SPL-053-03

AQUATIC PLANT MANAGEMENT PLAN

WILKE LAKE
TOWN OF SCHLESWIG
MANITOWOC COUNTY, WISCONSIN

January 7, 2004

Northern Environmental℠
Hydrologists • Engineers • Geologists

1214 West Venture Court
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January 7, 2004

Prepared for:

Town of Schleswig Sanitary District #2
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Project Number: WLA 01-3300-2452

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February 9, 2004
(WLA 01-3100-2452)

Ms. Mary Gansberg
Wisconsin Department of Natural Resources
1125 Military Avenue
Post Office Box 10448
Green Bay, Wisconsin 54307-0448

RE: Addendum to Aquatic Plant Management Plan, Harvesting Plan Worksheet, Wilke Lake, Manitowoc County, Wisconsin

Dear Ms. Gansberg:

Per your January 21, 2004 fax, a harvesting plan worksheet has been completed at your request and will be an addendum to the January 7, 2004 Aquatic Plant Management (APM) plan for Wilke Lake. The information requested in Sections I and II of the worksheet is discussed in the APM Plan. The remaining sections are discussed in the enclosed pages.

We trust this information meets your needs. Please contact Mr. Dave Rautmann of Northern Environmental Technologies, Incorporated at (800) 776-7140 if you have any questions.

Sincerely,
Northern Environmental Technologies, Incorporated

Tricia L. Deming
Environmental Scientist

TLD/lmh
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1.0 EXECUTIVE SUMMARY

Wilke Lake is a ground-water seepage lake located in Sections 2 and 3, Township 17 North, Range 21 East, town of Schleswig, Manitowoc County, Wisconsin. The town of Schleswig Sanitary District (the District) received a grant to conduct an aquatic plant survey and update their aquatic plant management plan. The District contracted Northern Environmental Technologies, Incorporated (Northern Environmental) to complete the survey.

Approximately 90 percent of Wilke Lake's 1.7 miles of shoreline is developed with residential property. The remaining 10 percent of shoreline is wetland. Wilke Lake is heavily used for recreation, with main uses including recreational boating and fishing. The lake has a history of problems with heavy aquatic macrophyte growth. Management of aquatic plants has occurred to enhance recreational activities since the 1960s. The last aquatic plant survey was completed during the summer of 1992.

Fifteen species of floating leaved and submerged aquatic vascular plants were identified during the 2003 survey in addition to three species of emergent plants. *Myriophyllum spicatum* (Eurasian watermilfoil) was the most abundant species found in the Lake, followed by *Chara* spp. (Chara) and *Najas flexilis* (slender naiad). The distribution and abundance of the lake's current macrophyte population is similar to that observed during 1992. The lake's trophic status is mesotrophic.

In general, the greatest species diversity was observed from the water's edge to a depth of 5 feet of water, particularly near the wetlands. These shallow areas exhibited low to moderate levels of macrophyte densities. The area of greatest macrophyte densities were observed between 5 and 10 feet of water. This area also exhibited a lower diversity; however, the lowest species diversity was observed from 10 to 20 feet of water.

Because native, non-invasive species occur at densities far below nuisance levels in depths up to 5 feet, they should be protected to prevent the spread of invasive species. Aquatic plant management options considered for the nuisance vegetation (Eurasian watermilfoil and curlyleaf pondweed) include harvesting, treatments of 2,4-D based aquatic herbicides, and dredging. Details of the survey and advantages and disadvantages of different management options are found in the attached report.

2.0 INTRODUCTION AND STUDY GOALS

Wilke Lake is a located in Sections 2 and 3, Township 17 North, Range 21 East, Town of Schleswig, Manitowoc County, Wisconsin. The lake location is shown in Figure 1. Wilke Lake has a history of problems with dense aquatic macrophyte growth.

Wilke Lake is heavily used for recreation, with main uses including recreational boating and fishing. It supports populations of largemouth bass, musky, northern pike, and panfish. Fish stocking has occurred by Wilke Lake Advancement Association and Kiel Fish and Game for many years.

Wilke Lake has 1.7 miles of shoreline that is approximately 90 percent developed with residential property. The remaining 10 percent of shoreline is wetland. The Wisconsin Department of Natural Resources (WDNR) owns a large portion of wetland on Wilke Lake's north shore, which includes forested wetlands with species such as white cedar and tamarack. Another large marsh, which contains turtle spawning habitat, is located on the western shore of the lake.

This report summarizes the lake management history, discusses the study's goals, describes the methods used to complete the study, describes the aquatic plant community, discusses aquatic plant management techniques, and provides a recommended action plan for the lake and aquatic plant management (APM).

2.1 Aquatic Plant Management History

Management of Wilke Lake aquatic plants began during the early 1960s. Between 1960 and 1964, chemicals were periodically applied to control aquatic plants. During the late 1960s, a small plant cutter was used. At that time, the plants were not harvested, which may have stimulated aquatic plant growth. Aquatic plant management did not occur during the 1970s. As a result, plant growth became excessive and boat traffic became severely restricted.

During 1980, the Town of Schleswig Sanitary District (the District) was formed with authority to control and manage aquatic plants. An APM was developed, and an aquatic plant harvester was purchased during 1981. A larger harvester was purchased during 1993 to replace the previous one.

The last aquatic plant survey was completed during the summer of 1992 as part of a lake management plan. Since 1992, the District has harvested and removed aquatic plants each weekday for 3 to 4 months during the summer. Harvesting has occurred within the approximately 80-acre management area shown in Figure 2. The harvesting area corresponds with the Eurasian watermilfoil (EWM) population and the open water areas that receive the most boat traffic. This plan has allowed unrestricted recreational boating on Wilke Lake.

The District applied for a Lake Management Planning Grant to develop an APM Plan. The District was awarded the WDNR Lake Management Planning Grant and hired Northern Environmental to complete an APM Plan. The most recent APM permit to harvest aquatic plants was issued during 2002 and expires during ~~2005.~~ Dec 31, 2003

2.2 Study Goals

The District's goal of developing an APM Plan is to set long-term management goals to control nuisance aquatic vegetation and improve recreational opportunities

3.0 INVESTIGATIVE METHODS

The goal of this study is to collect and interpret basic data and produce recommendations allowing the District to make better educated decisions regarding APM options. The study primarily followed the outline in the grant application, which included aquatic plant surveys and collection of water samples for chemical analysis of total phosphorus and chlorophyll a.

3.1 Existing Data Review

Reviewing existing data is instrumental to understanding the past, current, and potential future conditions of the lake and to ensure that study efforts are not duplicated. Northern Environmental reviewed a 1995 lake management study and a 1992 aquatic plant survey completed for Wilke Lake.

3.2 Water Quality Sampling

One surface-water "grab" sample was analyzed for total phosphorus and chlorophyll a. Phosphorus and chlorophyll a samples were placed in plastic bottles provided by the Wisconsin State Lab of Hygiene (SLOH). Phosphorus samples were preserved using sulfuric acid. Samples were analyzed by SLOH in Madison, Wisconsin. A copy of the laboratory report is included in Appendix A.

3.4 Aquatic Plant Survey

Aquatic plant surveys were completed during July and September, 2003. Completing two surveys allowed Northern Environmental to observe any changes in the Wilke Lake's plant community throughout the growing season. The aquatic plant surveys were completed in general accordance with the methodology of Jensen and Lound's *An Evaluation of a Survey Technique for Submerged Aquatic Plants*. Plants along the odd numbered transects from the 1992 Wilke Lake aquatic plant survey base map were sampled. The transects were distributed evenly around the perimeter of Wilke Lake (Figures 3 and 4). Transects extended perpendicular to the shoreline and were located at points that allowed adequate lake and bay coverage.

Latitude and longitude coordinates at the intersection of the shoreline and the termination of the transect were measured with a global positioning system. Along each transect, a 10-foot diameter circle (station point) was selected in various depth ranges. The circle was subdivided into four quadrants. A general density rating was determined for each species in each quadrant by eye or with a modified aqua-rake. In areas where the bottom could be clearly observed, visual means were used. The rake was thrown into each quadrant, allowed to settle, and was slowly retrieved. A density rating, based on the following criteria, and observations regarding substrate type were recorded along with the depth in feet.

Rake Recovery of Species

Recovery	General Density Rating
▲ Rake teeth 80-100% full	5
▲ Rake teeth 60-80% full	4
▲ Rake teeth 40-60% full	3
▲ Rake teeth 20-40% full	2
▲ Rake teeth 0-20% full	1

At each sample point, the species encountered were also recorded. If a species could not be identified in the field, a representative specimen was collected and placed on ice in a cooler for transportation. If a specimen could not be identified to the species level, it was referred to by the generic name followed by "sp." Various dichotomous keys and technical publications used to identify the aquatic plants.

Estimates of species abundance and density were determined using the recorded data. Specifically, the percent frequency of occurrence was determined by dividing the number of sampling sites at which a species occurred by the total number of sampling sites. Relative frequency was calculated by dividing the number of sample points a species was found in by the total number of occurrences of all species. Species mean density rating was obtained by averaging the density rating for all points where the species occurred.

4.0 LAKE MORPHOLOGY

Wilke Lake is a shallow ground-water seepage lake with a single perennial outlet. The lake has a maximum depth of 20 feet, an average depth of 9 feet, and a surface area of approximately 95 acres (Northern Environmental, 1995). A 1972 bathymetric map available from the WDNR is located in Figure 3. 5 However, the District does not believe the location of the 5-foot contour line on the bathymetric map is accurate due to sedimentation that has occurred since the map was created (Glomski, 2003). Bottom sediments are mostly silt and muck, with some sand present on the north and northeast side of the lake (WDNR, 1972). The 467-acre watershed is primarily agricultural (Northern Environmental, 1995).

5.0 WATER QUALITY STUDY

A water sample was analyzed for chlorophyll *a* and phosphorus and compared to data collected during 1995. The location of the water sample is shown in Figures 5 and 6. A copy of the laboratory analytical report is included in Appendix A.

5.1 Phosphorus

In 80 percent of Wisconsin lakes, phosphorus is the key nutrient controlling excessive aquatic plant and algae growth (Shaw, et al., 1994). Lake water phosphorus concentrations are usually measured as soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorous is readily available to plants. Consequently, its concentration can vary widely over short periods. A potentially better measure of lake water phosphorus level is total phosphorus, which measures dissolved phosphorus as well as phosphorus in plants and animal fragments suspended in lake water.

Phosphorus is very reactive in the environment, being absorbed by plants and attaching itself tightly to sediments. Consequently, sediments carried by surface water are typically the largest external source of phosphorus to lakes. Phosphorus does not readily dissolve in lake water, forming insoluble precipitate with iron, calcium, and aluminum. As a result, most fully oxygenated lakes have a net flux of phosphorus to the lake bottom. However, if lake water lacks oxygen, iron precipitates become unstable and release phosphorus to the overlying water.

The total phosphorus concentration observed in Wilke Lake during 2003 (23 micrograms per liter [µg/l]) is comparable to concentrations detected during 1995 (average of 15 µg/l). It is important to remember that only one surface-water sample was collected during 2003 and that phosphorus concentrations will vary in the lake depending on depth and location. Lakes with total phosphorus concentrations of approximately 20 to 30 µg/l are considered to have good water quality in terms of phosphorus (Shaw, et al., 1994).

5.2 Chlorophyll *a*

Chlorophyll *a* concentrations correspond to the abundance of algae in lake water. Chlorophyll *a* concentrations respond to seasonal light changes, lake water nutrient content and transparency, aquatic macrophyte growth, temperature, and zooplankton abundance. High chlorophyll *a* concentrations relate to algal blooms. Algal blooms most often occur after spring and fall turnovers in lakes with anoxic hypolimnia when nutrients are released from the sediments. The release of nutrients into the hypolimnia and subsequent mixing of water with the epilimnion during spring turnover causes these nutrients to be readily available to initiate algal blooms. Algal blooms can also occur when other events liberate nutrients into the lake system or otherwise upset nutrient equilibrium. Examples of events that could cause an algal bloom are:

- Severe thunderstorms washing nutrient-laden water or sediment into a lake
- Mid-season circulation of the hypolimnion caused by storms, flood flows, etc.
- Decrease in zooplankton abundance
- Anoxic water conditions destabilizing phosphorus bound in bottom sediments
- Significant manipulation of the macrophyte community

If aquatic macrophytes are destroyed and not removed from the water, the demand for limiting nutrients is decreased and nutrients are returned to the water from decomposing aquatic plants. This chain of events can cause algal blooms.

A chlorophyll *a* concentration of 6.28 μg/l was detected in Wilke Lake during September 2003, compared to an average of 5.19 μg/l detected during 1995. Chlorophyll *a* concentrations of 5 to 10 μg/l indicated good water quality. Values of 10 μg/l or higher are associated with algae blooms. Southeastern Wisconsin lakes have a mean chlorophyll *a* concentration of 9.9 μg/l (Lillie and Mason, 1983).

5.3 Transparency

Transparency is a function of water color and turbidity and usually measured with a secchi disk. A secchi disk is an 8-inch circular plate with alternating black and white quadrants fixed to a length of graduated cord. During the middle of the day, the disk is lowered on the shaded side of the boat until an observer can no longer see the secchi disk. The depth is noted, the disk is then raised until it just again is visible, and the depth again is noted. The two measurements are averaged to give a reading. The deeper the secchi disk reading, the clearer the water. High concentrations of algae or suspended sediment usually account for shallow secchi disk readings. In some instances, colored water can also account for low secchi disk readings.

A secchi depth measurement of 4.5 feet was observed during September 2003. Average measurements of 7.5 feet were observed during 1995. Secchi depth measurements are influenced by wind and wave energy, which may have resulted in the lower measurement observed during September 2003. Water clarity of 10 feet or greater is considered "good" while 20 feet or greater is considered "very good" (Shaw, et al., 1994). Southeastern Wisconsin lakes have a median secchi disk measurement of 4.5 feet.

