

**AQUATIC PLANT SURVEY RESULTS
LAKE PUCKAWAY
MAXIM PROJECT NO. 1155340219**

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1.0 INTRODUCTION AND SCOPE OF SERVICES

Maxim Technologies was retained by the Lake Puckaway Protection and Rehabilitation District (PRD) to perform services related to an aquatic plant survey for Lake Puckaway. Lake Puckaway is located in Green Lake County, east of the City of Montello.

The objective of the survey was to establish a baseline aquatic plant condition for Lake Puckaway, from which appropriate management techniques may be implemented and evaluated.

1.1 SCOPE OF SERVICES

The scope of services performed for the aquatic plant survey included the following activities:

- General site survey of Lake Puckaway
- Perimeter mapping of emergent/floating leaf species stands
- Aquatic plant survey utilizing the line-point intercept method
- Plant vouchering and preparation of plant collection
- Sediment type and depth sampling
- Attendance and assistance at public meetings
- Preparation of a final report detailing the study and the results, including maps based on Geographic Information Systems (GIS)

2.0 SITE LOCATION, DESCRIPTION AND PROJECT PURPOSE

Lake Puckaway is an approximately 5,038 acre lake with approximately 28 miles of shoreline, located in Green Lake County, T15N, R11&12E, Sections 17-33. Lake Puckaway is a shallow water lake with a maximum depth of 6 ½ feet. The Fox River flows through Lake Puckaway. A dam is located on the Fox River approximately eight miles downstream at Princeton. The dam raises the lake approximately 24 inches.

2.1 PROJECT PURPOSE

The project purpose is to complete a comprehensive aquatic plant survey of the lake utilizing the point-intercept method. The Lake Puckaway PRD approved a comprehensive lake management plan in June, 2004. Eight management goals were identified as key goals to promote the health of Lake Puckaway. Goal 3 was to monitor, maintain and improve healthy beds of native aquatic plant and coordinate the management of invasive non-native plants. To achieve this goal, an aquatic plant survey was to be completed to establish a baseline plant condition. A terminology and definitions section is included in Appendix A.

3.0 METHODS

Maxim Technologies biologists and Lake Puckaway volunteers conducted the field work on July 25-July 28, August 1-3 and August 10, 2005.

The comprehensive aquatic plant survey was completed utilizing a general lake survey, identifying emergent and floating-leaf communities and the point-intercept method. The general site survey was conducted by boating the lake, recording and identifying all plant species observed within Lake Puckaway and mapping plant occurrence and communities on a general basis. Emergent and floating-leaf plant communities were mapped utilizing a Trimble Global Positioning System (GPS) unit (Appendix B, Photo

13). Plant species within the stands were identifying and recorded. The aquatic plant survey included areas 300 meters up any inlets and 300 meters down any outlets. The sampling resolution was 225 meters for a total of 507 sample points (Figure 1). Locational data of each survey point was collected using a Trimble GPS with a nominal accuracy of 1 meter or less. One rake toss was conducted at each site. Plant species were recorded and an abundance rating of 0 to 5 was given per Department of Natural Resources (DNR) Recommended Baseline Monitoring of Aquatic Macrophytes, (April 2005). Photographic documentation of the abundance rating is included in Appendix C. A representative specimen of all identified plant species was vouchered and identification will be verified as all plant species were sent to the University of Wisconsin-Stevens Point Herbarium for documentation. A plant collection was given to the Lake Puckaway PRD for educational purposes. Water depths were taken at each sample point and are depicted in Figure 2.

The floristic quality index (FQI) was determined by multiplying the square root of the number of species present (N) by the mean of the floristic value of each species, C. Each aquatic plant in Wisconsin has been assigned a C value based on the plant quality. For example, a common aquatic plant in Wisconsin, common waterweed (*Elodea canadensis*) has a C value of 3 while a less common aquatic plant, grass-leaved arrowhead (*Sagittaria graminea*) has a C value of 9. The Simpson Diversity Index is a measure of species richness. A high value of D (diversity index) suggests a stable and undisturbed site and a low D value could suggest pollution, invasive species occurrence and agricultural influence. The index was calculated as follows; $D = N(N - 1) / n(n - 1)$.

