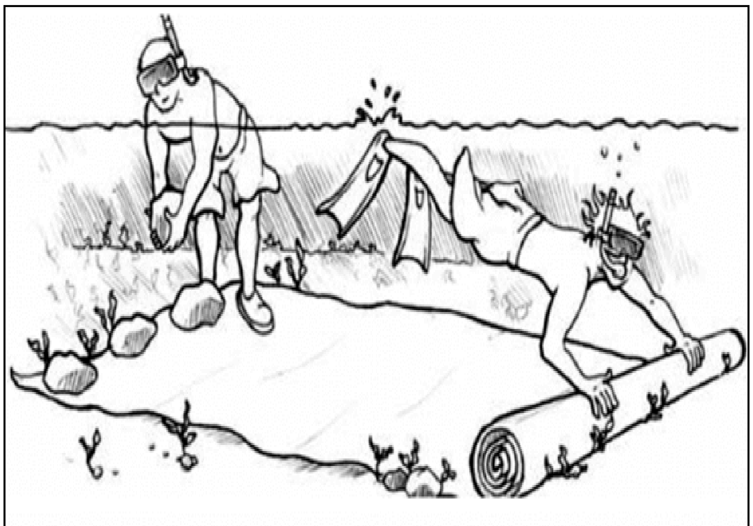

Figure 31. A Benthic Barrier. Photo courtesy of Cornell Cooperative Extension.

Figure 32. A Weed Roller.

3.1.4 Diver Assisted Suction Harvesting (DASH)

Suction harvesting via a Diver Assisted Suction Harvesting (DASH) boat (Figure 33) involves hand removal of individual plants by a SCUBA diver in selected areas of lake bottom with the use of a hand-operated suction hose. Samples are dewatered on land or removed via fabric bags to an offsite location. This method is generally recommended for small (less than 1 acre) spot removal of vegetation since it is costly on a large scale. It may be used in the future to remove small remaining areas of milfoil after large-scale initial treatments have been successful or is useful on nearshore growth.

This method is a sustainable option for removal of plant beds in beach areas and areas where herbicide treatments may be restricted. The process requires a permit from the MDEQ.

Figure 33. A DASH boat for hand-removal of milfoil or other nuisance vegetation. ©Restorative Lake Sciences

3.1.5 Laminar Flow Aeration and Bioaugmentation

Laminar flow aeration systems (Figure 34) are retrofitted to a particular site and account for variables such as water depth and volume, contours, water flow rates, and thickness and composition of lake sediment. The systems are designed to completely mix the surrounding waters and evenly distribute dissolved oxygen throughout the lake sediments for efficient microbial utilization. A laminar flow aeration system utilizes diffusers which are powered by onshore air compressors. The diffusers are connected via extensive self-sinking airlines which help to purge the lake sediment pore water of gases such as benthic carbon dioxide (CO_2) and hydrogen sulfide (H_2S).

A study by Turcotte et *al*. (1988) analyzed the impacts of bioaugmentation on the growth of Eurasian Watermilfoil and found that during two four-month studies, the growth and re-generation of this plant was reduced significantly with little change in external nutrient loading. Currently, it is unknown whether the reduction of organic matter for rooting medium or the availability of nutrients for sustained growth is the critical growth limitation factor and these possibilities are being researched. A reduction of Eurasian Watermilfoil is desirable for protection of native plant biodiversity, recreation, water quality, and reduction of nutrients such as nitrogen and phosphorus upon decay (Ogwada et *al*., 1984).

The Laminar Flow Aeration system has some limitations including the inability to break down mineral sediments, the requirement of a constant Phase I electrical energy source to power the units and possible unpredictable response by various species of rooted aquatic plants (currently being researched by RLS). Due to the high cost and the fact that the bottom of Center Lake is well-oxygenated, this technology would be cost-prohibitive at this time for solely milfoil reduction.

