8.12 Muskellunge Lake

8.12.1 An Introduction to Muskellunge Lake

Muskellunge Lake, Vilas County, is a 272-acre drainage lake. This eutrophic lake has a moderately sized watershed when compared to the size of the lake. Muskellunge Lake contains 30 native plant species, of which coontail is the most common plant. No exotic plant species are known to exist in the lake.

Field Survey Notes

Large lake with brown stained water and abundant vegetation. Dark organic sediments, mucky areas and rocky areas found along the shoreline. Lake bottom primarily muck with random rocky areas too. Many fish observed (bass, muskellunge) along with eagles. Very green water (algae bloom) observed during August 12th water quality sampling, was not seen during PI survey the previous week.

Lake at a Glance - Muskellunge Lake

Morphology	
Acreage	272
Maximum Depth (ft)	19*
Mean Depth (ft)	9
Shoreline Complexity	2.7
Vegetation	
Curly-leaf Pondweed Survey Date	June 15, 2009
Comprehensive Survey Date	August 5, 2009
Number of Native Species	30
Threatened/Special Concern Species	None
Exotic Plant Species	None
Simpson's Diversity Index	0.86
Average Conservatism Value	6.2
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	9.2
Sensitivity to Acid Rain	Not Sensitive
Watershed to Lake Area Ratio	6:1

** Maximum depth at ordinary high water level*

8.12.2 Muskellunge Lake Watershed Assessment

Muskellunge Lake's watershed is approximately 1,818 acres in size. Dominant land cover types include forests (1,011 acres or 56%) and wetlands (417 acres or 23%), while the lake surface (15%), pasture / grass (6%), and open water not connected to the lake (<1%) comprise the remaining areas of the watershed (Figure 8.12.2-1). The watershed is only six times larger than the lake itself (a ratio of 6:1). Lakes with a smaller watershed to lake area ratio are typically influenced strongly by the land cover types within the watershed. In the case of Muskellunge Lake, however, there are other factors regulating the water quality besides the land cover.

Muskellunge Lake's phosphorus and chlorophyll-*a* content are fairly high compared to other regional lakes (this is discussed in the Water Quality Section). To investigate potential sources of phosphorus input to the lake, the United States Geological Survey (USGS) conducted a 2003 study in cooperation with the Muskellunge Lake Association in which a phosphorus budget was developed for the lake. The report found Muskellunge Lake received approximately 437 lbs of phosphorus in 2001, 58% of which came from groundwater inputs, 16% from septic systems, 23% from surface water runoff, and 3% from precipitation (USGS 2003). The budget calculated an export of 206 lbs. (47%) of phosphorus through Muskellunge Creek, while the remaining 206 lbs. (53%) was deposited to the lake bottom. Furthermore, an analysis of sediment cores from the bottom of the lake revealed that the phosphorus levels and eutrophic conditions were present in Muskellunge Lake over 100 years ago. The investigators in the study concluded that the eutrophic conditions in Muskellunge Lake are naturally induced by groundwater flowing through naturally high phosphorus soils, primarily along the north shore of the lake. Although these conditions have remained so for the past 100 years, one change has been an increase in the density of the aquatic plant community.

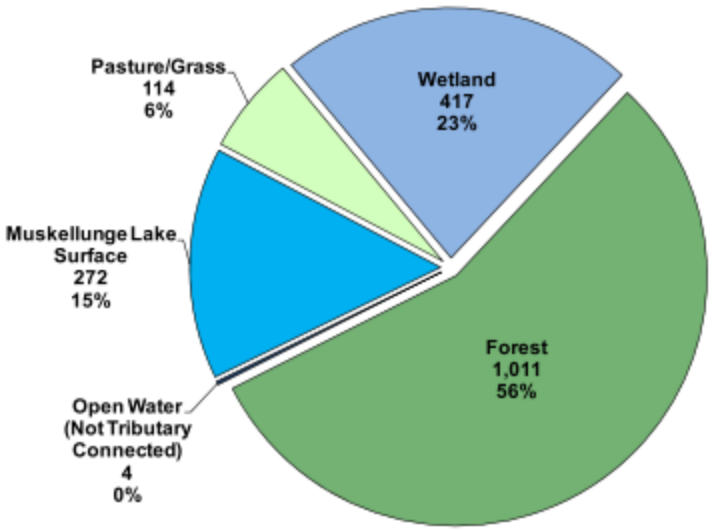


Figure 8.12.2-1. Muskellunge Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

8.12.3 Muskellunge Lake Water Quality

Water quality data was collected from Muskellunge Lake on three occasions in summer of 2009. Onterra staff sampled the deepest point in the lake for a variety of water quality parameters including total phosphorus, chlorophyll-*a*, Secchi disk clarity, temperature, and dissolved oxygen. Because Muskellunge Lake has had considerable water quality parameters measured in the past, historical data was collected and pooled with 2009 data to analyze potential trends.