5.4 Trophic Status

Total phosphorus, chlorophyll *a*, and secchi disk depths are used to classify the trophic state of a lake. A trophic state is an indicator of water quality. Using the September 2003 data for Wilke Lake (total phosphorus concentration of 23 micrograms per liter (μg/l), chlorophyll *a* concentration of 6.28 μg/l, and a secchi depth of 4.5 feet), Wilke Lake is classified as mesotrophic. Mesotrophic lakes typically have moderately clear water, can develop anoxic hypolimnia during the summer, may have excessive aquatic macrophytes, and will normally only support warm-water fisheries. The lake was also classified as mesotrophic during 1995. The current levels of phosphorus and chlorophyll a are slightly greater and transparency slightly lower during 2003. Northern Environmental recommends monitoring these parameters again in 5 years.

6.0 AQUATIC PLANTS

Aquatic plants are vital to the health of a water body. Unfortunately, people often refer to all rooted aquatic plants as weeds, and their ultimate goal is to eradicate them. This line of thinking must be avoided when trying to manage the entire lake ecosystem. Rooted macrophytes are extremely important for the well being of the lake community and posses many positive attributes. These attributes are what make the littoral zone the most important and productive aquatic habitat in fresh-water lakes. However, aquatic macrophytes can become a nuisance when exotics plant species occupy large portions of a lake. Excessive aquatic plant growth can negatively affect recreational activities. When "managing" aquatic plants, it is important to maintain a well-balanced, stable, and diverse aquatic plant community that contain high percentages of desirable native vegetation.

6.1 The Ecological Role of Aquatic Plants

Aquatic plants can be divided into two major groups: microphytes (phytoplankton and epiphytes) composed mostly of single-celled algae, and macrophytes that include macroalgae, flowering vascular plants, and aquatic mosses and ferns. Wide varieties of microphytes co-inhabit all hospitable areas of a lake. Their abundance depends on light, nutrient availability, and other environmental factors. In contrast, macrophytes are predominantly found in distinct habitats in the littoral (shallow near shore) zone where sufficient light can penetrate to the lake bottom. The littoral zone is the depth to which light penetrates permitting photosynthesis and colonization of aquatic macrophytes. The littoral zone can fluctuate based on water quality and turbidity. The littoral zone is subdivided into four distinct transitional zones: the eulittoral, upper littoral, middle littoral, and lower littoral as shown in Figure 6 (Wetzel, 1983).

Eulittoral Zone:	Includes the area between the highest and lowest seasonal water levels, and often contains many wetland plants.
Upper Littoral Zone:	Dominated by emergent macrophytes and extends from the water edge to water depths between 3 and 6 feet.
Middle Littoral Zone:	Occupies water depths of 3 to 9 feet, extending lakeward from the upper littoral zone. The middle littoral zone is often dominated by floating-leaf plants.
Lower Littoral Zone:	Extends to a depth equivalent to the limit of the photic zone.

In addition to dissolved nutrient availability, the abundance and distribution of aquatic macrophytes are also influenced by other factors such as light availability, lake trophic status as it relates to nutrients and water chemistry, sediment characteristics, and wind energy. Lake morphology and watershed characteristics relate to these factors independently and in combination (NALMS, 1997).

In many instances, aquatic plants serve as indicators of water quality due to the sensitive nature of plants to water quality parameters such as water clarity and nutrient levels. To grow, aquatic plants must have adequate supplies of nutrients. Microphytes and free-floating macrophytes (e.g., duckweed) derive all their nutrients directly from the water. Rooted macrophytes can absorb nutrients from water and/or sediment. Therefore, the growth of phytoplankton and free-floating aquatic plants is regulated by the supply of critical available nutrients in the water column. In contrast, rooted aquatic plants can normally continue to grow in nutrient-poor water if lake sediment contains adequate nutrient concentrations. Nutrients removed by rooted macrophytes from the lake bottom may be returned to the water column when the plants die. Consequently, killing aquatic macrophytes may increase nutrients available for algal growth.

In general, an inverse relationship exists between water clarity and macrophyte growth. That is, water clarity is usually improved with increasing abundance of aquatic macrophytes. Two possible explanations are postulated. The first is that the macrophytes and epiphytes out-compete phytoplankton for available nutrients. Epiphytes derive essentially all of their nutrient needs from the water column. The other explanation is that aquatic macrophytes stabilize bottom sediment and limit water circulation, preventing re-suspension of solids and nutrients (NALMS, 1997).

If aquatic macrophytes are reduced in abundance, water clarity can suffer. Water clarity reductions can further reduce the vigor of macrophytes by restricting light penetration, reducing the size of the littoral zone, and further reducing water clarity. Studies have shown that if 30 percent or less of the area of a lake occupied by aquatic plants is controlled, water clarity will generally not be affected. However, lake water clarity will likely be reduced if 50 percent or more of the macrophytes are controlled (NALMS, 1997).

Aquatic plants also play a key role in the ecology of a lake system. Aquatic plants provide food and shelter for fish, wildlife, and invertebrates. Plants also improve water quality by protecting shorelines and the lake bottom, improving water quality, adding to the aesthetic quality of the lake, and impacting recreational activities.

6.2 Aquatic Plant Survey

Aquatic macrophytes on Wilke Lake were surveyed during July and September 2003. These two surveys were conducted when aquatic plant growth would be optimal during different periods of the year. The 2003 aquatic plant survey transect and sample point locations are illustrated in Figures 3 and 4. Information gathered during the surveys concluded that Wilke Lake has moderate species diversity and a moderate amount of biomass. Fifteen species of floating leaved and submerged aquatic vascular plants were identified during the surveys in addition to three species of emergent plants. Aquatic macrophyte species identified in the Lake are presented in Table 1. July and September distribution of aquatic plant species is illustrated in Figures 3 and 4, respectively.

The most abundant species found in the Lake during both the July and September surveys was invasive *Myriophyllum spicatum* (Eurasian watermilfoil or EWM) with a 83 percent frequency of occurrence (percent of sample points containing that species) during July and September (Tables 2 and 3). In contrast, the native *Myriophyllum sibiricum* (northern watermilfoil) had just a 5 percent frequency of occurrence during July and 23 percent during September. *Chara* spp. (Chara) was the second most abundant species during July and September, with a 45 and 40 percent frequency of occurrence, respectively. *Najas flexilis* (slender naiad) was the third most abundant species with a 28 percent frequency of occurrence during July and a 38 percent frequency of occurrence during September.

Using relative frequency (the frequency of occurrence compared to the occurrence of all species) as a measure of aquatic plant abundance, Eurasian watermilfoil was again the most abundant species during both surveys, with an average relative frequency of 40 percent during July and 36 percent during September. During July, chara and curlyleaf pondweed (*Potamogeton crispus*) had the second and third highest relative frequencies with 17 and 9 percent, respectively. During September, Chara and slender naiad had the second and third highest relative frequencies with 40 percent and 38 percent, respectively. Aquatic plant distribution is summarized on Tables 2 and 3 and Figures 3 and 4.

A 1992 aquatic plant survey completed by Northern Environmental identified thirteen aquatic plant species present in the lake, many of which were also observed during the 2003 survey (Table 1). Eurasian watermilfoil was the most dominant plant species followed by Chara and slender naiad during the 1992 survey (Northern Environmental, 1995).

Overall, the distribution and abundance of the lake's current macrophyte population is very similar to that observed during 1992, with the exception that Eurasian watermilfoil appears to have extended its range to the northern shore. Curlyleaf pondweed was observed in a few additional locations in the lake, but at low densities. Two species, *Ceratophyllum spp.* (coontail) and *Lemna minor* (duckweed), present during 1992 were not observed during 2003. Six submergent and one emergent plant species identified during the 2003 survey were not identified during the earlier survey. Many of these species were observed near the wetlands adjacent to the Lake.

In general, the greatest species diversity was observed from the water's edge to a depth of 5 feet of water. These shallow areas exhibited low to moderate levels of macrophyte densities. However, the District believes only low to moderate densities were observed during the survey because property owners manually remove aquatic plants in the shallow areas. The District believes densities are really much higher in the shallow areas (Glomski, 2003). The area of greatest macrophyte densities were observed between 5 and 10 feet of water. This area also exhibited a lower diversity; however, the lowest species diversity was observed from 10 to 20 feet of water.

No sensitive areas occur within Wilke Lake; however, wetlands are located adjacent to the Lake. The areas of Wilke Lake adjacent to the wetlands have some of the best submergent macrophyte diversity observed in the Lake.

7.0 POSSIBLE MANAGEMENT OPTIONS

Existing management techniques and current available research were reviewed in detail. Based on these comparisons, the specific aquatic plant problems on Wilke Lake, and the District's desires, the following potential management strategies were considered. A comprehensive comparision of APM techniques and methods is included in Appendix C. Detailed descriptions describing the technology, benefits, drawbacks, and costs of each of these potential management methods are included in Appendix C. Northern Environmental recommends completing an aquatic plant survey in the APM area after 3 to 5 years (or as required by the WDNR) to evaluate the effectiveness of the selected APM strategy.

7.1 Harvesting

Continued harvesting is a potential management option. This technology allows easy treatment of large areas of nuisance aquatic plant stands. Advantages of this technology include immediate results, removal of plant material and nutrients, and the flexibility to move to problem areas at multiple times of the year "as needed." Disadvantages of this method include high initial equipment costs, disposal site requirements, creation of plant fragments that may move to other parts of the lake and re-colonize, and a need for trained staff to operate the harvester. An operator may also be tempted to harvest in areas where plant management is not allowed. Limited harvester operation in shallow areas may also be considered a disadvantage. A full discussion about harvesting is included in Appendix C. Approximately half the cost of a harvester can possibly by paid by the Wisconsin Waterway Commission (WCC). The District currently spends approximately $10,000 per year (including depreciation) to operate and maintain the current harvester.

7.2 Dredging

The District has expressed interest in dredging the southwestern portion of Wilke Lake for macrophyte control and because sedimentation has occurred that may hinder boating in the near future. Dredging can be used for macrophyte control as plants, roots, rhizomes, and seeds are removed with the sediments. However, if dredging does not occur to a depth over 15 feet (a depth exceeding the photic zone), macrophytes will re-colonize the area over a period of time. Dredging is often too expensive an option to be considered for macrophyte control alone. Dredging channels to piers for the purpose of navigation may be a less costly option than dredging the entire area.

Two transects sampled in the southwestern portion of Wilke Lake indicate that macrophyte densities in water up to 5 feet in depth are much lower than those in 5 to 15 feet of water. In addition, species diversity in the area adjacent to the southwestern wetland is among the best in the Lake. Therefore, if the District decides to pursue dredging, it is recommended that no dredging occur within depths of 0 to 5 feet of water adjacent to the southwestern wetland. Sediment sampling may be required by the WDNR before dredging. While the WWC helps fund dredging of channels defined by navigational aides, maintenance dredging of basins is not eligible for funding. Dredging is not eligible for funding from lake planning or lake protection and classification grants.

7.3 Combination of Chemical Treatment with 2,4-D and Harvesting

The District has expressed an interest in using an aquatic herbicide to manage aquatic plants in Wilke Lake. Chemical treatment of EWM is a potential management option. However, chemical treatment of native species is not recommended, due to their lower densities and value in the aquatic community. In general, chemical treatment of aquatic plants can offer more maneuverability for aquatic plant management in confined quarters and around docks that a harvester cannot. Chemical treatment of the more dense macrophytes between 5 and 15 feet is an option, but is likely to be too expensive as this area is nearly 80 acres in size. Due to the District's desire to try chemical treatment, Northern Environmental has selected the boat landing and shallow areas of the developed portions of the lake for chemical treatment, which will allow access to private piers and swimming areas (Figure 2). Since not all property owners may be comfortable with chemical treatment, we recommend that it occur only on the property of those who request it. Treating submergent plants near the wetlands is not recommended since these areas have the greatest species diversity.

The systemic herbicide 2,4-D was selected because of the potential for a longer effect and potential selectivity. Navigate*, a granular 2,4-D product, has demonstrated watermilfoil control while not affecting white or yellow water lilies. 2,4-D results can be seen in 10 to 14 days. Disadvantages include: while 2,4-D lasts only a short time in water, it can be detected in sediments for months after application. After application, water use restrictions may be necessary and will need to be enforced. Chemical treatments are discussed at length in Appendix C.

The proposed 2,4-D treatments must be applied by a licensed, qualified aquatic pesticide applicator at application rates that will not affect *potamogeton spp.* (pondweeds), waterlilies, or spatterdock. The applicator must follow the requirements of Chapter NR 107, Wisconsin Administrative Code. The applicator shall post signs at areas treated in compliance with NR 107. The District must obtain an aquatic nuisance control report from the applicator and submit it to WDNR within 30 days of treatment.

Applications of 2,4 D-based herbicides by a licensed applicator would cost approximately $540 per acre. One major treatment per season would be needed; however, one potential follow up "spot treatment" may also be needed. Therefore 2,4 D-based herbicides are too expensive to treat the entire management area. The cost of chemicals and application for chemical removal of EWM is eligible for funding by the WWC. However, applicable permits and a WDNR-approved aquatic plant management plan must be obtained before submitting a grant application. There is a $75,000 per year cap for all WWC-funded chemical treatment projects in the state.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

Water quality data collected during 1995 and 2003 indicate that Wilke Lake is a mesotrophic lake with good water quality. Adequate levels of nutrients and good water clarity contribute to abundant aquatic plant growth which can interfere with recreational activities.

Few changes have occurred in the macrophyte community between 1992 and 2003. Two invasive species, EWM and curlyleaf pondweed, were observed in Wilke Lake. EWM was observed throughout the Lake and has grown to nuisance levels at depths of 5 to 15 feet. The District believes EWM has also reached nuisance levels between 0-5 feet of water. Curlyleaf pondweed was observed in a few more locations than during 1992, but the plant is not abundant. Areas within a depth of up to 5 feet of water show the greatest species diversity and lower macrophyte densities. The District believes densities are greater in the shallower areas than were observed.

Because of the large size (80 acres) of the area historically harvested, Northern Environmental believes continued harvesting in depths greater than 5 feet of water to be the most feasible option for this area. As before, EWM plant fragments and floating plants should be harvested to the extent possible to try to prevent additional colonization of EWM in shallower areas. Additional management in the form of chemical treatment of EWM with 2,4-D may occur near the boat landing, and private piers and beaches. Chemical treatment should be voluntary and only properties with owners in favor of the treatment should be treated. Hand pulling or raking of EWM and curlyleaf pondweed is an alternative to chemical treatment.