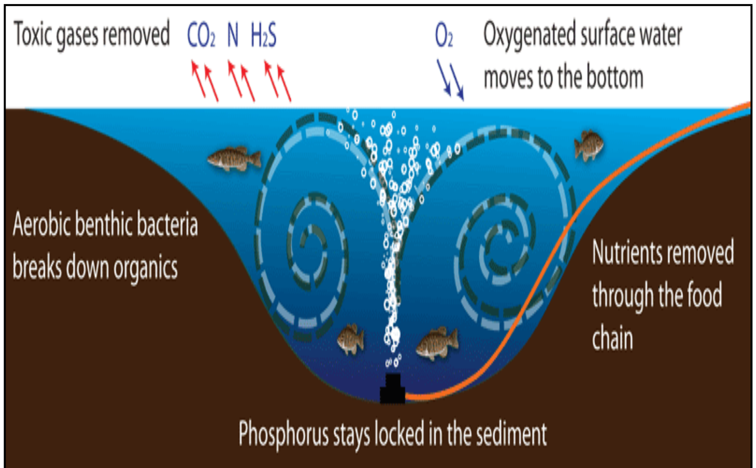

Figure 34. A diagram showing the laminar flow aeration mechanisms. ©RLS

3.2 Aquatic Invasive Species Prevention

An exotic species is a non-native species that does not originate from a particular location. When international commerce and travel became prevalent, many of these species were transported to areas of the world where they did not originate. Due to their small size, insects, plants, animals, and aquatic organisms may escape detection and be unknowingly transferred to unintended habitats. The first ingredient to successful prevention of unwanted transfers of exotic species to Center Lake is awareness and education.

Zebra Mussels

Zebra mussels (*Dreissena polymorpha*) were first discovered in Lake St. Clair in 1988 (Herbert et al. 1989) and likely arrived in ballast water or on shipping vessels from Europe (McMahon 1996). They are easily transferred to other lakes because they inherit a larval (nearly microscopic) stage where they can easily avoid detection. The mussels then grow into the adult (shelled) form and attach to substrates (i.e. boats, rafts, docks, pipes, aquatic plants, and lake bottom sediments) with the use of byssal threads. The fecundity (reproductive rate) of female zebra mussels is high, with as many as 40,000 eggs laid per reproductive cycle and up to 1,000,000 in a single spawning season (Mackie and Schlosser 1996). Although the mussels only live 2-3 years, they are capable of great harm to aquatic environments. In particular, they have shown selective grazing capabilities by feeding on the preferred zooplankton food source (green algae) and expulsion of the non-preferred blue green algae (cyanobacteria). Additionally, they may decrease the abundance of beneficial diatoms in aquatic ecosystems (Holland 1993). Such declines in favorable algae, can decrease zooplankton populations and ultimately the biomass of planktivorous fish populations. Zebra mussels are viewed by some as beneficial to lakes due to their filtration capabilities and subsequent contributions to increased water clarity. However, such water clarity may allow other photosynthetic aquatic plants to grow to nuisance levels (Skubinna et al. 1995).

The recommended prevention protocols for introduction of zebra mussels includes steam-washing all boats, boat trailers, jet-skis, and floaters prior to placing them into Center Lake. Fishing poles, lures, and other equipment used in other lakes (and especially the Great Lakes) should also be thoroughly steam-washed before use in Center Lake. Additionally, all solid construction materials (if recycled from other lakes) must also be steam-washed. Boat transom wells must always be steam-washed and emptied prior to entry into the lake. Excessive waterfowl should also be discouraged from the lake since they are a natural transportation vector of the microscopic zebra mussel larvae or mature adults.

Invasive Aquatic Plants

In addition to Eurasian watermilfoil (*M. spicatum*), many other invasive aquatic plant species are being introduced into waters of the North Temperate Zone. The majority of exotic aquatic plants do not depend on high water column nutrients for growth, as they are well-adapted to using sunlight and minimal nutrients for successful growth. These species have similar detrimental impacts to lakes in that they decrease the quantity and abundance of native aquatic plants and associated macroinvertebrates and consequently alter the lake fishery. Such species include *Hydrilla verticillata* and *Trapa natans* (Water Chestnut). *Hydrilla* was introduced to waters of the United States from Asia in 1960 (Blackburn et al. 1969) and is a highly problematic submersed, rooted, aquatic plant in tropical waters. Recently, *Hydrilla* was found in Lake Manitou (Indiana, USA) and the lake public access sites were immediately quarantined in an effort to eradicate it. *Hydrilla* retains many physiologically distinct reproductive strategies which allow it to colonize vast areas of water and to considerable depths, including fragmentation, tuber and turion formation, and seed production. Currently, the methods of control for

Hydrilla include the use of chemical herbicides, rigorous mechanical harvesting, and Grass Carp (*Ctenopharyngodon idella* Val.), with some biological controls currently being researched. However, use of the Grass Carp in Michigan is currently not permitted by the Michigan Department of Natural Resources (MDNR).

