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AQUATIC PLANT MANAGEMENT PLAN
&
AQUATIC INVASIVE SPECIES PREVENTION & CONTROL PLAN

CROOKED, BASS & GILKEY LAKES
OCONTO COUNTY, WISCONSIN

January 10, 2007

Prepared for:

Crooked Lake Protection & Rehabilitation District
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1.0 EXECUTIVE SUMMARY

Crooked, Bass and Gilkey Lakes (the Lakes) are a small chain of three lakes located in the Town of Riverview, Oconto County, Wisconsin (Figure 1). Crooked Lake is 143 acres, Gilkey Lakes covers 18 acres and Bass Lakes totals 32 acres. Recreational boating, waterskiing and fishing are popular on the Lakes. The Lakes exhibits good water quality but experience periods of dense aquatic plant growth. The aquatic plants on the lake provide important habitat for fish and wildlife, but dense plant growth has historically been a nuisance condition, interfering with recreation on the lake (e.g. boat navigation). The District currently operates one aquatic plant harvester to address nuisance plant growth on the lake and developed an Aquatic Plant Management (APM) Plan to obtain a harvesting permit from the Wisconsin Department of Natural Resources (WDNR). Aquatic invasive species (AIS) are also a concern on the Lakes as Eurasian water milfoil (EWM) is present in all three lakes. To address AIS concerns, the District has developed an AIS Prevention and Control Plan as a component of the APM plan.

Water quality data collected between 1993 and 2006 indicate a mesotrophic to olgiotrophic lake system. Nutrients from within the lake and from watershed land uses are likely enhancing aquatic plant growth. During summer 2006, aquatic plant surveys were completed on the Lakes. The Lakes were visually surveyed in June 2006 during a reconnaissance survey for curly-leaf pondweed (*Potamogeton crispus*). Curly-leaf pondweed was not observed during the June visual plants survey. A total of 32 plant species and 3 algal species were observed during the July 2006 plant survey. The most abundant aquatic plant observed in Bass and Crooked Lakes was fern pondweed *(Potamogeton robbinsii)*. The most abundant aquatic plant in Gilkey Lake was white water lily *(Nymphaea odorata)*. EWM was observed in all three lakes, with the highest frequency and abundance occurring in Crooked Lake.

The District has prepared a comprehensive APM Plan to manage nuisance aquatic plant growth on the Lakes which includes the following components.

Manual Removal:	Individual property owners can manually remove nuisance aquatic plants in the lake offshore from their property to a maximum width of 30 feet to provide pier or swimming raft access.
Harvesting:	The District will continue mechanical harvesting for navigation purposes in accordance with the conditions of a WDNR-issued harvesting permit.
Chemical Herbicide:	The District has established a program to apply aquatic herbicides to control EWM and prevent its spread to other parts of the Lakes. Herbicide applications will be in accordance with the conditions of the WDNR-issued permit.

In addition to the comprehensive APM plan, the District developed an AIS Prevention and Control Plan which includes the following components

Clean Boats, Clean Waters:	The District will continue to implement a boat launch monitoring program following the guidelines of the WDNR Clean Boats, Clean Waters (CBCW) program.
Annual monitoring for AIS:	The District will establish an annual monitoring program with trained volunteers to document EWM locations in all three lakes and to monitor the success of any EWM control methods.
Education and Information:	The District will prepare and gather education and information materials and/or speakers for the annual meeting. The goal will be to further educate District members on the subject of AIS.

2.0 INTRODUCTION

Crooked, Bass and Gilkey Lakes (the Lakes) are located in the Town of Riverview in Oconto County, Wisconsin. Figure 1 depicts the lake location [United States Geological Survey (USGS) 1982]. The Lakes provides year around activities ranging from, fishing, swimming, non-motorized boating (kayaking, sailing), motorized boating activities (jet boating, speed boating, wake boarding, water skiing, pontoon), snowmobiling, and ice fishing.

The Lakes exhibit good water quality but in some locations dense aquatic plant growth inhibits recreation. Additionally, aquatic invasive species (AIS) are present, specifically Eurasian Water Milfoil (EWM). While the aquatic plants on the lake provide important habitat for fish and wildlife, dense aquatic plant growth on the Lakes has historically interfered with recreation on the lake (e.g. boat navigation). In response to the lake users concerns, the District has operated an aquatic plant harvesting program. Recent changes in Wisconsin's aquatic plant management laws and the subsequent Wisconsin Department of Natural Resources' (WDNR) administration of their aquatic plant management program (NR 109 Wis. Adm. Code) required that the District develop an Aquatic Plant Management Plan (APM Plan). In addition to the APM plan, an AIS Prevention and Control Plan was developed to address concerns regarding EWM.

This APM Plan was designed to meet the District's needs for nuisance plant relief and the WDNR's requirements (e.g. applying for permits under Chapter NR 107 & 109 Wisconsin Administrative Code for aquatic herbicide application and aquatic plant harvesting). This APM Plan summarizes the lake morphology and lake watershed characteristics; reviews historical aquatic plant management activities; discusses the District's, goals and objectives; presents the aquatic plant ecology; presents results of the recent 2006 aquatic plant survey; evaluates feasible aquatic plant management alternatives; and provides a selected suite of aquatic plant management options in a comprehensive and integrated APM Plan.

2.1 Lake History and Morphology

Crooked Lake is 143 acres in size and has approximately 3.1 miles of shoreline. The maximum depth is reported as 37 feet on the WDNR lake survey map. Gilkey Lake is 18 acres with a reported maximum depth of 6 feet. Bass Lake is 11 acres with a reported maximum depth of 11 feet. Figure 2 illustrates the bathymetry of the Lakes measured during the July 2006 aquatic plant survey. A small unnamed tributary enters Crooked Lake in the northeast corner. The outlet is located in the northwest corner of Crooked Lake. A dam is located on the outlet. The WDNR lake survey map (1968) indicates the dam holds a 2-foot head. The outlet becomes Waupee Creek and flows into the Waupee Flowage.

The fishery is comprised of various panfish, largemouth bass, bullheads and northern pike. The most recent fisheries survey was completed in September of 1993 by electro-fishing. According to WDNR fisheries biologist, Justine Hasz, the fishery is considered average. Northern pike, large-mouth bass and blue gill species likely use the existing vegetation for spawning, nursery and feeding areas. (Personal communication 10/18/06).