Historical total phosphorus values were collected from the WDNR SWIMS website for Muskellunge Lake and scrutinized for accuracy. Several exceedingly high values from 2001 and 2003 were scrutinized, largely because these values did not have a depth associated with them. It is possible these samples were collected near the lake bottom, so because of this uncertainty these values were omitted from the data analysis.

Total phosphorus concentrations collected in summer 2009 were found to be higher than those collected in past years with a summer average of 43.2 µg/L, yet still remained in the WQI "Fair" category (Figure 8.12.3-1). In 2002 and years 2004 – 2007, summer average phosphorus values ranged from 11.7 to 33.0 µg/L, and fell largely within a WQI category of "Good". While the sudden increase in 2008 and 2009 phosphorus concentrations may seem drastic, it is likely part of seasonal/natural fluctuations which are also evident in the years 1992 – 2000 (Figure 8.12.3-1). Phosphorus levels in Muskellunge Lake are above averages of the Town of Cloverland lakes, Wisconsin natural lakes, and lakes in the northeast region. Of the Town of Cloverland lakes, Muskellunge Lake phosphorus summer averages were the second highest in 2009, behind Brazell Lake.

As discussed in the Muskellunge Lake Watershed section, the 2003 USGS study on the lake discovered significant groundwater inputs of phosphorus, particularly from the phosphorus rich soils on the north / northeast shoreline of the lake (USGS 2003). This input is the reason for Muskellunge Lake's high nutrient content, large plant biomass, and seasonal algae blooms. Interestingly, this has likely been the case for a number of years. By studying diatoms (a type of algae that forms silica based shells) in sediment cores taken from the lake bottom, researchers concluded that these eutrophic conditions were already present over 100 years ago. Based upon the diatom species found in the cores, it is likely that phosphorus concentrations have increased very little over the course of 100 years in Muskellunge Lake (USGS 2003).

It is worth noting that septic-system effluent plays a role in the phosphorus budget of Muskellunge Lake, as determined by the USGS. A total of 69.4 lbs. (16% of the total input) of phosphorus entered the lake from septic-systems in 2001. Using an empirical model to determine effects of removing this input to the lake, the researchers were able to forecast the potential impacts on the water quality. Unfortunately, reducing this input would only result in a slight decrease in phosphorus concentrations, a slight decrease in chlorophyll-*a* concentrations, and little change in the average summer Secchi disk depth (USGS 2003).

Chlorophyll-*a*, highly linked to phosphorus content in lakes, was also higher in 2009 than in past years (2001 and 2004 – 2008) with a summer average of 34.6 µg/L (Figure 8.12.3-2). This relationship is to be expected, as phosphorus was identified as the limiting nutrient for vegetative (plant and algal) growth in Muskellunge Lake and thus should heavily influence the abundance of all vegetation. The 2009 chlorophyll-*a* data falls within a WQI category of "Very Poor" in

2009, however summer averages range for this parameter between "Very Good" and "Very Poor" within the past 15 years (Figure 8.12.3-2). When weighting all averages between the years of available data, summer averages for the lake are 21.5 µg/L and are higher than averages for the Town of Cloverland lakes, Wisconsin natural lakes, and lakes in the northeast region. Of the Town of Cloverland lakes, Muskellunge Lake chlorophyll-*a* summer averages were the second highest in 2009, behind Boot Lake.

Muskellunge Lake Secchi disk depths ranged from 1.7 to 5.8 feet, and averaged 3.5 feet in summer 2009 (Figure 8.12.3-3). Historical summer averages for Muskellunge Lake usually range between 3 and 5 feet, a WQI rating of "Poor". However yearly variation has existed on the lake; since 1991 the depths have ranged from a WQI category of "Very Poor" to "Good". The Secchi disk readings correspond very strongly with chlorophyll-*a* concentrations. For example, in 1995 Secchi disk clarity was at its highest within the years of available data, while chlorophyll-*a* concentrations were at their lowest. This relationship is common in lakes for the reason that as algae growth increases, the visibility within the water column will decrease. With decreasing algal populations, we would consequently expect the visibility to increase.