The proposed 2,4-D treatments must be applied by a licensed, qualified aquatic pesticide applicator at application rates that will not affect Potamogeton (pondweed) species, water lilies, or spatterdock. The applicator must follow the requirements of Chapter NR 107, Wisconsin Administrative Code. The District must obtain an aquatic nuisance control report from the applicator and submit it to the WDNR within 30 days of treatment.

Native, non-invasive species that occur at densities far below nuisance levels in depths up to 5 feet should be protected. *While property owners may be tempted to eliminate all aquatic plants from their beaches and around piers, to do so may result in even more undesirable consequences as native plant communities are important to maintain a healthy aquatic ecosystem and help prevent the spreading of nuisance species.* Education of property owners about the aquatic plant communities of Wilke Lake (such as where native and invasive plants are located) and the importance of native aquatic plants is encouraged. The District may be interested in obtaining a copy of *Through the Looking Glass…A Field Guide to Aquatic Plants*, which includes information about plants value in the aquatic community. The book can be obtained from the University of Wisconsin Extension at 715-346-2166.

The District is also encouraged to look for a volunteer self-help citizen lake monitor (SHLM) to help track any changes to water quality over time. The WDNR provides all equipment to the volunteer and training is provided. More information about the SHLM program can be found at www.dnr.state.wi.us/org/water/fhp/lakes/selfhelp/index.htm or by calling the self-help coordinator for Manitowoc County, Mary Gansberg at 920-492-5799.

9.0 GLOSSARY

The following section is largely adapted from a University of Wisconsin Extension Publication entitled *Understanding Lake Data* (Shaw, et al., 1994).

Algae: One-celled (phytoplankton) or multi-cellular plants either suspended in water (plankton) or attached to rocks, rooted aquatic plants, and other substrates (epiphytes). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to help classify the trophic status of a lake. Algae are essential to the lake ecosystems and provide the food base for most lake organisms, including fish. Phytoplankton abundance and specie distribution vary widely from day to day, as life cycles are short.

Alkalinity: A measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity is the main indicator of susceptibility to acid rain. Increasing alkalinity is often related to increased algae productivity. Expressed as mg/l of calcium carbonate ($CaCO_3$) or as microequivalents per liter (μeq/l). 20 μeq/l = 1 mg/l of $CaCO_3$.

Ammonia: A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays, can be used by most aquatic plants, and is, therefore, an important nutrient. Ammonia converts rapidly to nitrate (NO_3^-) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic fish at relatively low concentrations in pH-neutral or alkaline water. Under acidic conditions, non-toxic ammonium ions (NH_4^+) form, but at high pH values, the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for fish and aquatic life is 0.02 mg/l of NH_4OH. At a pH of 7 and a temperature of 68°F (20°C), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH of 8, the ratio is 26:1.

Anion: Refers to the chemical ions present that carry a negative charge in contrast to cations, which carry a positive charge. There must be equal amounts of positive and negative charged ions in any water sample. Following are the common anions in decreasing order of concentration for most lakes: bicarbonate (HCO_3^-), sulfate $SO_4^=$), chloride (Cl^-), carbonate ($CO_3^=$), nitrate (NO_3^-), nitrate (NO_2^-), and phosphates ($H_2PO_4^-$, $HPO_4^=$, and $PO_4^=$).

Aquatic invertebrates: Aquatic animals without an internal skeletal structure, such as insects, mollusks, and crayfish.

Blue-green algae: Algae that is often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as the die. Many can fix atmospheric nitrogen (N_2) to provide their own nutrient source.

Calcium: The most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-baring minerals in the lake watershed, and reported in mg/l as calcium carbonate ($CaCO_3$) or mg/l as calcium ion (Ca^{++}).

Cation: Refers to chemical ions present that carry a positive charge. The common cations present in lakes in normal order of decreasing concentrations follow: calcium (Ca^{++}), magnesium

(Mg^{++}), potassium (K^+), sodium (Na^+), ammonium (NH_4^+), ferric iron (Fe^{+++}) or ferrous iron (Fe^{++}), manganese (Mn^{++}), and hydrogen (H^+).

Chloride: Chlorine in the chloride ion (Cl^-) form has very different properties from chlorine gas (Cl_2), which is used for disinfecting. The chloride ion (Cl^-) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll *a*: Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae and is, therefore, commonly used as a water-quality indicator.

Color: Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. The average color value for Wisconsin lakes is 39 units, with the color of state lakes raging from zero to 320 units. Color also affects light penetration, and therefore, the depth at which plants can grow.

Concentration units: Express the amount of a chemical dissolved in water. The most common ways chemical data are expressed is in mg/l and micrograms per liter (µg/l). One mg/l is equal to one part per million (ppm). To convert µg/l to mg/l, divide by 1000 (e.g., 30 µg/l = 0.03 mg/l). To convert mg/l to µg/l, multiply by 1000 (e.g., 0.5 mg/l = 500 µg/l). Microequivalents per liter (µeq/l) is also sometimes used, especially for alkalinity; it is calculated by dividing the weight of the compound by 1000 and then dividing that number into the mg/l.

Conductivity (specific conductance): Measures the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter (µmhos/cm) or an equivalent in microsiemens (µs), and is directly related to the total dissolved inorganic chemicals in the water. Values are commonly two times the water hardness unless the water is receiving high concentrations of contaminants introduced by humans.

Drainage basin: The total land area that drains toward the lake.

Drainage lakes: Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems but generally have shorter residence times than seepage lakes. Watershed protection is usually needed to manage lake water quality.

Epiphyte: See "Algae"

Filamentous algae: Algae that forms filaments or mats attached to sediment, weeds, piers, etc.

Food chain: The sequence of algae being eaten by small aquatic animals (zooplankton) that in turn are eaten by small fish that are then eaten by larger fish, and eventually by people or predators. Certain chemicals, such as polychlorinated biphenyls (PCBs), mercury, and some pesticides, can be concentrated from very low levels in the water to toxic levels in animals through this process.

Ground-water discharge lake: Often referred to as a spring-fed lake; has large amounts of ground water as its source, and a source outlet. Areas of high ground-water inflow may be visible as springs or sand boils. Ground-water drainage lakes often have intermediate retention times with water quality dependent on ground-water quality.

Hardness: The quantity of multivalent cations, primarily calcium (Ca^{++}) and magnesium (Mg^{++}) in the water, expressed as mg/l of $CaCO_3$. Amount of hardness relates to the presence of soluble minerals, especially limestone and dolomite, in the lake watershed.

Hypolimnion: see "Stratification"

Ion: A charged atom or group of atoms that have separated from an ion of the opposite charge. In water, some chemical molecules separate into cations (positive charge) and anions (negative charge). Thus, the number of cations equals the number of anions.

Insoluble: Incapable of dissolving in water.

Kjeldahl nitrogen: The most common analysis run to determine the amount of organic nitrogen in water. The test includes ammonium and organic nitrogen.

Limiting factor: The nutrient or condition in shortest supply relative to plant growth requirements. Plants will grow until stopped by this limitation; for example, phosphorous during summer and temperature or light during fall or winter.

Macrophytes: see "Rooted aquatic plants."

Marl: White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) in hard water lakes. Marl may contain many snail and clamshells, which also is $CaCO_3$. While it gradually fills in lakes, marl also precipitates phosphorous, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Metalimnion: see "Stratification."

Nitrate: An inorganic form of nitrogen important for plant growth. Nitrogen is in this stable form when oxygen is present. Nitrate (NO_3^-) often contaminates ground water when water originates from manure pits, fertilized fields, lawns, or septic systems. High levels of nitrate-nitrogen (over 10 mg/l) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO_3^-N) plus ammonium-nitrogen (NH_4^-N) of 0.3 mg/l in spring will support summer algae blooms if enough phosphorous is present.

Nitrite: A form of nitrogen that rapidly converts to nitrate (NO_3^-) and is usually included in the NO_3^- analysis.

Overturn: Fall cooling and spring warming of surface water increases density and gradually makes temperature and density uniform from top to bottom. This allows wind and wave action to mix the entire lake. Mixing allows bottom waters to contact the atmosphere, raising the oxygen content of the water. However, warming may occur too rapidly in the spring for mixing to be effective, especially in small sheltered kettle lakes.

Phosphorus: Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

Photosynthesis: Process by which green plants convert carbon dioxide (CO_2) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a food base for a lake and is an important source of oxygen for many lakes.

Phytoplankton: see "Algae."

Precipitate: A solid material that forms and settles out of water because of certain negative ions (anions) combining with positive ions (cations).

Retention time: The average length of time water resides in a lake, ranging from several days in small impoundments to many years in large seepage lakes. Retention time (turnover rate or flushing rate) is important in determining the impact of nutrient inputs. Long retention times result in recycling and greater nutrient retention in most lakes. Calculate retention time by dividing the volume of water passing through the lake per year by the lake volume.

Respiration: The process by which aquatic organisms convert organic material to energy. It is the reverse of photosynthesis. Respiration consumes oxygen (O_2) and releases carbon dioxide (CO_2). It also takes place as organic matter decays.

Rooted aquatic plants Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Secchi disc: An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration). The disc is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. For best results, the readings should be taken on sunny, calm days.

Sedimentation: Accumulated organic and inorganic matter on the lake bottom. Sediment includes decaying algae and weeds, marl, and soil and organic matter eroded from the watershed of the lake.

Seepage lakes: Lakes without a significant inlet or outlet, fed by rainfall and ground water. Seepage lakes lose water through evaporation and ground water moving on a downgradient. Lakes with little ground-water inflow tend to be naturally acidic and most susceptible to the effects of acid rain. Seepage lakes often have long residence times, and lake levels fluctuate with local ground-water levels. Water quality is affected by ground-water quality and the use of land on the shoreline.

Soluble: Capable of being dissolved.

Stratification: The layering of water due to differences in density. The greatest density of water occurs at 39°F (4°C). As water warms during the summer, cool water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion or thermocline.

Suspended solids: A measure of the particulate matter in a water sample expressed in milligrams per liter. When measured on inflowing streams, it can be used to estimate the sedimentation rate of lakes or impoundments.

Thermocline: see "Stratification."

Transparency: see "Secchi disc."

Trophic state: The degree to which a lake is enriched with nutrients, increasing the production of rooted aquatic plants and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrohic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Watershed: see "Drainage basin."

Zooplankton: Microscopic or barely visible animals that often eat algae. These suspended plankton are an important component of the lake food chain and ecosystem. For many fish, they are the primary source of food.

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MANAGEMENT AREAS OF WILKE LAKE

TOWN OF SCHLESWIG
MANITOWOC COUNTY, WISCONSIN

FIGURE 2

PROJECT NUMBER: WLA01-3100-2452

Northern Environmental[SM]
Hydrologists · Engineers · Geologists
1214 West Venture Court, Mequon, Wisconsin
Phone: 800-776-7140 Fax 262-241-8222

CREATION DATE: 10/02/01
DRAWN BY: KAA
REVISION DATE: 01/07/04

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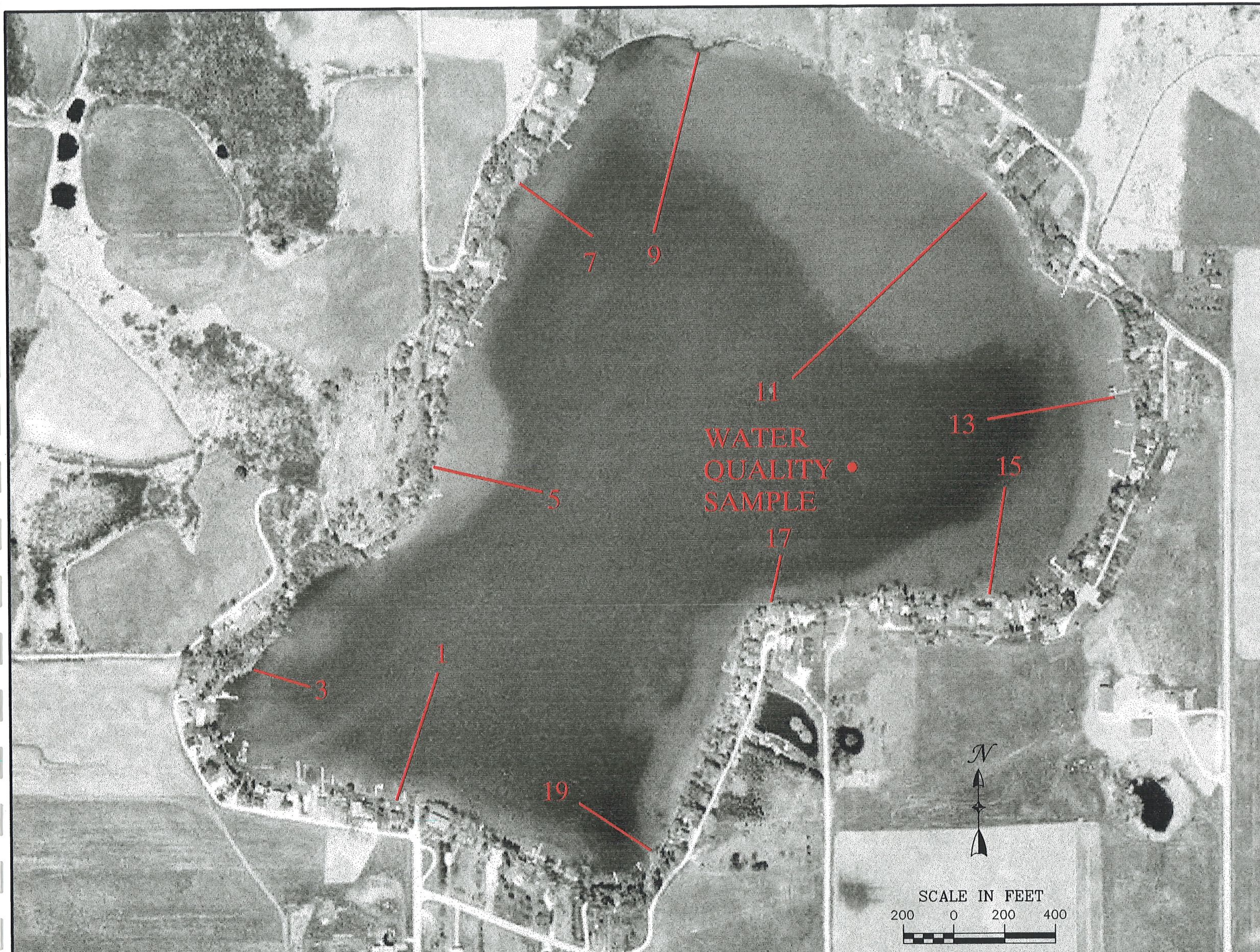