2.2 Watershed Overview

The Lakes watershed totals approximately 1,906 acres. The majority of the watershed is forested (66%) or about 1,258 acres. The remainder of the watershed is comprised of open water (10%), wetlands (10%), and agriculture (6%). Urban or developed land comprises 7% or about 133 acres of the watershed (Figure 3).

2.3 Water Quality

Water quality data has been collected on Crooked Lake since 1993 by a combination of WDNR baseline data and Citizen Lake Monitoring data. The water quality data indicates the following:

Crooked Lake is classified as an oligotrophic lake based upon water quality sampling events during 1993-2006. The Wisconsin Trophic State (TSI) index defines an olgiotrophic lake is generally clear, deep and free of weeds or large algae blooms. Though beautiful, they are low in nutrients and do not support large fish populations. However, oligotrophic lakes often develop a food chain capable of sustaining a very desirable fishery of large game fish. (Shaw, et.al, 1996)

Secchi disc (Secchi disk) readings are taken using an 8-inch diameter weighted disc painted black and white. The disc is lowered over the downwind, shaded side of the boat until it just disappears from sight, and then raised until it is just visible. The average of the two depths is recorded. Secchi readings indicate water clarity, which often indicates a lake's overall water quality, especially the amount of algae present.

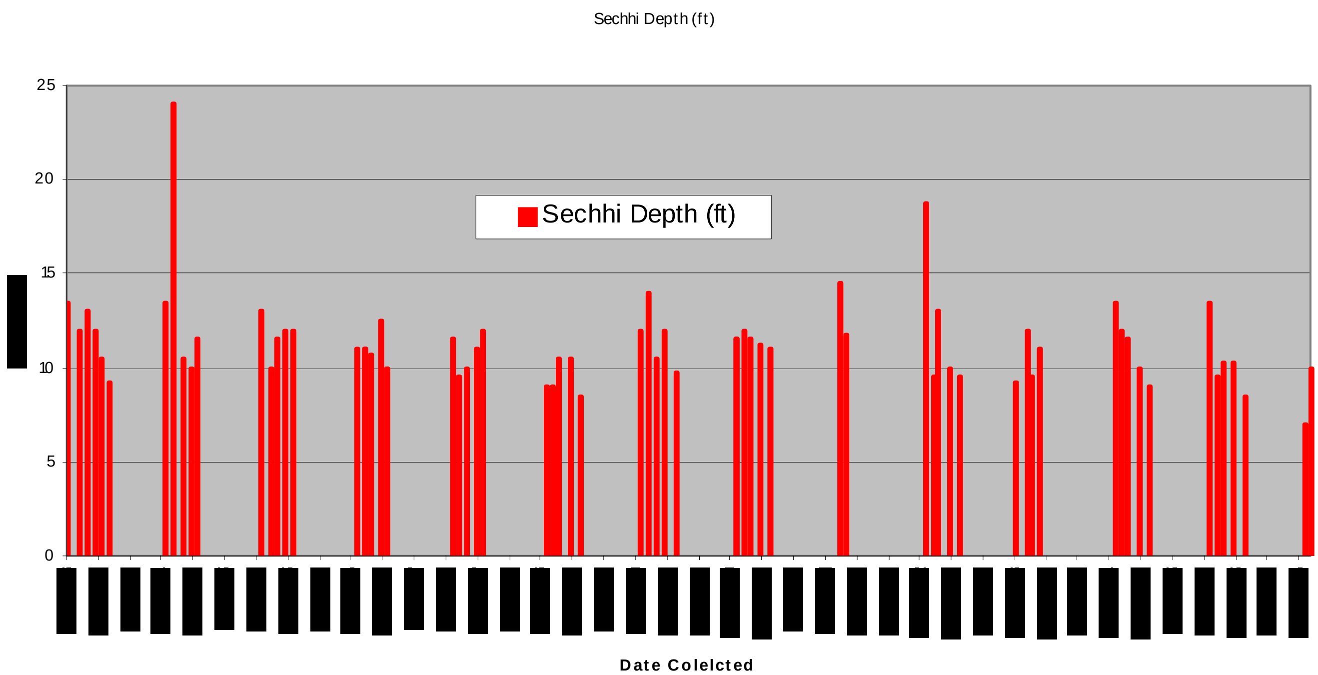
Table 1 depicts water clarity and secchi depth readings. (Shaw, et.al, 1996)

TABLE 1

Water clarity	Secchi depth (ft.)
Very poor	3
Poor	5
Fair	7
Good	10
Very good	20
Excellent	32

Secchi disc readings from Crooked Lake range from 7-24 feet with an average reading of 11.25 feet. The secchi disc readings indicate good to very good water quality on Crooked Lake. Table 2 depicts the secchi depths from 1993-2006.

TABLE 2 CROOKED LAKE



Phosphorus levels range from 6-29 µg/l on Crooked Lake, with an average of 12.44 µg/l. Phosphorus promotes excessive aquatic plant growth. In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and weed growth. Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns. The average phosphorus levels for natural lakes in Wisconsin are approximately 25 µg/l (Lillie and Mason, 1983). The phosphorus levels of Crooked Lake indicate very good water quality.