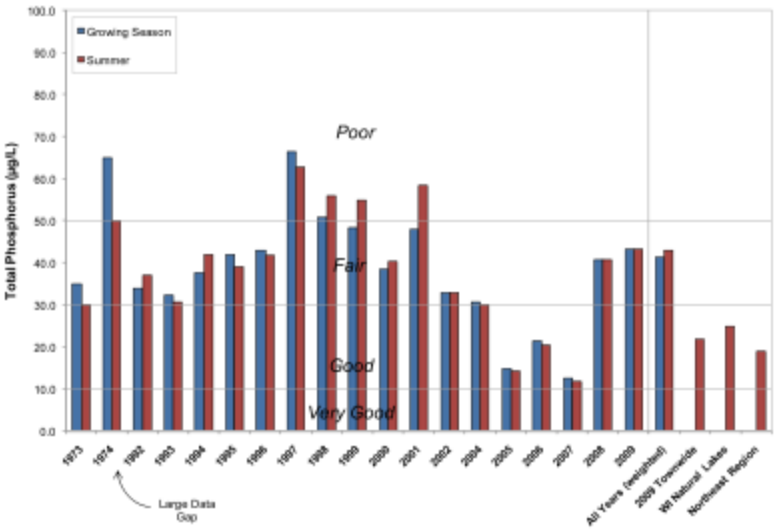


Figure 8.12.3-1. Muskellunge Lake, 2009 town-wide, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

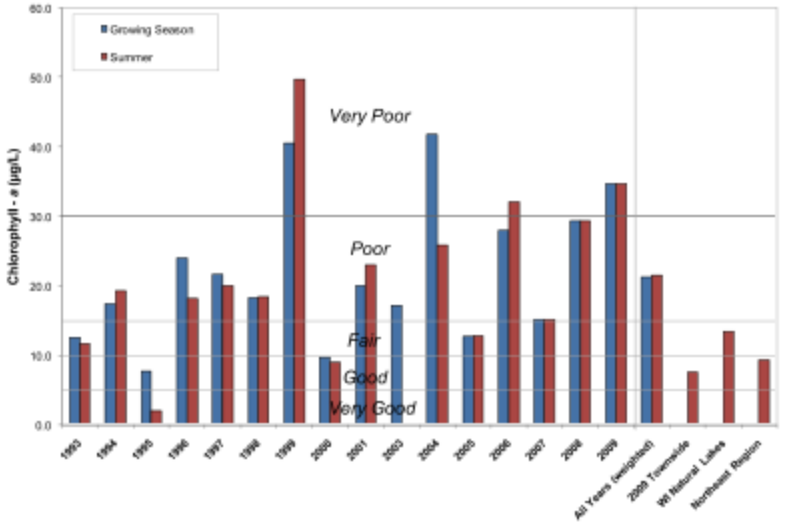


Figure 8.12.3-2. Muskellunge Lake, 2009 town-wide, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

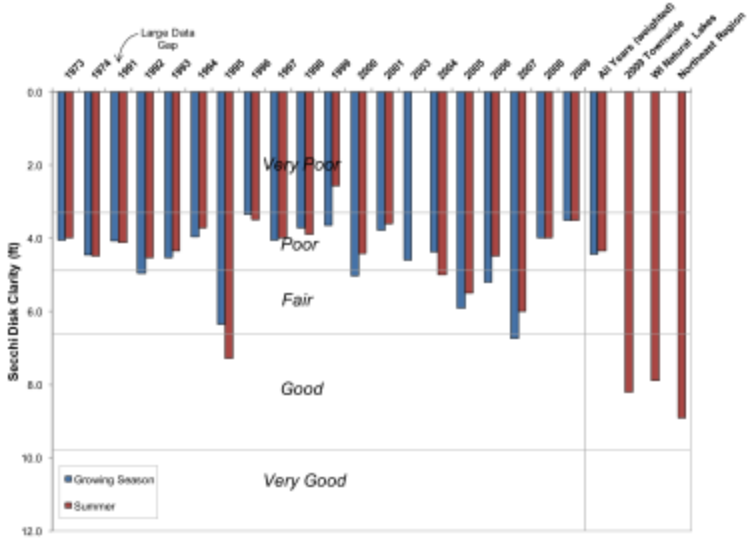


Figure 8.12.3-3. Muskellunge Lake, 2009 town-wide, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Muskellunge Lake Trophic State

The Wisconsin Trophic State Index (WTSI) values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values fall almost entirely within the eutrophic classification. It can therefore be concluded that Muskellunge Lake is in a eutrophic state (Figure 8.12.3-4). This classification is consistent with the classification given to the lake by the USGS in 2003.