LEGEND

● SAMPLE LOCATION

1 TRANSECT NUMBER

TRANSECT SPECIES

T1 EWM
NORTHERN WATERMILFOIL
CHARA
SLENDER NAIAD
CURLYLEAF PONDWEED

T3 SPATTERDOCK
WHITE WATER LILY
SLENDER NAIAD
SAGO PONDWEED
CHARA
CATTAIL
EWM
LARGE LEAF PONDWEED

T5 WHITE WATER LILY
EWM
CHARA
SLENDER NAIAD
ILLINOIS PONDWEED
SAGO PONDWEED
NITELLAS
CURLYLEAF PONDWEED

T7 EWM
SLENDER NAIAD
CHARA
CURLYLEAF PONDWEED
BULRUSH
CATTAIL

T9 EWM
ILLINOIS PONDWEED
SLENDER NAIAD
CHARA
CURLYLEAF PONDWEED

T11 EWM
ILLINOIS PONDWEED
CHARA
SLENDER NAIAD

T13 EWM
CHARA
ILLINOIS PONDWEED

T15 EWM
SAGO PONDWEED
CHARA
ILLINOIS PONDWEED
SLENDER NAIAD

T17 EWM
SLENDER NAIAD
LARGE LEAF PONDWEED
CHARA
ILLINOIS PONDWEED
CURLYLEAF PONDWEED
NITELLAS

T19 EWM
CHARA
SLENDER NAIAD
ILLINOIS PONDWEED
SAGO PONDWEED

JULY 2003 AQUATIC MACROPHYTE DISTRIBUTION

TOWN OF SCHLESWIG
MANITOWOC COUNTY, WISCONSIN

FIGURE 3

PROJECT NUMBER: WLA01-3100-2452

Northern Environmental
Hydrologists · Engineers · Geologists
1214 West Venture Court, Mequon, Wisconsin
Phone: 800-776-7140 Fax 262-241-8222

CREATION DATE: 10/02/01
DRAWN BY: KAA
REVISION DATE: 10/08/03

Table 2 July 2003 Aquatic Macrophyte Survey Results, Wilke Lake

Depth Zone	*N. variegata*	*N. odorata*	*EWM*	*M. sibiricum*	*Chara spp.*	*N. flexilis*	*P. crispus*	*P. amplifolius*	*P. pectinatus*	*P. illinoensis*	*Nitella spp.*
<1.75'	10.0	20.0	70.0	0.0	20.0	20.0	0.0	0.0	20.0	20.0	0.0
1.75'-5.0'	10.0	10.0	100.0	10.0	100.0	90.0	0.0	10.0	10.0	50.0	0.0
5.0'-10.0'	0.0	0.0	90.0	10.0	60.0	0.0	0.0	10.0	0.0	30.0	0.0
10.1'-20.0'	0.0	0.0	70.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	20.0
Average Frequency of Occurrence (percentage)	**5.0**	**7.5**	**82.5**	**5.0**	**45.0**	**27.5**	**12.5**	**5.0**	**7.5**	**25.0**	**5.0**
<1.75'	5.6	11.1	38.9	0.0	11.1	11.1	0.0	0.0	11.1	11.1	0.0
1.75'-5.0'	2.6	2.6	25.6	2.6	25.6	23.1	0.0	2.6	2.6	12.8	0.0
5.0'-10.0'	0.0	0.0	45.0	5.0	30.0	0.0	0.0	5.0	0.0	15.0	0.0
10.1'-20.0'	0.0	0.0	50.0	0.0	0.0	0.0	35.7	0.0	0.0	0.0	14.3
Average Relevant Frequency (percentage)	**2.1**	**3.4**	**39.9**	**1.9**	**16.7**	**8.6**	**8.9**	**1.9**	**3.4**	**9.7**	**3.6**
<1.75'	0.35	0.70	1.55	0.00	0.30	0.20	0.00	0.00	0.30	0.30	0.00
1.75'-5.0'	0.25	0.60	1.40	0.15	2.90	0.65	0.00	0.05	0.10	0.55	0.00
5.0'-10.0'	0.00	0.00	1.90	0.00	0.85	0.00	0.00	0.03	0.00	0.15	0.00
10.1'-20.0'	0.00	0.00	1.60	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.11
Average Density	**0.2**	**0.3**	**1.6**	**0.0**	**1.0**	**0.2**	**0.1**	**0.0**	**0.1**	**0.3**	**0.0**

Table 3 September 2003 Aquatic Macrophyte Survey Results, Wilke Lake

Depth Zone	*N. variegata*	*N. odorata*	*EWM*	*M. sibiricum*	*Chara spp.*	*N. flexilis*	*P. crispus*	*P. amplifolius*	*P. pectinatus*	*P. illinoensis*	*Nitella spp.*	*Sagittaria sp.*	*P. foliosus*	*P. diversifolius*	*P. natans*	*P. gramineus*
<1.75'	10.0	30.0	80.0	0.0	50.0	60.0	0.0	0.0	20.0	30.0	10.0	10.0	10.0	20.0	20.0	0.0
1.75'-5.0'	0.0	0.0	90.0	20.0	80.0	70.0	0.0	20.0	0.0	60.0	10.0	0.0	0.0	10.0	0.0	10.0
5.0'-10.0'	0.0	0.0	90.0	40.0	30.0	10.0	0.0	10.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
10.1'-20.0'	0.0	0.0	70.0	30.0	0.0	10.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0
Average Frequency of Occurrence (percentage)	**2.5**	**7.5**	**82.5**	**22.5**	**40.0**	**37.5**	**0.0**	**7.5**	**5.0**	**27.5**	**12.5**	**2.5**	**2.5**	**7.5**	**5.0**	**2.5**
<1.75'	2.9	8.6	22.9	0.0	14.3	17.1	0.0	0.0	5.7	8.6	2.9	2.9	2.9	5.7	5.7	0.0
1.75'-5.0'	0.0	0.0	24.3	5.4	21.6	18.9	0.0	5.4	0.0	16.2	2.7	0.0	0.0	2.7	0.0	2.7
5.0'-10.0'	0.0	0.0	45.0	20.0	15.0	5.0	0.0	5.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
10.1'-20.0'	0.0	0.0	50.0	21.4	0.0	7.1	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0
Average Relevant Frequency (percentage)	**0.7**	**2.2**	**35.6**	**11.7**	**12.7**	**12.0**	**0.0**	**2.6**	**1.4**	**8.7**	**6.8**	**0.7**	**0.7**	**2.1**	**1.4**	**0.7**
<1.75'	0.2	0.7	3.75	0.00	0.70	1.15	0.00	0.00	0.15	0.45	0.20	0.06	0.05	0.40	0.10	0.00
1.75'-5.0'	0.0	0.0	1.45	0.15	2.05	1.35	0.00	0.10	0.00	0.55	0.05	0.00	0.00	0.05	0.00	0.05
5.0'-10.0'	0.0	0.0	5.55	0.25	0.85	0.10	0.00	0.05	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
10.1'-20.0'	0.0	0.0	1.65	0.30	0.00	0.05	0.00	0.00	0.00	0.00	1.45	0.00	0.00	0.00	0.00	0.00
Average Density	**0.1**	**0.2**	**3.1**	**0.2**	**0.9**	**0.7**	**0.0**	**0.0**	**0.0**	**0.3**	**0.4**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**

Note:
EWM = Eurasian Watermilfoil

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APPENDIX A

LABORATORY REPORTS

Wisconsin Department of Natural Resources
Laboratory Report

Laboratory: **Wisconsin State Laboratory of Hygiene** *DNR ID* **113133790**
2601 Agriculture Dr.
Madison WI 53718
Phone : **800-442-4618** *Fax Phone :* **608-224-6276**

Sample:

Field #:	**WILSURFACE**	*Sample #:*	**IO005978**
Collection Start:	**09/03/2003 02:10 am**	*Collection End:*	
Collected by:	**DEMING**	*Waterbody/Outfall Id:*	**58000**
ID #:	**363286**	*ID Point #:*	
County:	**Manitowoc**	*Account #:*	**SL004**
Sample Location:	**WILKE LAKE**		
Sample Description:	**DEEP SPOT**		
Sample Source:	**SU**	*Sample Depth:*	
Date Reported:	**09/17/2003**	*Sample Status:*	**COMPLETE**
Project No:	**SPL053**		

Analyses and Results:

Analysis Method — *Analysis Date* — *Lab Comment*
VOLUME LAB FILT FOR CHLOROPHYLL A (09/08/2003

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
32000	SAMPLE SIZE LITERS		200	ML			

Analysis Method — *Analysis Date* — *Lab Comment*
CHLOROPHYLL A, FLUORESCENCE (WELS09/09/2003

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
99717	CHLOROPHYLL A, FLUORESCENCE (WELSCHMAYER 1994)	479618	6.28	UG/L	0.26		0.87

Analysis Method — *Analysis Date* — *Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1) 09/09/2003

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	PHOSPHORUS TOTAL	7723140	0.023	MG/L	0.005		0.016

Analysis Method — *Analysis Date* — *Lab Comment*
TEMPERATURE ON RECEIPT-ICED 09/04/2003

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

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APPENDIX B

AQUATIC PLANT SURVEY DATA

Wilke Lake - July 2003 Aquatic Macrophyte Survey (depth zone: <1.75')
Survey Date: July 8, 2003

Species Density Rating

	Nuphar variegata				*Nymphaea odorata*				*Myriophyllum spicatum (EWM)*				*Myriophyllum sibiricum*			
	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density
Transect 1A									1	1	1	1				
Transect 3A	2	2	2	1	3	3	3	3								
Transect 5A					1		1		2	1	2	1				
Transect 7A									2	2	2	2				
Transect 9A									1	1	1	1				
Transect 11A																
Transect 13A									1		1					
Transect 15A																
Transect 17A									1		1					
Transect 19A									1	2	1	1				
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	10.0				20.0				70.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	5.6				11.1				38.9				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.35				0.70				1.55				0.00			

	Chara spp.				*Najas flexilis*				*Potamogeton crispus*				*Potamogeton amplifolius*			
	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density
Transect 1A																
Transect 3A	1	1	1	2	1		1									
Transect 5A					1		1									
Transect 7A																
Transect 9A																
Transect 11A																
Transect 13A		1														
Transect 15A																
Transect 17A																
Transect 19A																
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	20.0				20.0				0.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	11.1				11.1				0.0				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.30				0.20				0.00				0.00			

	Potamogeton pectinatus				*Potamogeton illinoensis*				*Nitella spp.*			
	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density
Transect 1A												
Transect 3A												
Transect 5A	1	1	1	1	1		1	1				
Transect 7A												
Transect 9A					1	1		1				
Transect 11A												
Transect 13A												
Transect 15A												
Transect 17A												
Transect 19A	1	1										
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	20.0				20.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	11.1				11.1				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.30				0.30				0.00			

Wilke Lake - July 2003 Aquatic Macrophyte Survey (depth zone: 1.75'-5.0')

Survey Date: July 8, 2003

Species Density Rating

	Nuphar variegata Toss #1 Density	*Nuphar variegata* Toss #2 Density	*Nuphar variegata* Toss #3 Density	*Nuphar variegata* Toss #4 Density	*Nymphaea odorata* Toss #1 Density	*Nymphaea odorata* Toss #2 Density	*Nymphaea odorata* Toss #3 Density	*Nymphaea odorata* Toss #4 Density	*Myriophyllum spicatum (EWM)* Toss #1 Density	*Myriophyllum spicatum (EWM)* Toss #2 Density	*Myriophyllum spicatum (EWM)* Toss #3 Density	*Myriophyllum spicatum (EWM)* Toss #4 Density	*Myriophyllum sibiricum* Toss #1 Density	*Myriophyllum sibiricum* Toss #2 Density	*Myriophyllum sibiricum* Toss #3 Density	*Myriophyllum sibiricum* Toss #4 Density
Transect 1B									1	1	1	1	1	1	1	
Transect 3B	2	1	1	1	3	3	3	3	1	1	1	1				
Transect 5B									1	1	1	1				
Transect 7B										1	1					
Transect 9B										1						
Transect 11B									1	1	1					
Transect 13B									1	1	1	1				
Transect 15B											1	1				
Transect 17B									1	1		1				
Transect 19B										1						
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	10.0				10.0				100.0				10.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	2.6				2.6				25.6				2.6			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.25				0.60				1.40				0.15			

	Chara spp. Toss #1 Density	*Chara spp.* Toss #2 Density	*Chara spp.* Toss #3 Density	*Chara spp.* Toss #4 Density	*Najas flexilis* Toss #1 Density	*Najas flexilis* Toss #2 Density	*Najas flexilis* Toss #3 Density	*Najas flexilis* Toss #4 Density	*Potamogeton crispus* Toss #1 Density	*Potamogeton crispus* Toss #2 Density	*Potamogeton crispus* Toss #3 Density	*Potamogeton crispus* Toss #4 Density	*Potamogeton amplifolius* Toss #1 Density	*Potamogeton amplifolius* Toss #2 Density	*Potamogeton amplifolius* Toss #3 Density	*Potamogeton amplifolius* Toss #4 Density
Transect 1B	1	1	1	1		1										
Transect 3B	1	1	1	1	1											
Transect 5B	1	1	1	1				1								
Transect 7B	1	1	1		1	1		1								
Transect 9B	1	2	2	2		1										
Transect 11B	2	1	1	2				1								
Transect 13B	2	2	2	2												
Transect 15B	1	2	1				1									
Transect 17B	2	2	2	3				1								1
Transect 19B	2	2	2	3	1	1	1									
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	100.0				90.0				0.0				10.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	25.6				23.1				0.0				2.6			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	2.90				0.65				0.00				0.05			