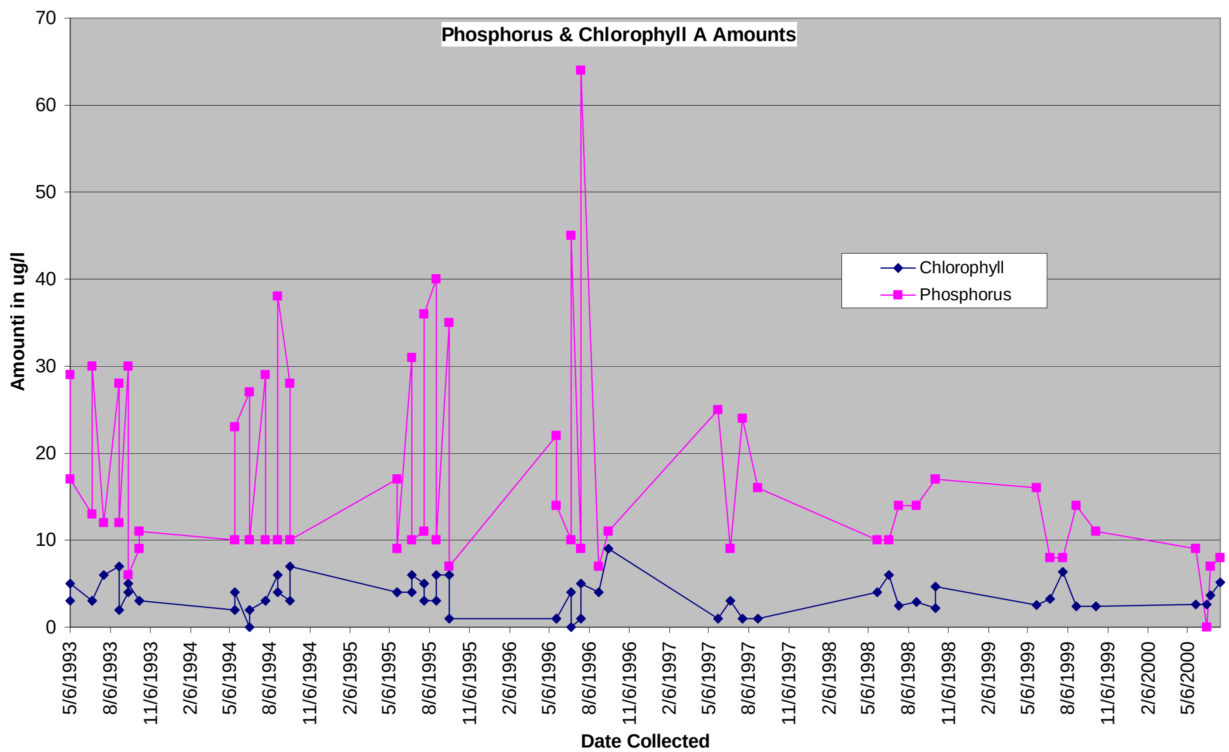
Chlorophyll _a_ concentration is a measure of the amount of algae present. Low levels of phosphorus are correlated to low levels of algae (chlorophyll _a)_ and high secchi disk readings. Chlorophyll _a_ levels range from 1-9 µg/l on Crooked Lake with an average reading of 3.52 µg/l. The chlorophyll _a_ levels indicate very good water quality.

These three factors combine to establish a trophic state index (TSI) for Crooked Lake. The trophic states associated with these three measures are shown below:

Trophic classification of Wisconsin Lakes based on chlorophyll *a*, water clarity measurements, and total phosphorus values. (Adapted from Lillie and Mason, 1983.)

Trophic class	**Total phosphorus** ug/l	**Chlorophyll *a*** ug/l	**Secchi Disc** feet
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

The 1993-2006 Citizen Lake Monitoring Annual Reports are included in Appendix A. As depicted in Table 2, the secchi disk readings have not significantly changed since 1993. Table 3 depicts phosphorus and chlorophyll *a* levels from 1993-2006. These levels have also not significantly changed in the past 13 years.



The water quality data of the Lakes indicates a mesotrophic-oligotrophic system with low levels of phosphorus and chlorophyll *a* and high secchi disc readings. The water quality has not changed significantly in the last 13 years.

2.4 Aquatic Plant Management History

An APM plan was completed in the late 1990's. At that time, lake users were concerned with dense native aquatic plant growth on the Lakes. The Crooked Lake Association obtained a WDNR grant to purchase a mechanical harvester in the late 1990's. EWM was confirmed in the Lakes in 2002. The District received a WDNR permit in 2003 and 2004 to conduct chemical control of EWM in 7.1 acres. The District continues to operate the harvester to manage the excessive native aquatic macrophyte growth. The harvester is operated an average of 100 hours during the growing season. The harvester is operated in high traffic areas such as boat landings and channels. The harvester is operated to cut vegetation to a depth of 4 feet to relieve nuisance conditions.

2.5 Goals and Objectives

Goals and objectives include developing an updated APM plan. The most recent plant survey and plan was developed in the late 1990's. Since that time, a mechanical harvester has been operated on the Lakes to control nuisance aquatic plants. EWM was discovered in the Lakes in 2002. At the time of the grant application, discussions with the District indicated that the following items were important APM Plan goals and objectives:

- Maintain and improve recreational opportunities
- Educate lake users on invasive species and benefits of native aquatic plant communities
- Preserve native aquatic plants
- Protect sensitive areas
- Control AIS present, EWM
- Prevent the spread of AIS, such as EWM, Curlyleaf pondweed (CLP), and Purple loosestrife (PL)
- Protect and improve fish and wildlife habitat
- Continue to manage the potential sources of pollutants already identified through previous studies

3.0 PROJECT METHODS

To accomplish the District's goals, the District needs to make informed decisions regarding APM on the Lakes. To make informed decisions, the District proposed to:

- Collect, analyze, and interpret basic aquatic plant community data
- Recommend practical, scientifically-sound aquatic plant management strategies

Offsite and onsite research methods were used during this study. Offsite methods included a thorough review of available background information on the Lakes, its watershed and water quality. Two aquatic plant community surveys were completed onsite to provide data needed to evaluate aquatic plant management alternatives.

3.1 Existing Data Review

A variety of background information resources were researched to develop a thorough understanding of the ecology of the Lakes. Information sources included:

- Local and regional pedologic, geologic, limnologic, hydrologic, and hydrogeologic research
- Discussions with District members
- Available topographic maps and aerial photographs
- Data from WDNR files
- Past Lake Study Reports

These sources were essential to understanding the historic, present, and potential future conditions of the Lakes, as well as to ensure that previously completed studies were not unintentionally duplicated. Specific references are listed in Section 7.0 of this report.

3.2 Aquatic Plant Survey and Analysis

The aquatic plant community of the Lakes was surveyed during June and July 2006. During those surveys the point intercept sampling method described by Madsen (1999) was used during the July survey, as is recommended in the draft guidance on APM in Wisconsin (WDNR, 2006). The point intercept method is readily adapted to "whole-lake" or large plot assessments as compared to the transect method that is best used in evaluating study plots or selected areas to evaluate aquatic macrophyte communities. The June survey was a visual reconnaissance survey to document the presence of curly-leaf pondweed (CLP).