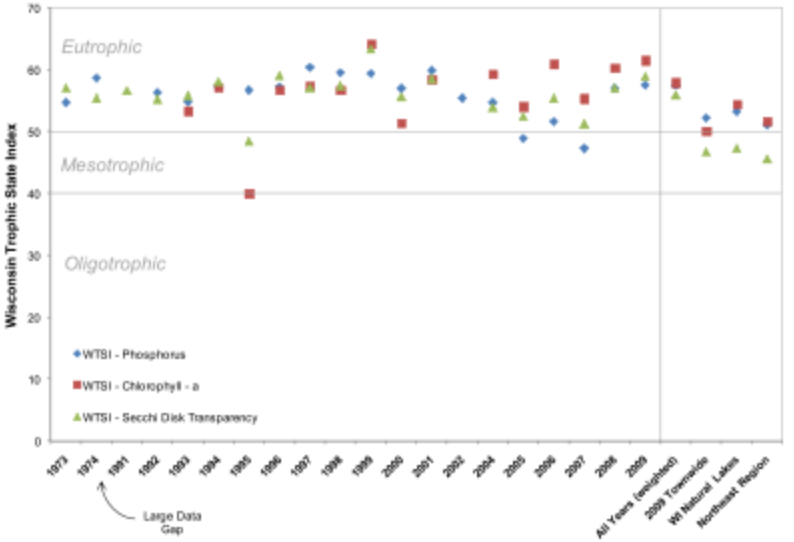


Figure 8.12.3-4. Muskellunge Lake, 2009 town-wide, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Dissolved Oxygen and Temperature in Muskellunge Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Muskellunge Lake by Onterra staff. Graphs of those data are displayed in Figure 8.12.3-5 for all three sampling events.

Muskellunge Lake was found to remain weakly stratified during the summer months, particularly in mid June. This is not uncommon in lakes of this size and depth. It is likely that stratification broke down during cooler periods or periods of high winds during the summer months. Dissolved oxygen levels remained sufficient (>3.0 mg/L) to support most aquatic life found in northern Wisconsin lakes throughout the entire summer in the upper 10-12 feet of the lake. In the upper five feet of the water column, abundant algae are producing oxygen through photosynthesis, resulting in concentrations of dissolved oxygen greater than 10 mg/L. However decomposition of organic materials is responsible for depleting the oxygen in the lower portions of the lake. In the aforementioned 2003 USGS study, researchers monitored the dissolved oxygen near the location of an aerator placed in southeast Muskellunge Lake for two winters, one with the aerator in operation and one winter without it operating. It was concluded that the aerator maintains adequate dissolved oxygen concentrations throughout the main body of the

lake, and without it the concentrations fall below levels acceptable for survival of most warmwater fish species.

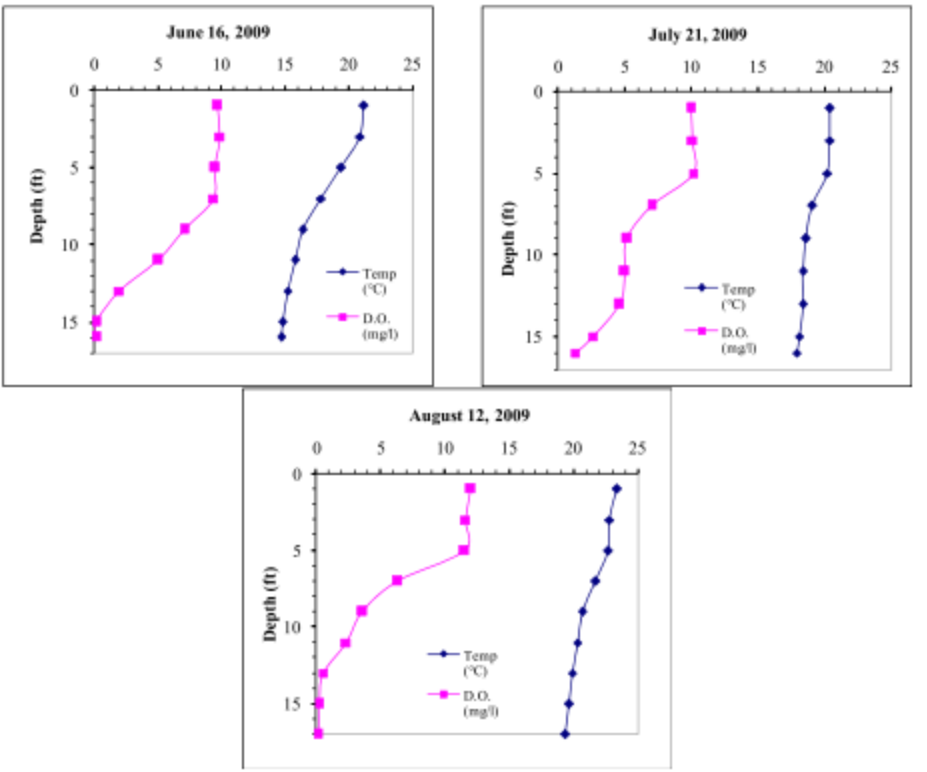


Figure 8.12.3-5. Muskellunge Lake dissolved oxygen and temperature profiles.