	Potamogeton pectinatus Toss #1 Density	*Potamogeton pectinatus* Toss #2 Density	*Potamogeton pectinatus* Toss #3 Density	*Potamogeton pectinatus* Toss #4 Density	*Potamogeton illinoensis* Toss #1 Density	*Potamogeton illinoensis* Toss #2 Density	*Potamogeton illinoensis* Toss #3 Density	*Potamogeton illinoensis* Toss #4 Density	*Nitella spp.* Toss #1 Density	*Nitella spp.* Toss #2 Density	*Nitella spp.* Toss #3 Density	*Nitella spp.* Toss #4 Density
Transect 1B												
Transect 3B												
Transect 5B							1					
Transect 7B												
Transect 9B												
Transect 11B					1							
Transect 13B												
Transect 15B		1	1		2	1	1	1				
Transect 17B							2	1				
Transect 19B								1				
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	10.0				50.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	2.6				12.8				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.10				0.55				0.00			

Wilke Lake - July 2003 Aquatic Macrophyte Survey (depth zone: 5.0'-10.0')
Survey Date: July 8, 2003

	Species Density Rating																																											
	Nuphar variegata				*Nymphaea odorata*				*Myriophyllum spicatum (EWM)*				*Myriophyllum sibiricum*				*Chara spp.*				*Najas flexilis*				*Potamogeton crispus*				*Potamogeton amplifolius*				*Potamogeton pectinatus*				*Potamogeton illinoensis*				*Nitella spp.*			
	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density
Transect 1C									2	3	4	3	2	1		3		1	1	2												1												
Transect 3C																																												
Transect 5C									3	2	4	5																																
Transect 7C									2	3	2	2																																
Transect 9C										1		1					1	2	3	2																		1						
Transect 11C										1		1					1	1	1	1																								
Transect 13C									2	3	2	2					3			4																				1				
Transect 15C									1	1	1	2					4	2	3	2																	1	1	1					
Transect 17C									1	2	3	3					2		2	1																								
Transect 19C									3	4	4	4																																
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0				0.0				90.0				10.0				60.0				0.0				0.0				10.0				0.0				30.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0				0.0				45.0				5.0				30.0				0.0				0.0				5.0				0.0				15.0				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00				0.00				3.85				0.30				1.95				0.00				0.00				0.05				0.00				0.25				0.00			

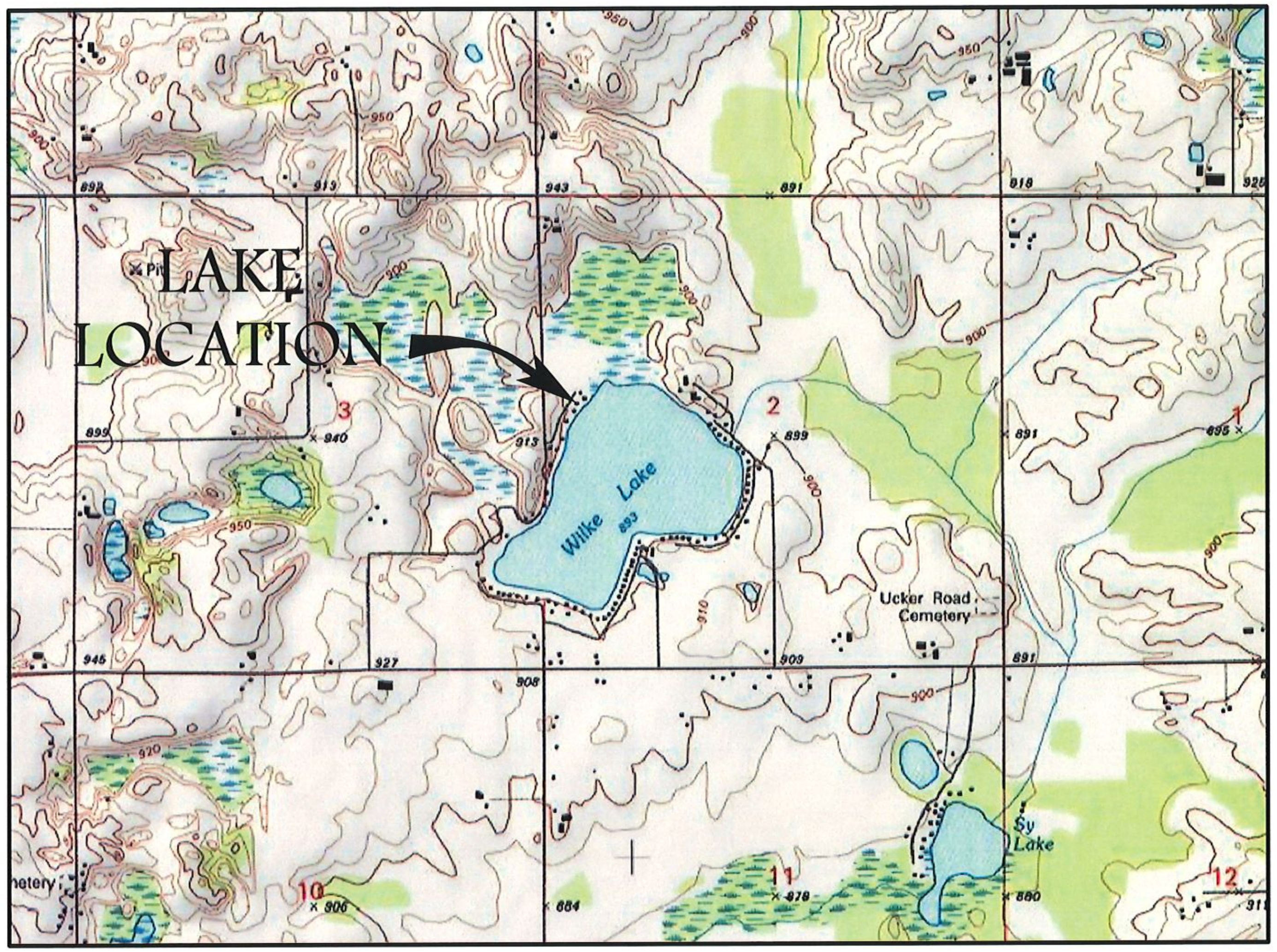
Wilke Lake - July 2003 Aquatic Macrophyte Survey (depth zone: >10.0')
Survey Date: July 8, 2003

Species Density Rating

0	*Nuphar variegata* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Nymphaea odorata* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Myriophyllum spicatum (EWM)* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Myriophyllum sibiricum* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density
Transect 1D									4	3	4	4				
Transect 3D																
Transect 5D									1	2	2	1				
Transect 7D										1	1	1				
Transect 9D									2	3	3	3				
Transect 11D										1		1				
Transect 13D												1				
Transect 15D																
Transect 17D									1	1	2	3				
Transect 19D																
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0				0.0				70.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0				0.0				50.0				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00				0.00				2.25				0.00			

0	*Chara spp.* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Najas flexilis* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Potamogeton crispus* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Potamogeton amplifolius* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density
Transect 1D									1	1	1	1				
Transect 3D																
Transect 5D									1	1						
Transect 7D										1						
Transect 9D									1	1						
Transect 11D																
Transect 13D																
Transect 15D																
Transect 17D											2	1				
Transect 19D																
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0				0.0				50.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0				0.0				35.7				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00				0.00				0.60				0.00			

0	*Potamogeton pectinatus* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Potamogeton illinoensis* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density	*Nitella spp.* Toss #1 Density	Toss #2 Density	Toss #3 Density	Toss #4 Density
Transect 1D												
Transect 3D												
Transect 5D											1	
Transect 7D												
Transect 9D												
Transect 11D												
Transect 13D												
Transect 15D												
Transect 17D									1			1
Transect 19D												
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0				0.0				20.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0				0.0				14.3			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00				0.00				0.15			



N

SCALE IN FEET

1" = 2000'

0 1000 2000 3000 4000 5000 6000 7000 8000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

BASE MAP SOURCE: USGS 7.5 MINUTE QUADRANGLE, SCHOOL HILL, WISCONSIN, 1992 (NATIONAL GEOGRAPHIC HOLDINGS, INC.)

Northern Environmental SM
Hydrologists • Engineers • Geologists • Surveyors
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WISCONSIN ▲ MICHIGAN ▲ ILLINOIS ▲ IOWA

LAKE LOCATION & LOCAL TOPOGRAPHY

TOWN OF SCHLESWIG
MANITOWOC COUNTY, WISCONSIN

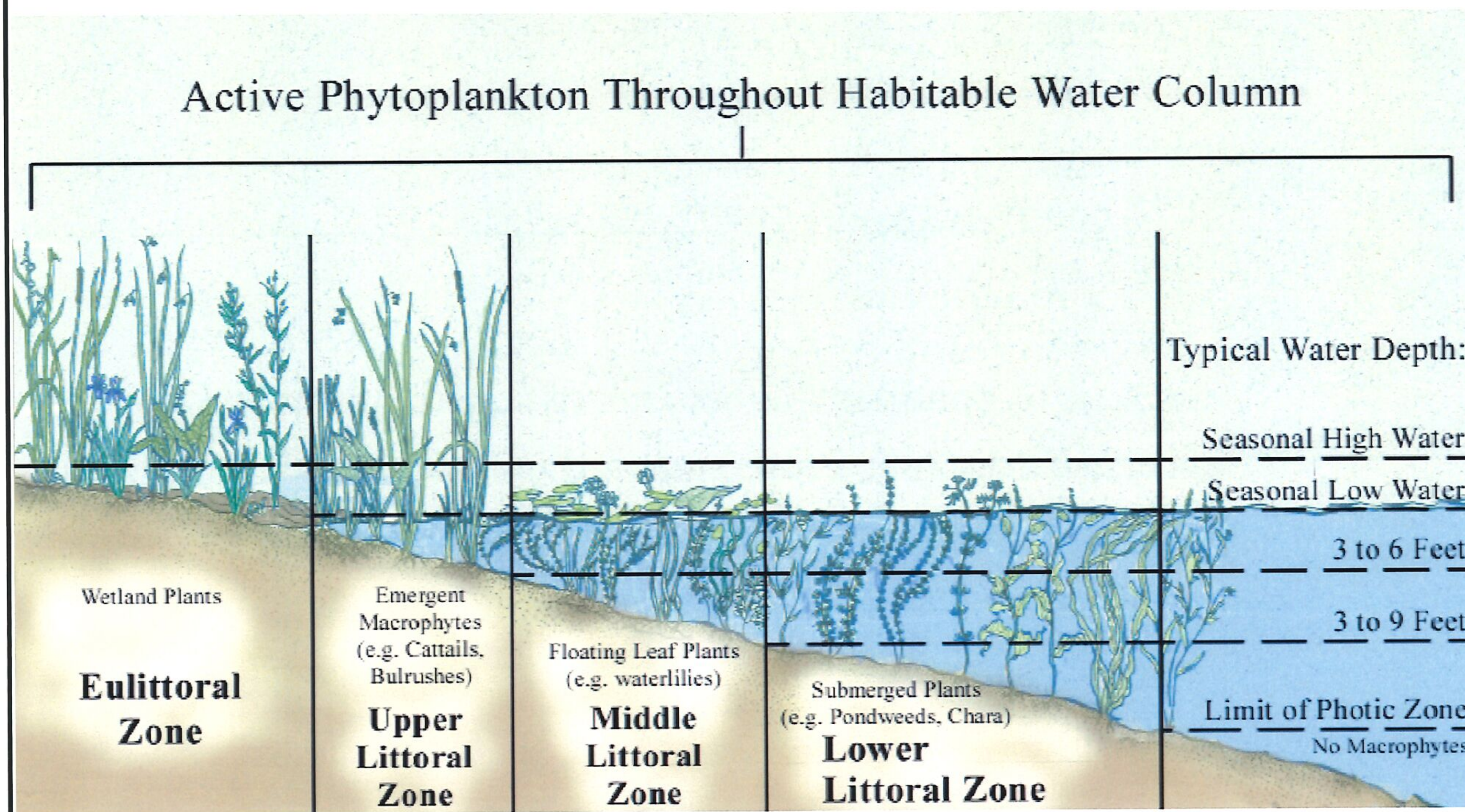
CREATION DATE: 10/02/03	THIS DRAWING AND ALL INFORMATION CONTAINED THEREON IS THE PROPERTY OF NORTHERN ENVIRONMENTAL INCORPORATED AND SHALL NOT BE COPIED OR USED EXCEPT FOR THE PURPOSE FOR WHICH IT IS EXPRESSLY FURNISHED.
DRAWN BY: KAA	
REVISION DATE:	

PROJECT NUMBER: WLA01-3100-2452 FIGURE 1

Table 1 Aquatic Macrophytes Observed in Wilke Lake during 2003 Surveys

Type	Genus	Species	Common Name	Observed During June 2003 Survey	Observed During September 2003 Survey
Floating Leaf Plants	*Nuphar*	*variegata*	Spatterdock+	X	X
	Nymphaea	*odorata*	White Water Lily+	X	X
Submerged Plants	*Myriophyllum*	*spicatum*	Eurasian Watermilfoil+	X	X
	Myriophyllum	*sibiricum*	Northern Watermilfoil*+	X	X
	Chara spp+		None+	X	X
	Najas	*flexilis*	Slender Naiad+	X	X
	Nitella spp.		Nitellas	X	X
	Potamogeton	*crispus*	Curlyleaf Pondweed*+	X	
	Potamogeton	*amplifolius*	Large Leaf Pondweed+	X	X
	Potamogeton	*pectinatus*	Sago Pondweed+	X	X
	Potamogeton	*illinoensis*	Illinois Pondweed	X	X
	Potamogeton	*foliosus*	Leafy Pondweed		X
	Potamogeton	*diversifolius*	Water-thread Pondweed		X
	Potamogeton	*natans*	Floating-leaf Pondweed		X
	Potamogeton	*gramineus*	Variable Pondweed		X
Emergent Plants	*Typha*	*latifolia*	Broad-leaved Cattail+	X	X
	Scirpus spp.		Bullrushs+	X	X
	Sagittaria spp.		Arrowheads		X

Note:
* Invasive
+ Also observed during 1992



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AQUATIC PLANT COMMUNITIES SCHEMATIC

TOWN OF SCHLESWIG
MANITOWOC COUNTY, WISCONSIN

CREATION DATE: 10/02/03
DRAWN BY: KAA
REVISION DATE:

PROJECT NUMBER: WLA01-3100-2452

FIGURE 6

S:\CAD\Mequon\Projects\WLA\2452\100203_6.dwg, Figure 6, 1/5/2004 10:06:28 AM

Wilke Lake - September 2003 Aquatic Macrophyte Survey (depth zone: <1.75')

Survey Date: September 3, 2003

Species Density Rating

	Nuphar variegata Density				*Nymphaea odorata* Density				*Myriophyllum spicatum (EWM)* Density				*Myriophyllum sibiricum* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1A									1	1	1	1				
Transect 3A	1	1	1	1	3	3	3	3	3	3	3	3				
Transect 5A									1	1	1	1				
Transect 7A								1	4	4	4	4				
Transect 9A									3	3	3	3				
Transect 11A																
Transect 13A										1	1	1				
Transect 15A																
Transect 17A									2	2	2	2				
Transect 19A					1				4	4	4	4				
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	10.0				30.0				80.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	2.9				8.6				22.9				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.20				0.70				3.75				0.00			

	Chara spp. Density				*Najas flexilis* Density				*Potomogeton crispus* Density				*Potomogeton amplifolius* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1A	1	1			1	1										
Transect 3A		1			1											
Transect 5A	1	1	1	1	1	1	1	1								
Transect 7A																
Transect 9A					2	2	2	2								
Transect 11A																
Transect 13A		1	1	1												
Transect 15A																
Transect 17A					1	1	1	1								
Transect 19A	1	1	1	1	1	1	1	1								
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	50.0				60.0				0.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	14.3				17.1				0.0				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.70				1.15				0.00				0.00			

	Potamogeton pectinatus Density				*Potamogeton illinoensis* Density				*Nitella spp.* Density				*Sagittaria spp.* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1A																
Transect 3A	1	1											1	1		
Transect 5A					1											
Transect 7A				1					1	1	1	1				
Transect 9A					1	1	1	1								
Transect 11A																
Transect 13A																
Transect 15A																
Transect 17A																
Transect 19A					1	1	1	1								
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	20.0				30.0				10.0				10.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	5.7				8.6				2.9				2.9			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.15				0.45				0.20				0.10			

	Potamogeton foliosus Density				*Potamogeton diversifolius* Density				*Potamogeton natans* Density				*Potamogeton gramineus* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1A																
Transect 3A																
Transect 5A																
Transect 7A																
Transect 9A	1				1	1	1	1								
Transect 11A																
Transect 13A																
Transect 15A									1							
Transect 17A					1	1	1	1								
Transect 19A									1							
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	10.0				20.0				20.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	2.9				5.7				5.7				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.05				0.40				0.10				0.00			

Wilke Lake - September 2003 Aquatic Macrophyte Survey (depth zone: 1.75'-5.0')

Survey Date: September 3, 2003

Species Density Rating

	Nuphar variegata				*Nymphaea odorata*				*Myriophyllum spicatum (EWM)*				*Myriophyllum sibiricum*			
	Density				Density				Density				Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1B									3	1	1	1				
Transect 3B											1			1		1
Transect 5B										1	1	1				
Transect 7B									1	1	1	1				
Transect 9B										1	1					
Transect 11B									1		1	1				
Transect 13B									1	1		1				
Transect 15B										1	1	1				
Transect 17B													1			
Transect 19B									1	1	1	1				
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0				0.0				90.0				20.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0				0.0				24.3				5.4			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00				0.00				1.45				0.15			

	Chara spp.				*Najas flexilis*				*Potamogeton crispus*				*Potamogeton amplifolius*			
	Density				Density				Density				Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1B								1								
Transect 3B	1	4	3	2												
Transect 5B	1	1	1	2												
Transect 7B					2	1	1	1								
Transect 9B	1					1	1									
Transect 11B		1	1	1	1	1	2	2								
Transect 13B	1	1	1	1	1	1	1	1								
Transect 15B	2	2	1	1												
Transect 17B		3	3	1	2	1	1	1					1			
Transect 19B	1	1	2	1	1	1	1	1								1
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	80.0				70.0				0.0				20.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	21.6				18.9				0.0				5.4			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	2.05				1.35				0.00				0.10			

	Potamogeton pectinatus				*Potamogeton illinoensis*				*Nitella spp.*				*Sagittaria spp.*			
	Density				Density				Density				Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1B																
Transect 3B							1									
Transect 5B											1					
Transect 7B																
Transect 9B																
Transect 11B							1	1								
Transect 13B						1										
Transect 15B					1	1	1	1								
Transect 17B								1								
Transect 19B					1		1									
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0				60.0				10.0				0.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0				16.2				2.7				0.0			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00				0.55				0.05				0.00			

	Potomogeton foliosus				*Potomogeton diversifolius*				*Potomogeton natans*				*Potamogeton gramineus*			
	Density				Density				Density				Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1B																
Transect 3B					1								1			
Transect 5B																
Transect 7B																
Transect 9B																
Transect 11B																
Transect 13B																
Transect 15B																
Transect 17B																
Transect 19B																
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0				10.0				0.0				10.0			
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0				2.7				0.0				2.7			
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00				0.05				0.00				0.05			

Wilke Lake - September 2003 Aquatic Macrophyte Survey (depth zone: 5.0'-10.0')

Survey Date: September 3, 2003

Species Density Rating

	Nuphar variegata				*Nymphaea odorata*				*Myriophyllum spicatum (EWM)*				*Myriophyllum sibiricum*				*Chara spp.*			
	Density				Density				Density				Density				Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1C									5	5	4	4		1						
Transect 3C									5	4	3	4								
Transect 5C									2	5	5	5								
Transect 7C									2	3	2	3	1							
Transect 9C									1	1		1					2	1	2	3
Transect 11C																	2	3	2	1
Transect 13C									4	3	5	4	1							
Transect 15C									1		1	1					1			
Transect 17C									1	2	3	3		1	1					
Transect 19C									5	5	4	5								

	Najas flexilis				*Potamogeton crispus*				*Potamogeton amplifolius*				*Potamogeton pectinatus*				*Potamogeton illinoensis*			
	Density				Density				Density				Density				Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1C																				
Transect 3C																				
Transect 5C																				
Transect 7C																				
Transect 9C																	1	1		1
Transect 11C	1		1															1		
Transect 13C										1										
Transect 15C																				
Transect 17C																				
Transect 19C																				

	Nitella spp.				*Sagittaria spp.*				*Potomogeton foliosus*				*Potomogeton diversifolius*				*Potomogeton natans*				*Potamogeton gramineus*			
	Density				Density				Density				Density				Density				Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1C																								
Transect 3C																								
Transect 5C																								
Transect 7C																								
Transect 9C																								
Transect 11C																								
Transect 13C																								
Transect 15C																								
Transect 17C																								
Transect 19C																								

	Nuphar variegata	*Nymphaea odorata*	*Myriophyllum spicatum (EWM)*	*Myriophyllum sibiricum*	*Chara spp.*	*Najas flexilis*	*Potamogeton crispus*	*Potamogeton amplifolius*	*Potamogeton pectinatus*	*Potamogeton illinoensis*	*Nitella spp.*	*Sagittaria spp.*	*Potomogeton foliosus*	*Potomogeton diversifolius*	*Potomogeton natans*	*Potamogeton gramineus*
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0	0.0	90.0	40.0	30.0	10.0	0.0	10.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0	0.0	45.0	20.0	15.0	5.0	0.0	5.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00	0.00	5.55	0.25	0.85	0.10	0.00	0.05	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00

Wilke Lake - September 2003 Aquatic Macrophyte Survey (depth zone: >10.0')
Survey Date: September 3, 2003

Species Density Rating

	Nuphar variegata Density				*Nymphaea odorata* Density				*Myriophyllum spicatum (EWM)* Density				*Myriophyllum sibiricum* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1D									1	3	4	3	1	1	1	1
Transect 3D																
Transect 5D									1				1			
Transect 7D										2						
Transect 9D									3	4	1					
Transect 11D									1	1	1	1				
Transect 13D									1		1	1				
Transect 15D																
Transect 17D										2	1	1			1	
Transect 19D																

	Chara spp. Density				*Najas flexilis* Density				*Potamogeton crispus* Density				*Potamogeton amplifolius* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1D																
Transect 3D																
Transect 5D																
Transect 7D																
Transect 9D																
Transect 11D																
Transect 13D																
Transect 15D																
Transect 17D						1										
Transect 19D																

	Potamogeton pectinatus Density				*Potamogeton illinoensis* Density				*Nitella spp.* Density				*Sagittaria spp.* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1D																
Transect 3D																
Transect 5D									4	1	3					
Transect 7D									5		4	4				
Transect 9D											3	5				
Transect 11D																
Transect 13D																
Transect 15D																
Transect 17D																
Transect 19D																

	Potomogeton foliosus Density				*Potomogeton diversifolius* Density				*Potomogeton natans* Density				*Potamogeton gramineus* Density			
	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4	Toss #1	Toss #2	Toss #3	Toss #4
Transect 1D																
Transect 3D																
Transect 5D																
Transect 7D																
Transect 9D																
Transect 11D																
Transect 13D																
Transect 15D																
Transect 17D																
Transect 19D																

	Nuphar variegata	*Nymphaea odorata*	*Myriophyllum spicatum (EWM)*	*Myriophyllum sibiricum*	*Chara spp.*	*Najas flexilis*	*Potamogeton crispus*	*Potamogeton amplifolius*	*Potamogeton pectinatus*	*Potamogeton illinoensis*	*Nitella spp.*	*Sagittaria spp.*	*Potomogeton foliosus*	*Potomogeton diversifolius*	*Potomogeton natans*	*Potamogeton gramineus*
Frequency of Occurrence =(# of sampling sites in which species occurs / total # of sample sites; [within depth interval])	0.0	0.0	70.0	30.0	0.0	10.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0
Relative Frequency= (# of sampling sites in which species occurs / total number of occurances of all species)	0.0	0.0	50.0	21.4	0.0	7.1	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0
Species Mean Density = (Sum of density ratings for species / # of sites; [within depth interval])	0.00	0.00	1.65	0.30	0.00	0.05	0.00	0.00	0.00	0.00	1.45	0.00	0.00	0.00	0.00	0.00

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APPENDIX C

SUMMARY OF AQUATIC PLANT MANAGEMENT ALTERNATIVES

AQUATIC PLANT MANAGEMENT

Aquatic plants are a critical component in an aquatic ecosystem. Any management of an ecosystem can have negative or even detrimental effects on the whole ecosystem. Therefore, the practice of managing aquatic plants should not be taken lightly. The concept of Aquatic Plant Management (APM) is highly variable since different aquatic resource users want different things. Ideal management to one individual may mean providing prime fish habitat, for another it may be to remove surface vegetation for boating. The practice of APM is also highly variable. There are numerous APM strategies designed to achieve different plant management goals. Some are effective on a small scale, but ineffective in larger situations. Others can only be used for specific plants or during certain times of the growing season. Of course, the types of plants that are to be managed will also help determine which APM alternatives are feasible. The following paragraphs discuss the APM methods used today. The discussion is largely adopted from *Managing Lakes and Rivers, North American Lake Management Society, 2001*, supplemented with other applicable current resources and references. The methods summarized here are largely for management of rooted aquatic plants, not algae. While some methods may also have effects on nuisance algae blooms, the focus is submergent rooted aquatic macrophytes. This information is provided to allow the user to gain a basic understanding of the APM method, it is not designed to an all-inclusive APM decision-making matrix. APM alternatives can be divided into the following categories: Physical Controls, Chemical Controls, and Biological Controls.

Physical Controls

Physical APM controls include various methods to prevent growth or remove part or all of the aquatic plant. Both manual and mechanical techniques are employed. Physical APM methods include:

- Hand pulling
- Hand cutting
- Bottom barriers
- Light limitation (dyes, covers)
- Mechanical harvesting
- Hydroraking/rototilling
- Suction Dredging
- Dredging
- Drawdown

Each of these methods is described below. The costs, benefits, and drawbacks of each APM strategy are provided.

Hand Pulling

This method involves digging out or hand removing the entire unwanted plant including stems and roots with a hand tool such as a spade. This method is highly selective and suitable for shallow areas for removing invasive species that have not become well established. This technique is obviously not for use on large dense beds of nuisance aquatic plants. It is best used in areas less than 3 feet deep, but can be used in deeper areas with divers using scuba and snorkeling equipment. It can also be used in combination with the suction dredge method. In Wisconsin, hand pulling may be completed outside a designated sensitive area without a permit but is limited to 30 feet of shoreline frontage. Removal of exotic species is not limited to 30 feet.

Advantages: This technique results in immediate clearing of the water column of nuisance plants. When a selective technique is desired in a shallow, small area, hand pulling is a good choice. It is also useful in sensitive areas where disruption must be minimized.

Disadvantages: This method is labor intensive. Disturbing the substrate may affect fish habitat, increase turbidity, and may promote phosphorus re-suspension and subsequent algae blooms.

Costs: The costs are highly variable. There is practically no cost using volunteers or lakeshore landowners to remove unwanted plants; however, using divers to remove plants can get relatively expensive. Hand pulling labor can range from $100 to $400 per hour.

Hand Cutting

This is another manual method where the plants are cut below the water surface. Generally the roots are not removed. Tools such as rakes, scythes, or other specialized tools are pulled through the plant beds by boat or several people. This method is not as selective as hand pulling. This method is well suited for small areas near docks and piers. Plant material must be removed from the water. In Wisconsin, hand cutting may be completed outside a designated sensitive area without a permit but is limited to 30 feet of shoreline frontage. Removal of exotic species is not limited to 30 feet.

Advantages: This technique results in immediate clearing of the water column of nuisance plants. Costs are minimal.

Disadvantages: This is also a fairly time-consuming and labor intensive option. Since the technique does not remove the entire plant (leaves root system and part of plant), it may not result in long-term reductions in growth.

Costs: The costs range from minimal for volunteers using hand equipment up to over $1,000 for a hand-held mechanized cutting implement. Hand pulling labor can range from $100 to $400 per hour.

Bottom Barriers

A barrier material is applied over the lake bottom to prevent rooted aquatics from growing. Natural barriers such as clay, silt, and gravel can be used although eventually plants may root in these areas again. Artificial materials can also be used for bottom barriers and anchored to the substrate. Barrier materials include burlap, nylon, rubber, polyethylene, polypropylene, and fiberglass. Barriers include both solid and porous forms. A permit is required to place any fill or barrier structure on the substrate of a water body. This method is well suited for areas near docks, piers, and beaches. Periodic maintenance may be required to remove accumulated silt or rooting fragments from the barrier.