To use the point intercept method, a base map was developed for each lake. Crooked Lake has 403 sampling points (i.e., intercept points) established on a 40 meter grid. Gilkey Lake has 89 sampling points established on a 30 meter grid. Bass Lake has 59 sampling points established on a 30 meter grid (Figure 4). Latitude and longitude coordinates and sample identifications were assigned to each intercept point on the grid (Appendix B). A Trimble GeoXT™ global positioning system (GPS) was used to navigate to intercept points. At each intercept point, plants were observed visually or collected with a rake on a telescopic pole or a rake attached to a rope. All observed plants were identified to the lowest practicable taxonomic level (e.g., typically genus or species) and recorded on field data sheets. Water depth and, when detectable, sediment types at each intercept point were also recorded on field data sheets.

The point intercept method was used to evaluate the existing emergent, submergent, floating-leaf, and free-floating aquatic plants at each intercept point. At each intercept point, a value of "1" was assigned if species were present and a "0" was assigned if a species was absent. For July surveys, the data for each sample point was entered into the WDNR "Worksheets" (i.e., a data-processing spreadsheet) to calculate the following statistics:

- **Taxonomic richness** (the total number of taxa detected)
- **Maximum depth of plant growth**
- **Community frequency of occurrence** (number of intercept points where aquatic plants were detected divided by the number of intercept points shallower than the maximum depth of plant growth)
- **Mean intercept point taxonomic richness** (the average number of taxa per intercept point)
- **Mean intercept point native taxonomic richness** (the average number of native taxa per intercept point)
- **Taxonomic frequency of occurrence within vegetated areas** (the number of intercept points where a particular taxon (e.g., genus, species, etc.) was detected divided by the total number of intercept points where vegetation was present)

- **Taxonomic frequency of occurrence at sites within the photic zone** (the number of intercept points where a particular taxon (e.g., genus, species, etc.) was detected divided by the total number of intercept points which are equal to or shallower than the maximum depth of plant growth)

- **Relative taxonomic frequency of occurrence** (the number of intercept points where a particular taxon (e.g., genus, species, etc.) was detected divided by the sum of all species' occurrences)

- **Mean density** (the sum of the density values for a particular species divided by the number of sampling site)

- **Simpson Diversity Index (SDI)** is an indicator of aquatic plant community diversity. SDI is calculated by taking one minus the sum of the relative frequencies squared for each species present. Based upon the index of community diversity, the closer the SDI is to one, the greater the diversity within the population.

- **Floristic Quality Index (FQI)** (This method uses a predetermined Coefficient of Conservatism (C), that has been assigned to each native plant species in Wisconsin, based on that species' tolerance for disturbance. Non-native plants are not assigned conservatism coefficients. The aggregate conservatism of all the plants inhabiting a site determines its floristic quality. The mean C value for a given lake is the arithmetic mean of the coefficients of all native vascular plant species occurring on the entire site, without

Regard to dominance or frequency. The FQI value is the mean C times the square root of the total number of native species. This formula combines the conservatism of the species present with a measure of the species richness of the site.

3.3 Shoreline Characterization

The point intercept method described above establishes grid points. The grid sampling may not accurately characterize emergent and floating leaved plants in shoreline areas. Therefore, a boat tour of the entire lake shoreline was used to map the emergent and floating leaved plant communities.

4.0 AQUATIC PLANTS

Aquatic plants are vital to the health of a water body. Unfortunately, people all too often refer to rooted aquatic plants as "weeds" and ultimately wish to eradicate them. This type of attitude, and the misconceptions it breeds, must be overcome in order to properly manage a lake ecosystem. Rooted aquatic plants (macrophytes) are extremely important for the well being of a lake community and posses many positive attributes. These attributes are what make the littoral zone the most important and productive aquatic habitat in freshwater lakes. Despite their positive role, aquatic macrophytes can become a nuisance when aquatic invasive species (AIS) occupy large portions of a lake and/or excessive growth of AIS or native macrophytes negatively affects recreational activities. When "managing" aquatic plants, it is important to maintain a well-balanced, stable, and diverse aquatic plant community that contains high percentages of desirable native species. To be affective, aquatic plant management in most lakes must maintain a plant community that is:

- Robust
- Species rich
- Diverse
- Mostly native

4.1 The Ecological Role of Aquatic Plants

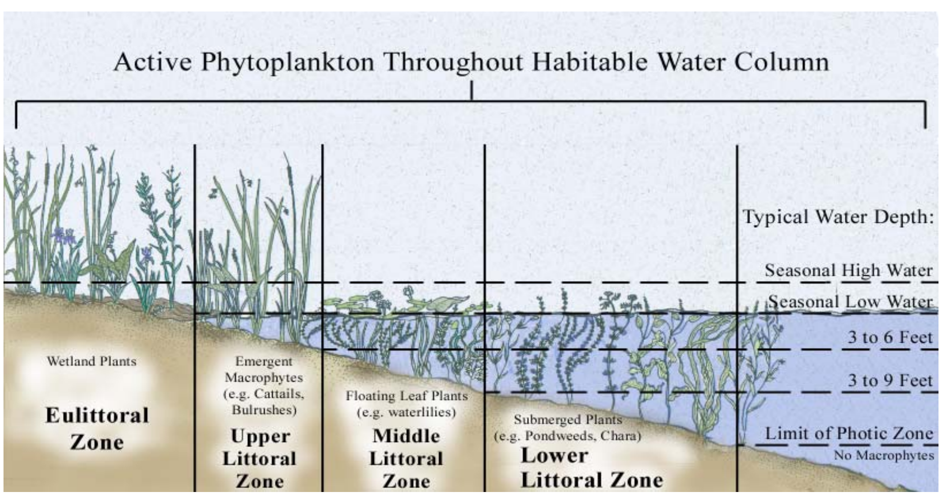
Aquatic plants can be divided into two major groups: microphytes (phytoplankton and epiphytes) composed mostly of single-celled algae, and macrophytes that include macroalgae, flowering vascular plants, and aquatic mosses and ferns. Wide varieties of microphytes co-inhabit all hospitable areas of a lake. Their abundance depends on light, nutrient availability, and other ecological factors. In contrast, macrophytes are predominantly found in distinct habitats located in the littoral (i.e., shallow near shore) zone where light sufficient for photosynthesis can penetrate to the lake bottom. The littoral zone is subdivided into four distinct transitional zones: the eulittoral, upper littoral, middle littoral, and lower littoral (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 dominated by floating-leaf plants.