8.12.4 Muskellunge Lake Aquatic Vegetation

As mentioned above, numerous plant surveys were completed as a part of this project. In June 2009, a survey was completed on Muskellunge Lake by Onterra staff that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of curly-leaf pondweed. It is believed that this AIS either does not occur in Muskellunge Lake or exists at an undetectable level.

The point intercept survey was conducted on Muskellunge Lake in early-August 2009 by Onterra. Additional surveys were completed by Onterra on Muskellunge Lake to create the aquatic plant community map (Muskellunge Community Map) during that same timeframe.

During the point-intercept and aquatic plant mapping surveys, 30 species of plants were located in Muskellunge Lake (Table 8.15.4-1), none of which are considered non-native species. 25 of these species were sampled during the point-intercept and were used within the aquatic plant analysis that follows. As shown within the Town-wide Aquatic Plant Section, this species richness is both higher than the ecoregion and state medians and the third highest of all the town-wide lakes that were surveyed (Pickerel and Tepee Lakes are higher). As stated within the Water Quality Section, Muskellunge Lake contains relatively high alkalinity values, likely explaining why almost all of the submergent plant species found within this lake are elodeid growth forms (Table 8.15.4-1). Interestingly, no isoetid plants were found within Muskellunge Lake, which exhibited the highest alkalinity value of lakes surveyed within the Cloverland Township.

It is important to note that of the point-intercept sample points that were in the depth range of plant growth (12 feet), approximately 72% of these locations contained aquatic plants. The large littoral area of Muskellunge Lake supports a high biomass of aquatic plants. When making future decisions regarding plant management in the lake, the relationship these plants have with algae must be recognized. The abundant plant growth provides cover and habitat for numerous aquatic species, including zooplankton. These small crustaceans feed upon algae throughout the water column. With removal of lush aquatic vegetation, zooplankton are exposed to small fish species and their populations will be reduced, and subsequently result in increased algae abundance.

Muskellunge Lake has a very high number of aquatic plant species, and because of this, one may assume that the system would also have a similar diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. The diversity index for Muskellunge Lake's plant community (0.86) is similar to the median value for lakes in the Northern Lakes and Forests ecoregion. Figure 8.15.4-1 shows that coontail flat-stem pondweed, and common waterweed are the most abundant plants within Muskellunge Lake. Because of their lack of developed root structures, coontail and common waterweed locations are largely influenced by water movement and their tendency to become entangled in plants, rocks, or debris.

Data collected during the aquatic plant surveys indicate that the average conservatism values (6.2) are lower than the state and Northern Lakes Ecoregion median. This shows that the aquatic plants within Muskellunge Lake are indicative of a disturbed system. Along with Boot Lake, Muskellunge exhibits the lowest average conservatism value of the Cloverland Project lakes.

Combining the lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in an exceptionally high value of 31.2 which is above the median values of the state and ecoregion.

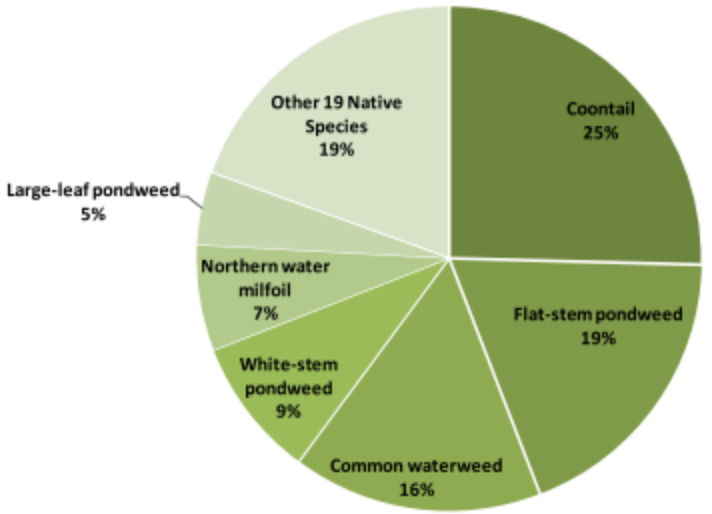


Figure 8.12.4-1 Muskellunge Lake aquatic plant relative frequency of occurrence analysis. Created using data from 2009 surveys. 25 of 30 total species were sampled during the point-intercept survey and used in this analysis.