Sediment samples were taken at each sample point and the sediment types are depicted in Figure 3. Sediment depths were observed by pushing a measured pole into the lake bottom (Appendix B, Photo 12).

4.0 RESULTS

4.1 GENERAL LAKE SURVEY

The general lake survey consists of visual observations of the aquatic plant community of Lake Puckaway. All plant species are photographed and are included in Appendix D. Table 1 lists the plant species in abundance order.

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE RANKING*
Wild celery	<i>Vallisneria americana</i>	1
Sago pondweed	<i>Stuckenia pectinatus</i>	2
Common waterweed	<i>Elodea canadensis</i>	3
Bushy pondweed	<i>Najas flexilis</i>	4
Coontail	<i>Ceratophyllum demersum</i>	5
White water lily	<i>Nymphaea odorata</i>	6
Flat-stem pondweed	<i>Potamogeton zosteriformis</i>	7
Lotus	<i>Nelumbo lutea</i>	8
Clasping-leaf pondweed	<i>Potamogeton richardsonii</i>	9
Spatterdock	<i>Nuphar variegata</i>	10

**TABLE 1 (CONTINUED)
AQUATIC PLANTS ABUNDANCE**

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE RANKING*
Wild rice	<i>Zizania palustris</i>	11
Grass-leaved arrowhead	<i>Sagittaria graminea</i>	11
Floating-leaf pondweed	<i>Potamogeton natans</i>	12
Softstem bulrush	<i>Scirpus validus</i>	13
Giant reed	<i>Phragmites australis</i>	14
Forked duckweed	<i>Lemna trisulca</i>	15
Narrow-leaved cattail	<i>Typha angustifolia</i>	16
Reed canary grass	<i>Phalaris arundinacea</i>	17
Large-leaf pondweed	<i>Potamogeton amplifolius</i>	17
Curly-leaf pondweed	<i>Potamogeton crispus</i>	17
Northern water milfoil	<i>Myriophyllum sibiricum</i>	18
Eurasian water milfoil	<i>Myriophyllum spicatum</i>	18
Muskgrass	<i>Chara spp</i>	19

*Abundance ranking determined by frequency of occurrence

4.2 EMERGENT AND FLOATING LEAF PLANTS

Emergent and floating leaf plant beds were identified and mapped to depict their present location and size. General observations included the presence of emergent plants and floating leaf plants near the west shore and the Dead River area, adjacent to the Dredge Bank, Haystack Point, Bluebill Bay, Squaw Island and other small beds as depicted on Figure 4. The total acreage of emergent and floating leaf plants is 560 or approximately 11% of Lake Puckaway. Table 2 shows the named plant beds and their associated acreages. Photographs of the identified plant beds are included in Appendix B. These plant communities are highly variable and their size should be considered a result of the conditions of the growing season, including water clarity and water levels.

**TABLE 2
EMERGENT AND FLOATING LEAF PLANT BEDS**

PLANT BED ID	DOMINANT VEGETATION	ACREAGE
1	lotus, wild rice, spatterdock, white water lily, softstem bulrush & arrowhead	237
2	lotus, wild rice, spatterdock, white water lily, softstem bulrush & arrowhead, <i>Phragmites</i> (cane)	117
3	<i>Phragmites</i> (cane)	48
4	lotus, wild rice, spatterdock, white water lily, softstem bulrush, arrowhead, floating leaf pondweed, narrow-leaved cattails	111

TABLE 2 (CONTINUED)
EMERGENT AND FLOATING LEAF PLANT BEDS

PLANT BED ID	DOMINANT VEGETATION	ACREAGE
5	<i>Phragmites</i> (cane), softstem bulrush	10
6	<i>Phragmites</i> (cane), softstem bulrush	5
7	Lotus, white water lily, spatterdock, arrowhead, wild rice	32

4.3 AQUATIC PLANT SURVEY

Submergent plants were observed in water generally less than three feet in depth. Figure 5 depicts the extent of submergent plant coverage of Lake Puckaway. The maximum depth of water where aquatic plants were observed was 6 feet. The average number of species per sample site was 1. As depicted in Figure 5, the aquatic plant community is limited to near-shore areas and areas of low water.