Lower Littoral Zone: Extends to a depth equivalent to the limit of the photic zone, which is defined as percent of surface light intensity.



Aquatic Plant Communities Schematic

The abundance and distribution of aquatic macrophytes are controlled by 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 resuspension of solids and nutrients (NALMS, 1997).

If aquatic macrophyte abundance is reduced, then water clarity may 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.

4.2 Aquatic Plant Survey (2006)

The aquatic macrophyte community of the Lakes included 32 floating leaved, emergent, and submerged aquatic vascular plant species and 2 algal genera during 2006. The surveys include sampling at a total of 551 intercept points and the observed taxa are summarized in Appendix A. The distribution of aquatic plant species during July 2006 are illustrated in Figures 5a-5d.

A diverse plant community inhabited the Lakes during 2006. During July, the Simpson Diversity Index values of the community was 0.87 (Bass Lake), 0.90 (Crooked Lake) and 0.91 (Gilkey Lake). Aquatic vegetation was detected at 98% (Bass Lake), 82% (Crooked Lake) and 71% (Gilkey Lake) of photic zone intercept points during July.

The average number of plant species per sample site was 3.7 (Bass Lake), 2.4 (Crooked Lake), and 1.7 (Gilkey Lake) during July.

The most abundant aquatic plant was fern pondweed *(Potamogeton robbinsii)* in Bass and Crooked Lake. It had a 90% (Bass Lake) and 50% (Crooked Lake) frequency of occurrence (percent of photic zone intercept points at which the taxa was detected) during July. Further, it was detected at 49 of 55 (Bass Lake) and 117 of 283 (Crooked Lake) photic zone intercept points during July, respectively, and had greater relative frequency values than other taxa. White water lily *(Nymphaea odorata)* was the most abundant plant in Gilkey Lake. It had a 41% frequency of occurrence and was detected at 25 of 61 photic zone intercept points.

EWM (*Myriophyllum spicatum*) was detected in all three lakes. It had a 21% (Bass Lake), 17% (Crooked Lake) and 10% (Gilkey Lake) frequency of occurrence (percent of photic zone intercept points at which the taxa was detected) during July. Further, it was detected at 12 of 55 (Bass Lake) and 50 of 283 (Crooked Lake) and 9 of 51 (Gilkey Lake) photic zone intercept points during July. The total acreage of EWM in the Lakes totaled 25 acres. Bass Lake contained 2.7 acres, Gilkey Lake has 2.0 acres and Crooked Lake had 19.8 acres of EWM (Figure 6).

4.2.1 Free-Floating Plants

No free-floating aquatic plant species were identified during the 2006 aquatic plant survey.

4.2.2 Floating-Leaf Plants

Floating-leaf aquatic plant species were identified during the 2006 aquatic plant surveys. A brief description of these plant species follows (Figure 7).

Brasenia schreberi (Watershield)

Watershield
Source: University of Florida Website

Brasenia schreberi (Watershield) has floating leaves with elastic stems with the leaf stalk attaching to the middle of the leaves. All submersed portions of the plant are usually covered with a gelatinous coating. Watershield is commonly identified by the lack of a leaf notch and the central location of the petiole. Watershield is most commonly found growing in soft sediments that contain partially decomposed organic matter. The seeds, leaves, stems and buds are a source of food by waterfowl. The floating leaves also offer shelter and shade for fish and invertebrates (Borman, et al., 1997). Watershield is a sensitive aquatic plant this is not tolerant of pollutants and adverse human impacts to the lake ecosystem (Nichols, 1999).

Nuphar variegata (Spatterdock)

Spatterdock
Source: UW Herbarium Website

Nuphar variegata (Spatterdock) shows a preference for soft sediment and water that is 6 feet or less in depth. Floating leaves emerge in early summer from rhizomes that are actively growing in the soft sediments. Yellow flowers occur throughout the summer. Floating leaves provide cover and shade for fish as well as habitat for invertebrates (Borman, et al., 1997).

Nymphaea odorata (White Water Lily)

White Water Lily
Source: UW Herbarium Website

Nymphaea odorata (White Water Lily) has a flexible stalk with a round floating leaf. Most of the leaves float on the water surface. White Water Lily is typically found growing in a variety of sediment types in less than 6 feet of water. Floating leaves emerge in early summer from rhizomes that are growing in the soft sediments. White flowers occur throughout the summer. The floating leaves provide shelter and shade for fish as well as habitat for invertebrates (Borman, et al., 1997).

4.2.3 Submergent Plants

Submergent aquatic plant species were identified during the 2006 aquatic plant surveys. A brief description of some of these plant species follows.

Ceratophyllum demersum (Coontail)

Ceratophyllum demersum (Coontail) has long, trailing stems that lack true roots. The leaves are stiff and arranged in whorls of 5-12 at a node. Each leaf is forked once or twice. The leaf divisions have teeth along the margins that are tipped with a small spine. Whorls of leaves are usually more closely spaced near the ends of branches, creating the raccoon tail appearance. A tolerance for cool water and low light conditions allows coontail to overwinter as an evergreen plant, continuing photosynthesis at a reduced rate under the ice. The stiff whorls of leaves offer prime habitat for a host of critters, particularly during the winter when many other plants are reduced to roots and rhizomes (Borman, et al., 1997).

Coontail
Source: UW Herbarium Website

Elodea canadensis (Elodea)

*Elodea canadensis (*Elodea or common waterweed) is an abundant native plant species that is distributed statewide. It prefers soft substrate and water depths to 15 feet (Nichols, 1999). Elodea reproduces by seed and sprigs (USDA, 2002). The stems of elodea offer shelter and grazing to fish, but very dense elodea can interfere with fish movement. Elodea can be considered invasive at times and out-competes other more desirable plants.