Muskellunge Lake's plant population also includes a high incidence of emergent and floating-leaf plant communities that occur in many areas. The 2009 community map indicates that approximately 35 acres of the lake contains these types of plant communities (Muskellunge Community Map). Eleven floating-leaf and emergent species were located on Muskellunge Lake, providing valuable fish and wildlife habitat important to the ecosystem of the lake.

A series of aquatic plant surveys were conducted in 2004 on Muskellunge Lake. Unfortunately, the methodology and level of detail of this survey does not allow a true comparison to be made with the survey conducted in 2009. However, that survey did note the occurrence of wild rice from Muskellunge Lake, which was not located during the 2009 surveys.

The community map represents a snapshot of the important plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Muskellunge Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Table 8.12.4-1. Aquatic plant species located in Muskellunge Lake during a-2009 survey.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	*Calla palustris*	Water arum	9
	Carex comosa	Bristly sedge	5
	Eleocharis palustris	Creeping spikerush	6
	Equisetum fluviatile	Water horsetail	7
	Sagittaria latifolia	Common arrowhead	3
	Schoenoplectus tabernaemontani	Softstem bulrush	4
	Typha latifolia	Broad-leaved cattail	1
FL	*Nymphaea odorata*	White water lily	6
	Nuphar variegata	Spatterdock	6
FL/E	*Sparganium angustifolium*	Narrow-leaf bur-reed	9
	Sparganium eurycarpum	Common bur-reed	5
Submergent	*Chara sp.*	Muskgrasses	7
	Ceratophyllum demersum	Coontail	3
	Elodea canadensis	Common waterweed	3
	Heteranthera dubia	Water stargrass	6
	Megalodonta beckii	Water marigold	8
	Myriophyllum sibiricum	Northern water milfoil	7
	Nitella sp.	Stoneworts	7
	Najas flexilis	Slender naiad	6
	Potamogeton gramineus	Variable pondweed	7
	Potamogeton pusillus	Small pondweed	7
	Potamogeton richardsonii	Clasping-leaf pondweed	5
	Potamogeton robbinsii	Fern pondweed	8
	Potamogeton foliosus	Leafy pondweed	6
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton praelongus	White-stem pondweed	8
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Utricularia vulgaris	Common bladderwort	7
	Vallisneria americana	Wild celery	6
FF	*Lemna minor*	Lesser duckweed	5

FL = Floating Leaf
FL/E = Floating Leaf and Emergent
FF = Free Floating

8.12.5 Muskellunge Lake Implementation Plan

The Implementation Plan below is a result of collaborative efforts between Muskellunge Lake stakeholders, the CTLC, and ecologists/planners from Onterra. This plan provides goals and actions created to protect the quality and integrity of Muskellunge Lake and will serve as reference for keeping stakeholders on track and focused upon these science-driven management activities.

While the Town of Cloverland lakes are geographically similar, they are definitely ecologically diverse. The latter is detailed throughout this report. This diversity leads to the need for diverse plans aimed at managing the lakes. Some of the project lakes, including Muskellunge Lake, have more complicated management needs than others, but in general most of the lakes' needs center on protecting the current quality of the lake as opposed to performing activities aimed at enhancing or resolving particular of issues. The Town-wide Implementation Plan will serve each of the project lakes well in terms of protecting their current condition; therefore, Muskellunge Lake's implementation plan is compiled by describing how Muskellunge Lake stakeholders should proceed in implementing applicable portions of the town-wide implementation plan for their lake. Then, the specific management goals and actions aimed at addressing Nuisance native aquatic plants are detailed.

Town-wide Implementation Plan – Specific to Muskellunge Lake

Town-wide Management Goal 1: Promote Lake Protection and Enjoyment through Education

Management Action: Support an Education & Communication Committee to promote safe boating, water quality, public safety, and quality of life on Muskellunge Lake.

Muskellunge Lake stakeholders can assist in the implementation of this action by participating in the CTLC's initiatives. Participation may include presentation of educational topics, volunteering at local and regional events, participating in committees, or simply notifying the lakes committee of concerns involving Muskellunge Lake and its stakeholders.

Town-wide Management Goal 2: Maintain Current Water Quality Conditions

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network (CLMN) or similar program.

Currently, Muskellunge Lake is enrolled in the CLMN's advanced water quality monitoring program. This means that in addition to Secchi disk clarity, volunteers also monitor phosphorus and chlorophyll-*a* on the lake. Although this is a great accomplishment, it must be continued in order to ensure the quality of Muskellunge Lake is protected. Volunteers from Muskellunge Lake must be proactive in recruiting others to participate.

Town-wide Management Goal 3: Prevent Aquatic Invasive Species establishment within Muskellunge Lake

Management Action: Maintain and expand stakeholder education.

Muskellunge Lake contains a public access and as a result, the threat of AIS introduction is increased when compared to lakes with no public access.