Advantages: This technique does not result in production of plant fragments. Properly installed, it can provide immediate and multiple year relief.

Disadvantages: This is a non-selective option, all plants beneath the barrier will be affected. Some materials are costly and installation is labor intensive. Other disadvantages include limited material durability, gas accumulation beneath the cover, or possible re-growth of plants from above or below the cover. Fish and invertebrate habitat is disrupted with this technique. Anchored barriers can be difficult to remove.

Costs: A 20-foot by 60-foot panel cost $265, while a 30-foot by 50-foot panel cost $375 (this does not include installation costs). Costs for materials vary from $0.15 per square foot ($ft^2$) to over $0.35/ ft^2. The costs for installation range from $0.25 to $0.50/ ft^2. Barriers can cost $20,000 to $50,000 per acre.

Light Limitation

Limiting the available light in the water column can prevent photosynthesis and plant growth. Dark-colored dyes and surface covers have been used to accomplish light limitation. Dyes are effective in shallow water bodies where their concentration can be kept at a desired concentration and loss through dilution is less. This method is well suited for small, shallow water bodies with no outlets such as private ponds.

Surface covers can be a useful tool in small areas such as docks and beaches. While they can interfere with aquatic recreation, they can be timed to produce results and not affect summer recreation uses.

Advantages: Dyes are non-toxic to humans and aquatic organisms. No special equipment is required for application. Light limitation with dyes or covers method may be selective to shade tolerant species. In addition to submerged macrophyte control, it can also control the algae growth.

Disadvantages: The application of water column dyes is limited to shallow water bodies with no outlets. Repeated dye treatments may be necessary. The dyes may not control peripheral or shallow-water rooted plants. This technique must be initiated before aquatic plants start to grow. Covers inhibit gas exchange with the atmosphere.

Costs: Costs for a commercial dye and application range from $100 to $500 per acre.

Mechanical Harvesting

Mechanical harvesters are essentially cutters mounted on barges that cut aquatic plants at a desired depth. Maximum cutting depths range from 5 to 8 feet with a cutting width of 6.5 to 12 feet. Cut plant materials require collection and removal from the water. Conventional harvesters combine cutting, collecting, storing, and transporting cut vegetation into one piece of equipment. Transport barges and shoreline conveyors are also available to remove the cut vegetation. The cut plants must be removed from the water body. The equipment needs are dictated by severity of the aquatic plant problem. Contract harvesting services are available in lieu of purchasing used or new equipment. Trained staff will be necessary to operate a mechanical harvester. To achieve maximum removal of plant material, harvesting is usually completed during the summer months while submergent vegetation is growing to the surface. The duration of control is variable and re-growth of aquatic plants is common. Factors such as timing of harvest, water depth, depth of cut, and timing can influence the effectiveness of a harvesting operation. Harvesting is suited for large open areas with dense stands of exotic or nuisance plant species. Permits are now required in Wisconsin to use a mechanical harvester.

Advantages: Harvesting provides immediate visible results. Harvesting allows plant removal on a larger scale than other options. Harvesting provides flexible area control. In other words, the harvester can be moved to where it is needed and used to target problem areas. This technique has the added benefit of removing the plant material from the water body, and therefore also eliminates a possible source of nutrients often released during fall decay of aquatic plants. While removal of nutrients through plant harvesting has not been quantified, it can be important in aquatic ecosystem with low nutrient inputs.

Disadvantages: Drawbacks of harvesting include limited depth of operation, not selective within the application area, and expensive equipment costs. Harvesting also creates plant fragments, which can be a concern since certain plants have the ability to reproduce whole plants from a plant fragment (e.g., Eurasian watermilfoil). Plant fragments may re-root and spread a problem plant to other areas. Harvesting can have negative effects on non-target plants, young of year fish, and invertebrates. The harvesting will require trained operators and maintenance of equipment. Also, a disposal site or landspreading program will be needed for harvested plants.

Costs: Costs for a harvesting operation are highly variable dependant on program scale. New harvesters range from $40,000 for small machines to over $100,000 for large, deluxe models. Costs vary considerably, depending on the model, size, and options chosen. Specially designed units are available, but may cost more. The equipment can last 10 to 15 years. A grant for half the equipment cost can be obtained from the Wisconsin Waterways Commission, and a loan can be obtained for the remaining capital investment. Operation costs include insurance, fuel, spare parts, and payroll. Historical harvesting values have been reported at $200 up to $1,500 per acre. A survey of recent Wisconsin harvesting operations reported costs to be between $100/acre and $200/acre.

A used harvester can be purchased for $10,000 to $20,000. Maintenance costs are typically higher.

Contract harvesting costs approximately $125/per hour plus mobilization to the water body. Contractors can typically harvest a quarter to a half acre per hour for an estimated cost of $250 to $500/per acre.

Hydroraking/Rototilling

Hydroraking is the use of a boat- or barge-mounted machine with a rake that is lowered to the bottom and dragged. The tines of the rake rip out roots of aquatic plants. Rototilling, or rotovation, also rips out root masses but uses a mechanical rotating head with tines instead of a rake. Harvesting may need to be completed in conjunction with these methods to gather floating plant fragments. This application would best be used where nuisance populations are well established and prevention of stem fragments is not critical. A permit would be required for this type of APM and would only be issued in limited cases of extreme infestations of nuisance vegetation. *In Wisconsin, this method is not permitted by the WDNR.*

Advantages: These methods have the potential for significant reductions in aquatic plant growth. These methods can remove the plant stems and roots, resulting in thorough plant disruption. Hydroraking/rototilling can be completed in "off season" months avoiding interference with summer recreation activities.

Disadvantages: Hydroraking/rototilling are not selective and may destroy substrate habitat important to fish and invertebrates. Suspension of sediments will increase turbidity and can possibly cause algae blooms. These methods can cause floating plant and root fragments, which may re-root and spread the problem. Hydroraking/rototilling are expensive and not likely to be permitted by regulatory agencies.

Costs: Bottom tillage costs vary according to equipment, treatment scale, and plant density. For soft vegetation costs can range from $2,000 to $4,000 per acre. For dense, rooted masses, costs can be up to $10,000 per acre. Contract bottom tillage reportedly ranges from $1,200 to $1,700 per acre (Washington Department of Ecology, 1994).

Suction Dredging

Suction dredging uses a small boat or barge with portable dredges and suction heads. Scuba divers operate the suction dredge and can target removal of whole plants, seeds, and roots. This method may be applied in conjunction with hand cutting where divers dislodge the plants. The plant/sediment slurry is hydraulically pumped to the barge through hoses carried by the diver. Its effectiveness is dependent on sediment composition, density of aquatic plants, and underwater visibility. Suction dredging may be best suited for localized infestations of low plant density where fragmentation must be controlled. A permit will be required for this activity.

Advantages: Diver suction dredging is species-selective. Disruption of sediments can be minimized. These methods can remove the plant stems and roots, resulting in thorough plant disruption and potential longer-term control. Fragmentation of plants is minimized. This activity can be completed near and around obstacles such as piers or marinas where a harvester could not operate.

Disadvantages: Diver suction dredging is labor intensive and costly. Upland disposal of dredged slurry can require additional equipment and costs. Increased turbidity in the area of treatment can be a problem. Release of nutrients and other pollutants can also be a problem.

Costs: Suction dredging costs can be variable depending on equipment and transport requirements for slurry. Costs range from $5,000 per acre to $10,000 per acre.

Dredging

Sediment removal through dredging can work as a plant control technique by limiting light through increased water depth or removing soft sediments that are a preferred habitat to nuisance rooted plants. Soft sediment removal is accomplished with drag lines, bucket dredges, long reach backhoes, or other specialized dredging equipment. Dredging has had mixed results in controlling aquatic plant; however, it can be highly effective in appropriate situations. Dredging is most often applied in a major restructuring of a severely degraded system. Generally, dredging is an activity associated with other restoration efforts. Comprehensive pre-planning will be necessary for these techniques and a dredging permit would be required.

Advantages: Dredging can remove nutrient reserves that result in nuisance rooted aquatic plant growth. Dredging, when completed, can also actually improve substrate and habitat for more desirable species of aquatic plants, fish, and invertebrates. It allows the complete renovation of an aquatic ecosystem. This method has the potential for significant reductions in aquatic plant growth. These methods can be completed during "off season" months, avoiding interference with summer recreation activities.

Disadvantages: Dredging can temporarily destroy important fish and invertebrate habitat. Suspension of sediments usually increases turbidity significantly and can possibly release nutrients causing algae blooms. Dredging is extremely expensive and requires significant planning. Dredged materials may contain toxic materials (metals, PCBs). Dredged material transportation and disposal of toxic materials are additional management considerations and potentially expensive. It could be difficult and costly to secure regulatory permits and approvals.

Costs: Dredging costs depend upon the scale of the project and many other factors. It is generally an extremely expensive option.

Drawdown

Water level drawdown exposes the plants and root systems to prolonged freezing and drying to kill the plants. It can be completed any time of the year; however, it is generally more effective during winter, exposing the lake bed to freezing temperatures. If there is a water level control structure capable of drawdown, it can be an inexpensive way to control some aquatic plants. Aquatic plants vary in their susceptibility to drawdown; therefore, accurate identification of problem species is important. Drawdown is often used for other purposes of improving waterfowl habitat or fishery management but sometimes has the added benefit of nuisance rooted aquatic plant control. This method can be used in conjunction with a dredging project to excavate nutrient-rich sediments. This method is best suited for use on reservoirs or shallow man-made lakes. A drawdown would require regulatory permits and approvals.

Advantages: A drawdown can result in compaction of certain types of sediments and can be used to facilitate other lake management activities such as dam repair, bottom barrier, or dredging projects. Drawdowns can significantly impact populations of aquatic plants that propagate vegetatively. It is inexpensive.

Disadvantages: This method is limited to situations with a water level control structure. Pumps can be used to de-water further if ground-water seepage is not significant. This technique may also result in the removal of beneficial plant species. Drawdowns can decrease bottom dwelling invertebrates and overwintering reptiles and amphibians. Drawdowns can affect adjacent wetlands, alter downstream flows, and potentially impair well production. Drawdowns and any water level manipulation are often highly controversial since shoreline landowners' access and public recreation are limited during the drawdown. Fish populations are vulnerable during a drawdown due to over-harvesting by fisherman in decreased water volumes.

Costs: If a suitable outlet structure is available then costs should be minimal. If dewatering pumps would be required or additional management projects such as dredging are completed, additional costs would be incurred. Other costs would include recreational losses and perhaps loss in tourism revenue.

Chemical Controls

Using chemical herbicides to kill nuisance aquatic plants is the oldest APM method. However, past pesticide uses being linked to environmental or human health problems have led to public wariness of chemicals in the environment. Current pesticide registration procedures are more stringent than in the past. While no chemical pesticide can be considered 100 percent safe, federal pesticide regulations are based on the premise that if a chemical is used according to its label instructions, it will not cause adverse environmental or human health effects.

Chemical herbicides for aquatic plants can be divided into two categories: systemic and contact herbicides. Systemic herbicides are absorbed by the plant, translocated throughout the plant, and are capable of killing the entire plant including the roots and shoots. Contact herbicides kill the plant surface with which it comes in contact, leaving roots capable of re-growth. Aquatic herbicides exist under various trade names, causing some confusion. Aquatic herbicides include the following.

- Endothall-Based Herbicide
- Diquat-Based Herbicide
- Fluridone-Based Herbicide
- 2-4 D-Based Herbicide
- Glyophosate-Based Herbicide
- Triclopyr-Based Herbicide
- Phosphorus Precipitation

Each of these methods is described below. The costs, benefits, and drawbacks of each chemical APM alternative are provided.

Endothall-Based Herbicide

Endothall is a contact herbicide, attacking a wide range of plants at the point of contact. The chemical is not readily transferred to other plant tissue; therefore, re-growth can be expected and repeated treatments may be needed. It is sold in liquid and granular forms under the trade names of Aquathol K*, Aquathol*, or Hydrothol*. Hydrothol* is also an algaecide. Most endothall products break down easily and do not remain in the aquatic environment. Endothall products can result in plant reductions for a few weeks to several months. Multi-season effectiveness is not typical. A permit is required for use of this herbicide.

Advantages: Endothall products work quickly and exhibit moderate to highly effective control of floating and submersed species. This herbicide has limited toxicity to fish at recommended doses.

Disadvantages: The entire plant is not killed when using endothall. Endothall is non-selective in the treatment area. High concentrations can kill fish easily. Water use restrictions (time delays) are necessary for recreation, irrigation, and fish consumption after application.

Costs: Costs vary with treatment area and dosage. Average costs for chemical application range between $400 and $700 per acre.

Diquat-Based Herbicide:

Diquat is a fast-acting contact herbicide effective on a broad spectrum of aquatic plants. It is sold under the trade name of Reward®. Diluted forms of this product are also sold as private label products. Since diquat binds to sediments readily, its effectiveness is reduced by sediment suspended waters. Multi-season effectiveness is not typical. A permit is required for use of this herbicide.

Advantages: Diquat works quickly and exhibit moderate to highly effective control of floating and submersed species. This herbicide has limited toxicity to fish at recommended doses.

Disadvantages: The entire plant is not killed when using diquat. Diquat is non-selective in the treatment area. Diquat can be inactivated by suspended sediments. Diquat is sometimes toxic to zooplankton at the recommended dose. Limited water used restrictions (water supply, agriculture, and contact recreation) are required after application.

Costs: Costs vary with treatment area and dosage. A general cost estimate for treatment is between $200 and $500 per acre.

Fluridone-Based Herbicide

Fluridone is a slow-acting systemic herbicide that is effectively absorbed and translocated by both plant roots and stems. Sonar® or Avast® are the trade names and are sold in liquid or granular form. Fluridone requires a longer contact time and demonstrates delayed toxicity to target plants. Watermilfoil is more susceptible to fluridone than other aquatic plants. This allows a semi-selective approach when low enough doses are used. Since the roots are also killed, multi-season effectiveness can be achieved. It is best applied during the early growth phase of the plants. *Fluridone-based aquatic herbicides are not currently permitted for use in Wisconsin.*

Advantages: Fluridone is capable of killing roots, thereby producing a longer lasting effect than other herbicides. A variety of emergent and submersed aquatics are susceptible to this herbicide. Fluridone can be used selectively based on concentration. A gradual killing of target plants limits severe oxygen depletion from dead plant material. It has demonstrated low toxicity to aquatic fauna such as fish and invertebrates. 3- to 5-year control has been demonstrated. Extensive testing has shown that, when used according to label instructions, it does not pose negative health affects.