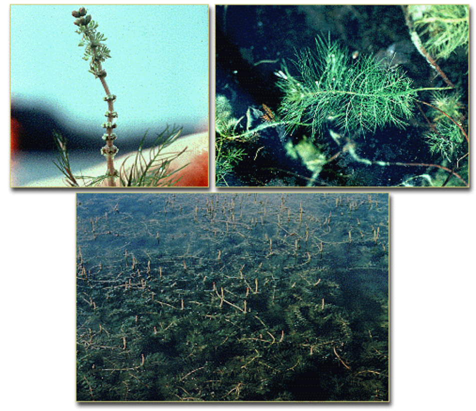
Elodea
Source: UW Herbarium Website

Isoetes spp. (Quillworts)

Isoetes spp. (Quillworts) have leaves that grow out of a fleshy, lobed, underground stem with forked roots. Each leaf has a central vein and four longitudinal air chambers that can be seen in cross section. Spores form in sacks located on the spoon-like bases of the leaves. Other species that may be confused with quillwort include plantain shoreweed (*Littorella uniflora*) and pipewort (*Eriocaulon aquaticum*). The foliage is sometimes consumed by waterfowl or game birds such as sharp-tailed grouse (Borman, et al., 1997).

Quillwort
Source: UW Herbarium Website

<u>*Myriophyllum spicatum* (Eurasian watermilfoil)</u>



Myriophyllum spicatum (Eurasian watermilfoil, EWM) is usually found in water 1 to 4 meters deep. It can grow in a variety of sediments, but is most productive in fine textured, inorganic sediment. EWM has long, spaghetti-like stems, sometimes 2 or meters in length, that emerge from roots and rhizomes. Stems often branch repeatedly at the water's surface, creating a canopy of floating stems and foliage. Leaves are divided like a feather, with a short stalk and about 14-20 pairs of thread-like leaflets. The leaf divisions are all about the same length and closely spaced, resembling the bones on a fish spine. Leaves are in whorls of 4-5 and can be widely spaced. EWM most closely resembles northern water milfoil (*Myriophyllum sibircum*). The most reliable way to distinguish them is by the number of leaf divisions. EWM usually has more than 14 pairs of leaflets, whereas northern water milfoil has less than 14 (usually 5-12). Growth can begin early in the spring when water temperatures are still cool (about 59º F. After flowering and fruit production, portions of the stems break apart in fragments. These fragments can float to new locations and take root. Its fast growing shoots and extensive canopy formation can obstruct recreation and navigation. The ability to grow in cool water gives it a quick start in the spring. EWM often crowns and shades native plants, giving it a competitive advantage (Borman, et al., 1997).

<u>*Myriophyllum tenellum* (Dwarf watermilfoil)</u>

Dwarf water milfoil, Source UW-Green Bay Website

Myriophyllum tenellum (Dwarf watermilfoil) looks very different than other water milfoil species. The slender, unbranched stems (2-15 cm tall) arise singly along a buried rhizome. The leaves are reduced to small scales or bumps. The chain of toothpick-like stems gives dwarf water milfoil a unique appearance. Dwarf water milfoil occurs primarily on sandy sites out to a depth of about 4 meters. It can form a dense turf of closely spaced stems. Dwarf water milfoil provided good spawning habitat for panfish and shelter for small invertebrates. The network of rhizomes helps stabilize sediment (Borman, et al., 1997).

<u>*Najas flexilis* (Slender Naiad)</u>


Slender Naiad
Source: UW Herbarium Website

Najas flexilis (Slender Naiad) is sometimes called bushy pondweed and has fine branched stems that emerge from a slight rootstalk. Leaves are paired and sometimes smaller leaves are bunched. Slender Naiad can grow in very shallow and very deep water. Waterfowl, marsh birds, and muskrats consume the stems, leaves, and seeds of naiad. The foliage produces forage and shelter opportunities for fish and invertebrates (Borman, et al., 1997).

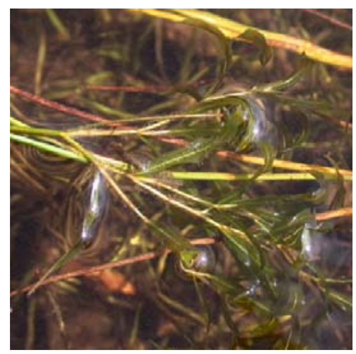
Potamogeton amplifolius (Large-leaf Pondweed)

Large-leaf Pondweed
Source: UW Herbarium Website

Potamogeton amplifolius (Large-leaf Pondweed) has robust stems that emerge from black-scaled rhizomes. The submersed leaves are the broadest of any pondweed and are slightly folded. The blade is also lined with many veins (25 to37). Floating leaves are oval and on long stalks. Large-leaf pondweed is most frequently found in soft sediments in water 1 to several feet deep. It is sensitive to increased turbidity. Large-leaf pondweed is commonly grazed by waterfowl. It offers habitat for invertebrates and offers foraging opportunities for fish (Borman, et al., 1997).

Potamogeton gramineus (Variable pondweed, grass-leaved pondweed)

Potamogeton gramineus (Variable pondweed, grass-leaved pondweed) has stems that emerge from spreading rhizomes and often sprawl on the sediment and branch repeatedly. Each side branch has a leafy appearance, with many linear to lance-shaped leaves. The leaves lack stalks, but taper slightly at the point where they attach to the stem. Each leaf has 3-7 veins. The appearance of variable pondweed can change depending on where it grows-sometimes it is compact with small leaves, other times rangy with larger leaves. The fruits and tubers of variable pondweed are grazed by a variety of waterfowl including geese and wood duck (Borman, et al., 1997).



Grass-leaved pondweed
Source: UW-Green Bay Website

Potamogeton illinoensis (Illinois Pondweed)

Illinois Pondweed
Source: University of Florida Website

Potamogeton illinoensis (Illinois Pondweed) has stout stems that emerge from thick rhizomes. Most of the submersed leaves are lance-shaped to oval and either attach directly to the stem or have a short stalk. The leaves often have a sharp, needle like tip. The stipules are free in the axils of the leaves and have two prominent ridges called keels. Floating leaves which have a thick stalk and ellipse shaped blade are sometimes produced. Illinois pondweed is usually found in water with moderate to high pH and fairly good water clarity. The fruit produced by Illinois pondweed can be locally important to ducks and geese. The plant may also be grazed by muskrat, deer and beaver. This pondweed also offers excellent shade and cover for fish and good surface area for invertebrates.