Water Chestnut (*Trapa natans*) is a non-native, annual, submersed, rooted aquatic plant that was introduced into the United States in the 1870's yet may be found primarily in the northeastern states. The stems of this aquatic plant can reach lengths of 12-15 feet, while the floating leaves form a rosette on the lake surface. Seeds are produced in July and are extremely thick and hardy and may last for up to 12 years in the lake sediment. If stepped on, the seed pods may even cause deep puncture wounds to those who recreate on the lake. Methods of control involve the use of mechanical removal and chemical herbicides. Biological controls are not yet available for the control of this aquatic plant.

4.0 CENTER LAKE PROJECT CONCLUSIONS & RECOMMENDATIONS

The urgent control of the submersed Eurasian Watermilfoil, Starry Stonewort, and the emergent Purple Loosestrife in and around Center Lake is essential for the long-term preservation of the favorable (non-nuisance) native aquatic plant communities in the lake. The use of aquatic herbicides for species-specific control of these plants is preferred over other methods at this time for reasons described above with each method. Additional improvements would include continued monitoring of the lake and education of the lake residents on future invasive species.

Furthermore, a professional limnologist/aquatic botanist should perform regular GPS-guided whole-lake surveys each spring and late summer/early fall to monitor the growth and distribution of all invasives and nuisance aquatic vegetation growth prior to and after treatments to determine treatment efficacy. The lake manager should oversee all management activities and would be responsible for the creation of aquatic plant management survey maps, direction of the herbicide applicator to target-specific areas of aquatic vegetation for removal, administrative duties such as the processing of contractor invoices, and lake management education.

4.1 Cost Estimates for Center Lake Improvements

The proposed aquatic vegetation management program for the control of Eurasian Watermilfoil, and Starry Stonewort growth in Center Lake would begin during the 2016 season. A breakdown of estimated costs associated with the various proposed treatments in Center Lake is presented in Table 3. It should be noted that proposed costs are estimates and may change in response to changes in environmental conditions (i.e. increases in aquatic plant growth or distribution, or changes in herbicide costs).

The SAD should include all riparian properties around Center Lake which would derive benefit from the intended improvements mentioned in the management plan. Under P.A. 188 of 1954, it is critical that the properties within the SAD be equitable to properties within a particular category. Furthermore, it is suggested that the Township work closely with the Center Lake residents on this project as both as important stakeholders for this unique water resource. All aquatic herbicides to be used in Center Lake must be registered by the United States Environmental Protection Agency (EPA) and also must be used according to the safety guidelines listed for that particular herbicide on the MSDS sheet. The aquatic herbicide registration process requires that intense studies on human exposure and health, effects on fisheries and wildlife, bio-persistence, and analysis of chemical breakdown products all be assessed to determine if these substances are safe to use in aquatic habitats for the control of nuisance aquatic vegetation.

Proposed Center Lake Improvement Item	Estimated 2016 Cost	Estimated 2017-2018 Cost[4]
Systemic herbicides for Watermilfoil @$580/acre for 3.75 acres	$2,175	$1,088
Contact herbicides for kill of Starry Stonewort @$600/acre for 0.70 acres	$420	$210
$200 MDEQ permit fee (MDEQ fee structure for 2016)	$200	$200
Professional services (limnologist surveys, oversight, processing, education)[2]	$1,000	$1,000
Contingency[3]	$380	$250
Total Annual Estimated Cost	$4,175	$2,748

Table 3. Center Lake proposed lake improvement program costs (2016-2018).

[1] Herbicide treatment scope may change annually due to changes in the distribution and/or abundance of aquatic plants.

[2] Professional services includes two annual GPS-guided, aquatic vegetation surveys, pre and post-treatment surveys for aquatic plant control methods, oversight and management of the aquatic plant control program, processing of all invoices from contractors and others billing for services related to the improvement program, education of local riparians through the development of a high-quality annual report in PDF format that can be emailed through a list, and attendance at an annual regularly scheduled board meeting.

[3] Contingency is 10% of the total project cost, to assure that extra funds are available for unexpected expenses. Note: Contingency may be advised and/or needed for future treatment years. Contingency funds may also be used for other water quality improvements and watershed management.

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