Muskellunge Lake stakeholders can work together with the CTLC to reduce the chances that AIS find their way into the lake through numerous opportunities. By working with the Educational & Communication Committee, property owners can learn proper boat cleansing techniques and AIS identification. Additionally, volunteers should continue work with the CBCW program. By monitoring the Muskellunge Lake boat launch with CBCW volunteers, potential AIS introduction to the lake is reduced. An added benefit is that this interaction allows an opportunity to educate boaters about AIS and the importance of boat cleaning and inspection.

Additionally, AIS monitoring should occur on a regular basis within the lake. Because Muskellunge Lake is a public access lake, professional AIS surveys should occur once every 5 years. In between these professional surveys, the CTLC's Education & Communication Committee can train volunteers not only on AIS identification, but methods to monitor the lake for AIS as well. These surveys should be documented and reported to CBCW, and if AIS is discovered, locations of the species should be identified using GPS technology. The Town Wide Implementation Plan provides a step-by-step process for this type of monitoring.

Town-wide Management Goal 4: Minimize user conflicts on Town of Cloverland lakes

Management Action: Develop Framework for No Combustion Motor Ordinance on select Town of Cloverland lakes

Muskellunge Lake is a relatively large lake, and results from the stakeholder survey indicate that many stakeholders use motor boats on the lake (Stakeholder Survey, Question #8). Therefore, this management goal, while applicable to other lakes within the township, is not realistic for Muskellunge Lake.

Management Goal 5: Maintain Public Boating Access within Muskellunge Lake

Management Action: Support reasonable and responsible actions to gain navigational access to open water areas of Muskellunge Lake

Timeframe: Begin 2011

Facilitator: Association Board of Directors

Description: Almost 66% of stakeholder survey respondents stated that aquatic plant control was needed (answered *definitely yes* or *probably yes*) on Muskellunge Lake (Stakeholder Survey, Question #20). Nuisance levels of aquatic plants were also stated to be the single greatest factor negatively impacting Muskellunge Lake (Stakeholder Survey, Question #17 & 18). At the time when this management plan was being created, the Muskellunge Lake Association Board of Directors did

not feel that the inclusion of an actual harvesting plan was appropriate. Still, they felt strongly that mechanical harvesting may be an option they would consider in the future, as they have in the past, if the association membership called for it. The information contained in this management action is intended to lay the initial groundwork for the creation of a harvesting plan for Muskellunge Lake.

It is unrealistic to quantitatively define the term "nuisance," as this designation is subjective by nature. However, WDNR Science Services researchers indicate that nuisance levels of a given aquatic plant species likely occur when frequency of occurrences exceed 35% (Alison Mikulyuk, personal comm.). Coontail, flat-stem pondweed, and common waterweed all exceeded this somewhat arbitrary benchmark during the 2009 aquatic plant survey (65%, 48%, and 41% littoral frequency of occurrence, respectively).

The association supports reasonable and environmentally sound mechanical harvesting actions to facilitate access to open water areas of Muskellunge Lake consistent with the Aquatic Plant Management Strategy Northern Region WDNR 2007 document, available from the WDNR. These actions would target nuisance levels of aquatic plants in order to restore watercraft access to open water areas of the system. Reasonable and environmentally sound actions are those that meet WDNR regulatory and permitting requirements and do not impact anymore shoreland or lake surface area required to permit the access. These actions do not include areas that can be controlled through manual removal such as riparian swimming areas. This guidance document clearly states that no individual permits will be issued.