Potamogeton natans (Floating-Leaf Pondweed)

Floating-leaf Pondweed
Source: UW Herbarium Website

Potamogeton natans (Floating-Leaf Pondweed) has stems that emerge from red-spotted rhizomes. Submersed leaves are stalk-like, with no obvious leaf blade. Floating leaves are heart-shaped at their base. Floating-leaf pondweed is usually found in water less than 1.5 meters deep. Fruit of floating-leaf pondweed is held on the stalk until late in the growing season. It provides valuable grazing opportunities for ducks and geese. It may also be consumed by muskrat, beaver and deer (Borman et al. 1997).

(*Potamogeton pusillus*) Small Pondweed

Small Pondweed (*Potamogeton pusillus*) has small slender stems, emerges from a slight rhizome, and branches repeatedly near its ends. Small pondweed over-winters as rhizomes and winter buds. There is some limited reproduction by seed. Small pondweed can be locally important as a food source for a variety of wildlife. Waterfowl tend to feed on small pondweed as well as deer, muskrat, and some small fish (Borman, et al., 1997).

Small Pondweed
Source: UW Herbarium Website

Potamogeton richardsonii (Clasping Leaf Pondweed)

Clasping Leaf Pondweed
Source: UW Herbarium Website

Potamogeton richardsonii (Clasping Leaf Pondweed) is a submergent aquatic plant with sinuous stems that emerge from a spreading rhizome. Oval to somewhat lance-shaped leaves clasp the stem with the heart-shaped base of each leaf covering one-half to three-quarters of the stem circumference. Clasping leaf pondweed can be found growing in a variety of sediment types in water up to 12 feet deep and can tolerate disturbance and is often found growing with *Ceratophyllum demersum* (Coontail) and *Potamogeton pusillus* (Small Pondweed) (Borman, et al., 1997).

Potamogeton robbinsii (Fern Pondweed)

Fern Pondweed
Source: UW Herbarium Website

Potamogeton robbinsii (Fern Pondweed) is a submergent pondweed with robust stems of fern pondweed that emerge from a spreading rhizome. The leaves are strongly two-ranked, creating a feather or fern-like appearance which is most evident when the plant is still in the water. Each leaf is firm and linear, with a base that wraps around the stem. The leaf base is distinctive and has small ear-like lobes at the juncture with the stipule and is fused with the fibrous stipule. The leaves are closely spaced and have a finely serrated margin. Fern pondweed sprouts in the spring and thrive in deeper water. Fern pondweed provides habitat for invertebrates that are grazed by waterfowl and also offers good cover for fish, particularly northern pike (Borman, et al., 1997).

Potamogeton zosteriformis (Flat-Stem Pondweed)

Flat- Stem Pondweed
Source: UW Herbarium Website

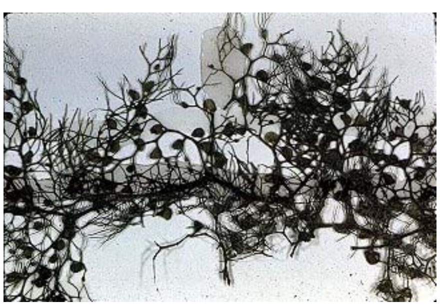
Potamogeton zosteriformis (Flat-Stem Pondweed) is a submergent pondweed with freely-branched stems of flat-stem pondweed that emerge from a slight rhizome. The stems are strongly flattened and have an angled appearance. Flat-stem pondweed has a prominent midvein and many fine, parallel veins. Flat stem pondweed is commonly confused with water stargrass (see description below) (Borman, et al., 1997).

Schoenoplectus subterminalis (Water bulrush)

Schoenoplectus subterminalis (Water bulrush) is the most truly aquatic bulrush in our region with only the tips of fertile stems poking out of the water. Stems develop from a fine rhizome. Slender, limp stem float in the water along with hair-like leaves that arise near the base. Submersed leaves of water bulrush could be confused with the fine, submersed stems of Robbins spikerush (*Eleocharis robbinsii*). However, the leaf-like stems of Robbins spikerush are all separate, while the leaves of water bulrush sheath each other at the base. Grass-like meadows of water bulrush provide invertebrate habitat and shelter for fish (Borman, et al., 1997).

Water bulrush
Source: UW-Green Bay Website

Utriculari vulgaris (Common bladderwort)



Common bladderwort
Source: UW-Herbarium Website

Utriculari vulgaris (Common bladderwort) has floating stems that can reach 2-3 meters in length. Along the stem are leaf-like branches that are finely divided. The divisions are filament-like, have no midrib, and fork 3-7 times. Scattered on these branches are the bladders that trap prey. Young bladders are transparent and green tinted, but they become dark brown to black as they age. The branches also have fine spines (spicules) scattered along their margins. Yellow, two-lipped flowers are produced on stalks that protrude above the water surface. Common bladderwort is free-floating and can be found in water ranging from a few inches to several metes deep. The trailing stems of common bladderwort provide food and cover for fish. Because they are free-floating, they can grow in areas of very loosely consolidated sediment. This provides needed fish habitat in areas that are not readily colonized by rooted plants (Borman, et al., 1997).

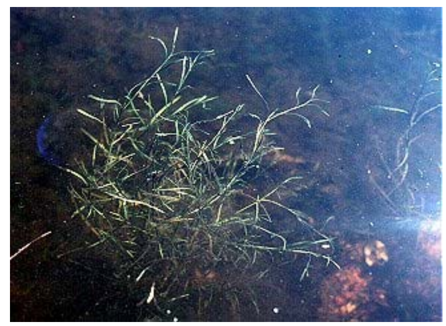
Vallisneria americana (Wild Celery)

Wild Celery
Source: UW Herbarium Website

Vallisneria americana (Wild Celery) also known as eel-grass or tape-grass, has ribbon-like leaves that tend to grow until they emerge in clusters along the waters surface. Wild celery is a premiere source of food for waterfowl. All portions of the plant are consumed. Beds of wild celery are also considered good fish habitat providing shade, shelter and feeding opportunities (Borman, et al., 1997). The District reports nuisance conditions with wild celery in late summer. This is common in many Wisconsin lakes, although the District noticed an increase in the abundance of wild celery in 2006.