Disadvantages: Fluridone is a slow-acting herbicide sometimes taking up to several months for visible effects. It requires a long contact time. Fluridone is extremely soluble and mixable; therefore, not effective in flowing water situations or for treating a select area in a large open lake. Impacts on non-target plants are possible at higher doses. Time delays are necessary on use of the water (water supply, irrigation, and contact recreation) after application.

Costs: Costs vary with treatment area and dosage. Treatment costs range from $500 to $2,000 per acre.

2,4-D-Based Herbicide

2,4-D-based herbicides are sold in liquid or granular forms under various trade names. It is a systemic herbicide that affects broad leaf plants. It has been demonstrated effective against Eurasian watermilfoil, but it may not work on many aquatic plants. Since the roots are also killed, multi-season effectiveness may be achieved. It is best applied during the early growth phase of the plants. Visible results are evident within 10 to 14 days. A permit is required for use of this herbicide.

Advantages: 2,4-D is capable of killing roots, thereby producing a longer lasting effect than some other herbicides. It is fairly fast and somewhat selective based on application timing and concentration. 2,4-D-containing products are moderately to highly effective on a few emergent, floating, or submersed plants.

Disadvantages: 2,4-D can have variable toxicity effects to aquatic fauna, depending on formulation and water chemistry. 2,4-D lasts only a short time in water but can be detected in sediments for months after application. Time delays are necessary on use of the water (agriculture and contact recreation) after application. The label does not permit use of this product in water used for drinking, irrigation, or livestock watering.

Costs: Costs vary with treatment area and dosage. Treatment costs range from $300 to $800 per acre.

Glyophosate-Based Herbicide

Glyophosate has been categorized as both a contact and a systemic herbicide. It is applied as a liquid spray and sold under the trade name Rodeo® or Pondmaster®. It is a non-selective, broad-based herbicide effective against emergent or floating leaved plants but not submergents. Its effectiveness can be reduced by rain. A permit is required for use of this herbicide.

Advantages: Glyophoshate is moderately to highly effective against emergent and floating-leaf plants resulting in rapid plant destruction. Since it is applied by spraying plants above the surface, the applicator can apply it selectively to target plants. Glyophosate dissipates quickly from natural waters, has a low toxicity to aquatic fauna, and carries no restrictions or time delays for swimming, fishing, or irrigation.

Disadvantages: Glyophoshate is non-selective in the treatment area. Wind can dissipate the product during the application, reducing its effectiveness and causing damage to non-target organisms. Therefore, spray application should only be completed when wind drift is not a problem. This compound is highly corrosive; therefore, storage precautions are necessary.

Costs: Costs average $500 to $1,000 per acre depending on the scale of treatment.

Triclopyr-Based Herbicide

Triclopyr is a systemic herbicide. It is registered for experimental aquatic use in selected areas only. It is applied as a liquid spray or injected into the subsurface as a liquid. Triclopyr has shown to be an effective control to many floating and submersed plants. It has been demonstrated to be highly effective against

Eurasian watermilfoil, having little effect on valued native plants such as pondweeds. Triclopyr is most effective when applied during the active growth period of younger plants.

Advantages: This herbicide is fast acting. Triclopyr can be used selectively since it appears more effective against dicot plant species, including several difficult nuisance plants. Testing has demonstrated low toxicity to aquatic fauna.

Disadvantages: At higher doses, there are possible impacts to non-target species. There is a time delay of 30 days for fish consumption from treated areas. *This herbicide is experimental for aquatic use and restrictions on use of the treated water are not yet certain.*

Biological Controls

There has been recent interest in using biological technologies to control aquatic plants. This concept stems from a desire to use a "natural" control and reduce expenses related to equipment and/or chemicals. While use of biological controls is in its infancy, potentially useful technologies have been identified and show promise for integration with physical and chemical APM strategies. Several biological controls that are in use or are under experimentation include the following.

- Herbivorous Fish
- Herbivorous Insects
- Plant Pathogens
- Native Plants

Each of these methods is described below. The costs, benefits, and drawbacks of each biologic APM method are provided.

Herbivorous Fish

An herbivorous fish, such as the non-native grass carp, can consume large quantities of aquatic plants. These fish have high growth rates and a wide range of plant food preferences. Stocking rates and effectiveness will depend on many factors, including climate, water temperature, type and extent of aquatic plants, and other site-specific issues. Sterile (triploid) fish have been developed resulting in no reproduction of the grass carp and population control. This technology has demonstrated mixed results and is most appropriately used for lake-wide, low intensity control of submersed plants. Some states do not allow stocking of herbivorous fish. *In Wisconsin, stocking of grass carp is prohibited.*

Advantages: This technology can provide multiple years of aquatic plant control from a single stocking. Compared to other long-term aquatic plant control techniques such as bottom tillage or bottom barriers, costs may be relatively low.

Disadvantages: Sterile grass carp exhibit distinct food preferences, limiting their applicability. Grass carp may feed selectively on the preferred plants while less preferred plants, including milfoil, may increase. The effects of using grass carp may not be immediate. Overstocking may result in an impact on non-target plants or eradication of beneficial plants, altering lake habitat. Using grass carp may result in algae blooms and increased turbidity. If precautions are not taken (i.e., inlet and outlet control structures to prevent fish migration), the fish may migrate and have adverse effects on non-target vegetation.

Costs: Costs can range from \$50/acre to over \$2,000/acre at stocking rates of five fish/acre to two hundred fish/acre.

Herbivorous Insects

Non-native and native insect species have been used to control rooted plants. Using herbivorous insects is intended to selectively control target species. These aquatic larvae of moths, beetles, and thrips use specific host aquatic plants. Several non-native species have been imported under USDA approval and used in integrated pest management programs, a combination of biological, chemical, and mechanical controls.

These non-native insects are being used in southern states to control nuisance plant species and appear climate-limited, their northern range being Georgia and North Carolina. While successes have been demonstrated, non-native species have not established themselves for solving biological problems, sometimes creating as many problems as they solve. Therefore, government agencies prefer alternative controls.

Native insects such as the larvae of midgeflies, caddisflies, beetles, and moths may be successful APM controls in northern states. Recently, however, the native aquatic weevil *Euhrychiopsis lecontei* has received the most attention. This weevil has been associated with native northern water milfoil. The weevil can switch plant hosts and feed on Eurasian watermilfoil, destroying its growth points. *While the milfoil weevil is gaining popularity, it is still experimental.*

Advantages: Herbivorous insects are expected to have no negative effects on non-target species. The insects have shown promise for long-term control when used as part of integrated aquatic plant management programs. The milfoil weevils do not use non-milfoil plants as hosts.

Disadvantages: Natural predator prey cycles indicate that incomplete control is likely. An oscillating cycle of control and re-growth is more likely. Fish predation may complicate controls. Large numbers of milfoil weevils may be required for a dense stand and can be expensive. The weevil leaves the water during the winter, may not return to the water during the spring, and are subject to bird predation in their terrestrial habitat. Application is manual and extremely time consuming. Introducing any species, especially non-native ones, into an aquatic ecosystem may have undesirable effects. Therefore, it is extremely important to understand the life cycles of the insects and the host plants.

Costs: Reported costs of herbivorous insects rang from \$300/acre to \$3,000/acre. Specifically, the native milfoil weevils cost approximately \$1 per weevil. It is generally considered appropriate to use five to seven weevils per stem. Dense stands of milfoil may contain one to two million stems per acre. Therefore, costs of this new technology are currently prohibitive.

Plant Pathogens

Using a plant pathogen to control nuisance aquatic plants has been studied for many years; however, *this practice still remains largely experimental.* Fungi are the most common pathogens, while bacteria and viruses have also been used. There is potential for highly specific plant applications.

Advantages: Plant pathogens may be highly species-specific. They may provide substantial control of a nuisance species.

Disadvantages: Pathogens are experimental. The effectiveness and longevity of control is not well understood. Possible side effects are also unknown.

Costs: These techniques are experimental; therefore, a supply of specific products and costs are not established.

Native Plants

This method involves removing the nuisance plant species through chemical or physical means and re-introducing seeds, cuttings, or whole plants of desirable species. Success has been variable. When using seeds, they need to be planted early enough to encourage the full growth and subsequent seed production of those plants. Transplanting mature plants may be a better way to establish seed producing populations of desirable aquatics. Recognizing that a healthy, native, desirable plant community may be resistant to infestations of nuisance species, planting native plants should be encouraged as an APM alternative. Non-native plants can not be translocated.

Advantages: This alternative can restore native plant communities. It can be used to supplement other methods and potentially prevent future needs for costly repeat APM treatments.

Disadvantages: While this appears to be a desirable practice, it is experimental at this time and there are not many well-documented successes. Nuisance species may eventually again invade the areas of native plantings. Careful planning is required to ensure that the introduced species do not themselves become nuisances. Hand planting of aquatic plants is labor intensive.

Costs: Costs can be highly variable depending on the selected native species, numbers of plants ordered, and the nearest dealer location.

Aquatic Plant Prevention

The phrase "an ounce of prevention is worth a pound of cure" certainly holds true for APM. Prevention is the best way to avoid nuisance aquatic plant growth. Prevention of the spread of invasive aquatic plants must also be achieved. Inspecting boats, trailers, and live wells for live aquatic plant material is the best way to prevent nuisance aquatic plants from entering a new aquatic ecosystem. Protecting the desirable native plant communities is also often important to maintain a healthy aquatic ecosystem and preventing the spread of nuisance aquatics once they are present.

Prolific growth of nuisance aquatic plants can be prevented by limiting nutrient (i.e., phosphorus) inputs to the water body. Aeration or phosphorus precipitation can achieve controls of in-lake cycling of phosphorus;

however, if there are additional outside sources of nutrients, these methods will be largely ineffective in controlling algae blooms or intense aquatic macrophyte infestations. Watershed management activities to control nutrient-laden storm-water runoff are critical to controlling excessive nutrient loading to the water bodies. Nutrient loading can be prevented/minimized by the following:

- Shoreline buffers
- Using non-phosphorus fertilizers on lawns
- Settling basins for storm water effluents

Northern Environmental℠
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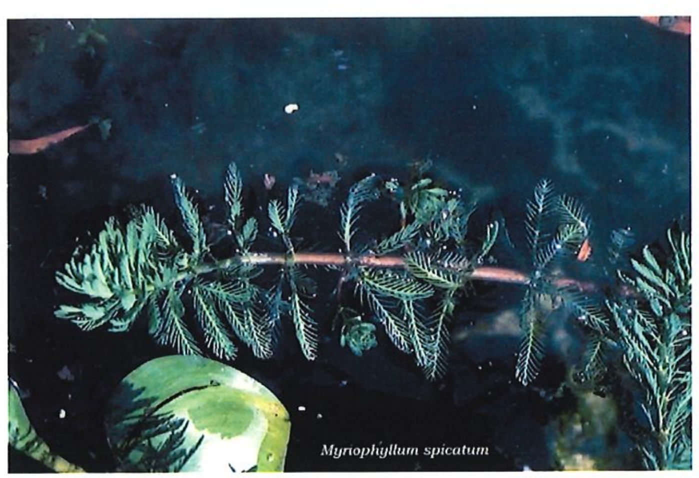
APPENDIX D

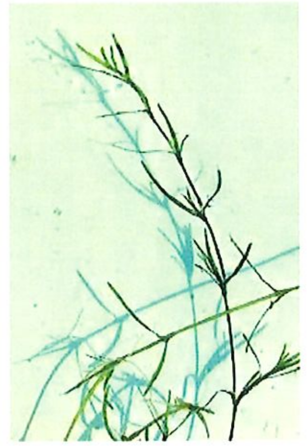
PHOTOGRAPHS OF AQUATIC PLANTS IN WILKE LAKE

Chara spp

Northern Watermilfoil *(Myriophyllum sibiricum)*



Eurasian Watermilfoil *(Myriophyllum spicatum)*



Slender naiad ***(Najas flexilis)***

Spatterdock ***(Nuphar variegata)***

White Water Lily ***(Nymphaea odorata)***

Large-leaf Pondweed
(Potamogeton amplifolius)

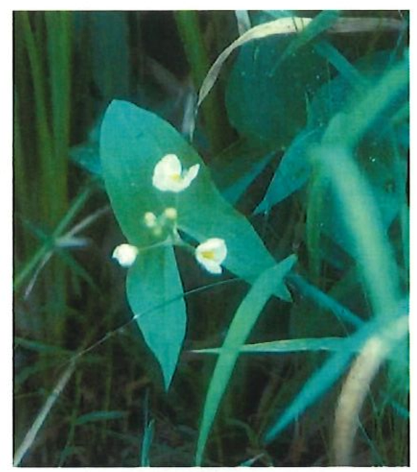
Curlyleaf Pondweed
(Potamogeton crispus)

Water-thread Pondweed
(Potamogeton diversifolius)

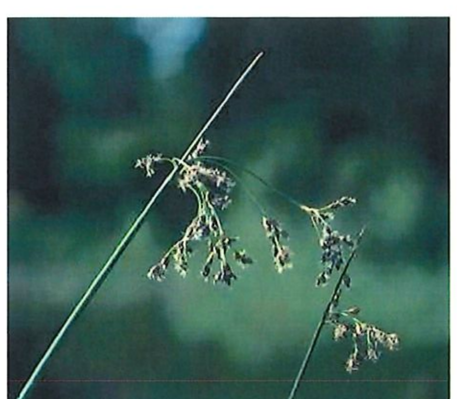
Illinois Pondweed
(Potamogeton illinoensis)

Floating-leaf Pondweed
(Potamogeton natans)

Sago Pondweed
(Potamogeton pectinatus)



Arrowhead
(Sagittaria spp.)



Bulrush
(Scripus spp.)

Broad-leaved Cattail
(Typha latifolia)