Wild celery (*Vallisneria americana*), is the dominant aquatic plant observed in Lake Puckaway. The relative frequency of wild celery is 17.3%, occurring in 91 sample sites throughout the lake. However, of the 161 sites where aquatic plants were found, the frequency of occurrence of wild celery occurred 56.5% of the time. The leaves are ribbon-like with a distinct stripe in the central portion. The leaves grow from a cluster anchored in the lakebed. The female flowers rise to the surface on spiral-coiled stalks (Appendix D, Photo 3). Wild celery grows mostly underwater with the leaf tips lying on the water surface (Appendix B, Photos 1 & 2). Wild celery is an important waterfowl food source, especially for canvasback ducks. Beds of wild celery also provide habitat for shorebirds, such as herons and egrets as well as fish habitat. Wild celery also absorbs and dampens wave and wind energy, thus reducing shoreline erosion. The Lake Puckaway PRD actively managed wild celery in the 1980s by planting tubers gathered from the Mississippi River.

Other species of aquatic plants commonly found in Lake Puckaway include coontail (*Ceratophyllum demersum*), common waterweed (*Elodea canadensis*), sago pondweed (*Stuckenia pectinata*), lotus (*Nelumbo lutea*), white water lily (*Nymphaea odorata*), bushy pondweed (*Najas flexilis*), and flat-stem pondweed (*Potamogeton zosteriformis*). The common species listed above represent a diverse aquatic plant community of native species.

The Floristic Quality Index (FQI) for Lake Puckaway is 24.65. The higher an FQI value, the greater the diversity of the native plant community is. According to the WDNR (2005) the median FQI for lakes within the State of Wisconsin is 22.2. The FQI value of an aquatic plant community is valuable to assess changes in the diversity and quality of the plant community over time. The specific statistics are included in Appendix E. The Simpson Diversity Index for Lake Puckaway is 0.89. The Simpson Diversity Index is an estimator of community heterogeneity. The closer the Simpson Diversity Index is to 1, the more diverse the community.

Aquatic Invasive Species

Two species of aquatic invasive species were observed in Lake Puckaway. Curly-leaf pondweed (CLP) (*Potamogeton crispus*) was found at three sites out of 507 sample sites. Eurasian water milfoil (EWM) (*Myriophyllum spicatum*) was found at eight sites. Figure 6 depicts the location of CLP and EWM. These species rank 17 and 18, respectively, out of 24 different species present, in abundance ranking. These communities should be closely monitored for any changes in size, abundance and distribution.

EWM is an exotic plant originating from Europe and Asia. EWM has long, limp stems that branch repeatedly at the water's surface. The leaves are finely divided like a feather with thread-like leaflets in pairs of 14-20. The leaf divisions resemble the bones of a fish. EWM does not produce winter buds but does reproduce by fragmentation. EWM leaflets can begin to form adventitious roots and root. EWM can form dense mats on the surface of the water inhibiting navigation and water movement. Management efforts in Wisconsin have included mechanical harvesting, chemical treatment and biological controls. Seven other native species of milfoil exist in Wisconsin and EWM can easily be confused with these native species. Coontail, (Appendix D, Photo 4) is also commonly confused with EWM.

CLP is an exotic plant species originating from Europe. CLP has slightly flattened stems with oblong leaves with wavy edges and finely serrated leaf margins (Appendix D, Photo 2). It is most commonly confused with clasping-leaf pondweed (Appendix D Photo 17). CLP produces vegetative buds called turions that look like small, brown pine cones on shortened branches along the stem. CLP is a unique plant because of its growth pattern. It grows under the ice, thus becoming the first plant present during the spring and early summer months. CLP dies in mid-July, while other plants are reaching their peak growth. The decaying CLP releases its nutrients into the water column where nutrients such as phosphorus become available for other aquatic plants and/or algae. The turions of CLP lie dormant until the water cools in autumn and falls below 75°F. After the water reaches this temperature, the turions germinate to produce winter foliage. It is these turions that pose a major challenge in controlling CLP through mechanical or chemical means.

4.4 SEDIMENT SAMPLING

The dominant sediment types observed in Lake Puckaway are muck and sand. Muck is defined as an organic soil or material. Muck was observed in 59% of the lake and sand is observed in 40% of the lake, as depicted in Figure 3. The remainder of the lake bottom is covered by rock (1%). The average sediment depth was 0.5 feet. Figure 7 depicts the sediment depths found in the lake.