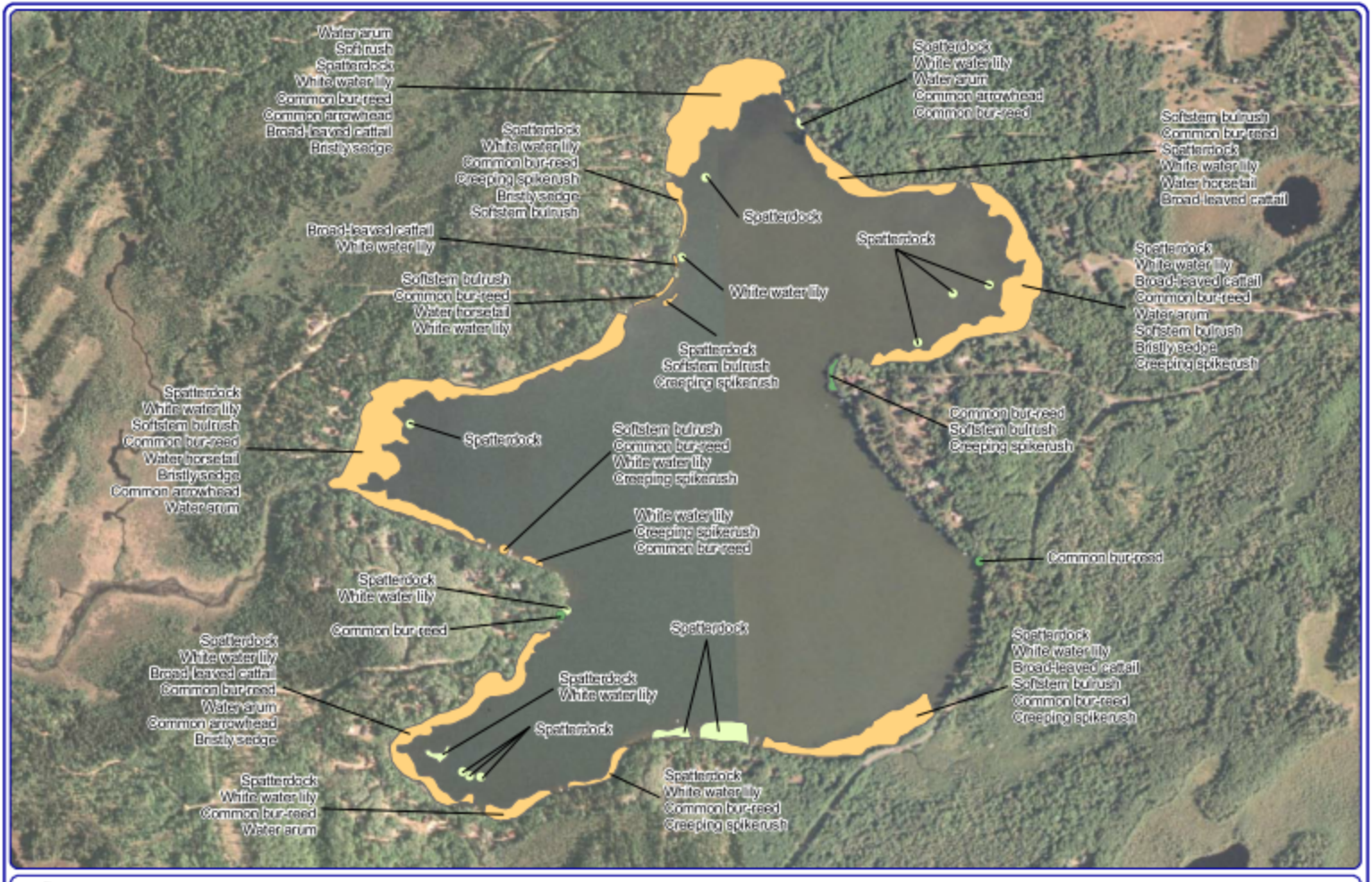
Lake groups facilitate harvesting by operating a harvester they have purchased or by contracting with a harvesting firm. While the cost of contracting the harvesting is more expensive than operating owned equipment, the initial capital investment of purchasing the equipment is quite high. Based on the perceived needs of the association, contracting a company to mechanically harvest 20-30 foot access lanes through nuisance areas would be the most feasible option.

As with all aquatic plant management techniques, harvesting has its advantages and disadvantages. Advantages include the removal of plants and associated nutrients from the waterbody, immediate relief of nuisance plants, harvesting is less controversial than chemical use, and specific areas can be treated accurately. Disadvantages include sediment re-suspension, fragmentation of plants, need for repeated treatments within a single year, and lack of ability to select specific plant species for treatment. Mechanical harvesting in areas that contain aquatic invasive species may increase the rate of spread of these species as it 'drags' cut fragments to other parts of the system.

Before control of native aquatic plant species occur on the lake, a defined plan of management would need to be developed to serve as an amendment to the current lake management plan.

Action Steps:

1. The association documents the impairment, either on their own or by hiring a professional as described in the Aquatic Plant Management Strategy Northern Region WDNR
2. The association requests a site visit by the WDNR to verify impairment.
3. The association updates the current management plan to further define the management objective and associated actions (mechanical harvesting) needed to augment the impairment.
4. Association obtains a permit to implement mechanical harvesting after WDNR verifies impairment and approves the update to the management plan.



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Feet

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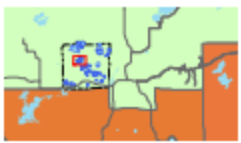
Sources:
Aquatic Plants: Onterra, 2009
Orthophotography: NAIP, 2005
Map Date: February 25, 2010



Extent of large map shown in red.

Legend

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Muskellunge Lake - Map 1
Cloverland Lakes
Vilas, County, Wisconsin

Aquatic Plant Communities