4.5 SHORELAND WETLANDS

Shoreland wetland plant communities were observed from the water due to difficulties with access. These areas were characterized based on general visual observation. Plants observed within these areas include reed canary grass, wild rice, *Phragmites*, cattails, willows, stinging nettle and blue vervain.

A portion of Lake Puckaway was not surveyed due to low water conditions. This portion of the lake is located east of Squaw Island. The water levels at the time of the survey were less than six inches with two feet or more of organic muck, restricting navigation. The aquatic plant community in this area was generally observed to include spatterdock, white water lily, coontail and sago pondweed.

5.0 CONCLUSIONS

The following are the results of the aquatic plant survey:

- Wild celery (*Vallisneria americana*), is the dominant aquatic plant in Lake Puckaway
- 23 species of aquatic plants were observed in Lake Puckaway
- Emergent and floating-leaf aquatic plant beds total 560 acres or 11% of Lake Puckaway
- The FQI for Lake Puckaway is 24.65
- The Simpson Diversity Index is 0.89
- EWM was found at 8 sample points in Lake Puckaway
- CLP was found at 3 sample points in Lake Puckaway

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APPENDIX A
TERMINOLOGY & DEFINITIONS

TERMINOLOGY AND DEFINITIONS

- 1) **Emergent aquatic plant community** - an emergent aquatic plant community can be defined as a plant community in which the plants emerge or grow above the surface of the water. Emergent aquatic plants are rooted with the majority of the vegetative portion of the plant above the surface of the water. They provide a variety of benefits including habitat for fish, furbearers, waterfowl, shorebirds and aquatic insects. Beds of emergent plants reduce wave energy caused by wind or motor boats, thus reducing shoreline erosion. Common emergent aquatic plants found in Lake Puckaway include *Phragmites* (cane), bulrush, cattail, arrowhead and wild rice.
- 2) **Floating-leaf aquatic plant community** - a floating leaf aquatic plant community can be defined as a plant community in which the majority of the vegetative portion of the plant (usually the leaf) lies on the surface of the water. They provide a variety of benefits including habitat for fish, waterfowl, shorebirds and aquatic insects. Beds of floating-leaf plants reduce wave energy caused by wind or motor boats, thus reducing shoreline erosion. Common floating-leaf aquatic plants found in Lake Puckaway include white water lily, spatterdock and lotus.
- 3) **Point-intercept method** - the point-intercept method is a sampling protocol in which the location and number of sample points is determined by establishing a grid pattern for a specific lake based on the size of the lake and complexity of the shoreline. The distance from each sample point is termed the sampling resolution. Each sample point is equal distance from another point. For example, the sampling resolution for Lake Puckaway was 225 meters spacing between each sample point.
- 4) **Relative frequency** - relative frequency can be defined as the frequency of a species divided by the sum of the decimal frequencies of all species. The sum of all frequencies should equal 100 percent. This statistic presents an indication of how the plants occur throughout a lake in relation to each other.
- 5) **Frequency of occurrence-frequency** - of occurrence can be defined as the number of times a species was observed, divided by the total number of sampling points.
- 6) **Floristic Quality Index (FQI)** - the FQI can be defined as an indicator of a lake quality. This value is helpful in comparing lakes around the state or comparing a single lake's plant community over time.
- 7) **Simpson Diversity Index** - is an estimator of community heterogeneity. It is based on relative frequency. The closer the Simpson Diversity Index is to 1, the more diverse the community.
- 8) **Heterogeneity** - heterogeneity can be defined for the purpose of this report diverse or mixed aquatic plant community
- 9) **Aquatic invasive species** - aquatic invasive species are defined in NR 198.12(1) "Aquatic invasive species" means non-indigenous water or wetland-dwelling organisms or their hybrids whose introduction into aquatic ecosystems causes or is likely to cause adverse economic, recreational or environmental impacts or harm to human health. Common aquatic invasive plant species include Eurasian watermilfoil (EWM) and Curly-leaf pondweed (CLP), both of which occur in Lake Puckaway.



APPENDIX B
LAKE PLANT PHOTOS



APPENDIX C

PLANT ABUNDANCE RANKING PHOTOS



APPENDIX D
PRESERVED PLANT PHOTOS



APPENDIX E
STATISTICS SUMMARY