Zosterella dubia (Water stargrass)

Zosterella dubia (Water stargrass) has slender, freely branches stems that emerge from a buried rhizome. The narrow, alternate leaves attach directly to the stem with leaf stalk and lack a prominent midvein. Yellow, star-shaped flowers are produced individually. The narrow, alternate leaves of water stargrass can look like a flat-stem pondweed (*Potamogeton zosteriformis)* or small pondweed (*Potamogeton pusillus)* at first glance. However, the leaves of water stargrass lack a definitive midvein and when it is in flower, the yellow blossoms clearly separate *Zosterella* from the pondweeds. Water stargrass can be a locally important source of food for geese and ducks including northern pintail, blue-winged teal and wood duck. It also offers good cover and foraging opportunities for fish (Borman, et al., 1997



Water stargrass
Source: UW Herbarium Website

Chara, sp. (Muskgrass / Chara)

Chara sp.
Source: UW Herbarium Website

Although *Chara, sp.* (Muskgrass / Chara) looks like a vascular plant, it actually is a multi-celled algae. Muskgrass is usually found in hard waters and prefers muddy or sandy substrate and can often be found in deeper water than other plants. Muskgrass beds provide valuable habitat for small fish and invertebrates. Muskgrass is also a favorite waterfowl food. Its rhizoids slow the movement and suspension of sediments and benefit water quality in the ability to stabilize the lake bottom (Borman, et al., 1997). It can easily be identified by its characteristic "musty" odor.

Nitella sp. (Nitella)

Nitella is another type of algae that looks like a vascular plant. Nitella is similar in appearance to muskgrass and is often found in similar habitats. However, Nitella can be distinguished from muskgrass by its stems and branches, which are smooth (Borman, et al., 1997).

Nitella sp.
Source: UW Herbarium Website

4.2.4 Emergent Plants

Emergent aquatic plant species were identified during the 2006 aquatic plant surveys. A brief description of some of these plant species follows (Figure 7).

Pontederia cordata (Pickerelweed)

Pickerelweed
Source: UW Herbarium Website

Pontederia cordata (Pickerelweed) has glossy, heart-shaped leaves that emerge from a robust, sprawling rhizome. The leaves have long, air-filled stalks with firm blades. The flower spike is crowded with small blue flowers. The blue-flowered spike of pickerelweed is distinctive. When it is not in flower, the leaves might be mistaken for arrowhead (*Sagittaria* sp.), water plantain (*Alisma* spp.) or wild calla (*Calla palustris*). The flowering stalk of pickerelweed is a haven for many insects-some seeking nectar and others a spot to rest. The seeds are consumed by waterfowl as well as muskrats. Beds of pickerelweed can be important shoreline stabilizers and help dampen wave action (Borman, et al., 1997).

Sagittaria latifolia (Arrowhead)

Sagittaria latifolia (Arrowhead) is an emergent plant the usually produces leaves that are true to its name – shaped like an arrowhead. Leaves emerge in a cluster from tuber tipped rhizomes. The size and shape of the leaf is highly variable with blades that range form a slender “A” shape to a broad wedge. Common arrowhead is found in the shallow water of lakes, ponds, streams and marshes and usually found in water only ankle-deep, but will sometimes grow in water about 1 meter deep. Common arrowhead is one of the highest value aquatic plants for wildlife and waterfowl depend on the high-energy tubers during migration. The seeds are also consumed by a wide variety of ducks, geese, marsh birds and shore birds. (Borman, et al., 1997).

Arrowhead
Source: UW Herbarium Website

Scirpus validus (Softstem bulrush)

Softstem bulrush
Source: UW Herbarium Website

Scirpus validus (Softstem bulrush) has tall, flexible stems that emerge from a shallow rhizome. The cylindrical, bluish-green stems are spongy when pressed between your fingers. This is due to the large air chambers that fill the stems. The stems emerge from a slender, buried rhizome and appear to be leafless. It is most similar in appearance to hardstem bulrush (*Scirpus acutus*). However, hardstem has an olive-green, firm stem filled with smaller chambers than softstem. Softstem bulrush offer habitat for invertebrates and shelter for young fish. Bulrushes also provide nesting material and cover for waterfowl, marsh birds and muskrats. (Borman, et al., 1997).

Sparaganium fluctuans (Floating-leaf bur-reed)

Sparaganium fluctuans (Floating-leaf bur-reed) has flat, wide floating leaves. The flower stalk is branched with 2-4 fruitng heads. The leaves of bur-reed can be recognized by holding one up to the light to see the very fine checkerboard of veins. Colonies of bur-reed help anchor sediment and provide nesting sites for waterfowl and shorebirds.

Typha latifolia (Broad-leaf Cattail)

Typha latifolia (Broad-leaf Cattail) has pale green, sword-like leaves that emerge from a robust, spreading rhizome. The leaves are sheathed around on another at the base and junction of the leaf sheath and blasé the sheath is usually tapered. Broad-leaved cattail can be distinguished from narrow-leaved cattail by the presence of male and female flower spikes immediately adjacent to each other, and the leaves are wider and flatter. Cattails provide nesting habitat for many marsh birds and cover for small fish (Borman, et al., 1997).

Broad-leaf Cattail
Source: UW Herbarium Website

4.2.5 Aquatic Invasive Plant Species

Aquatic invasive species (AIS) are plant species that can alter ecological relationships among native plant species and can affect ecosystem function, economic value of ecosystems, and human health. A species is regarded as invasive if it has been introduced by human action to a location, area, or region where it did not previously occur naturally (i.e., is not native), becomes capable of establishing a breeding population in the new location without further intervention by humans, and spreads widely throughout the new location. NR 109 lists three species of aquatic plants as invasive statewide, Eurasian Water milfoil (EWM), curly leaf pondweed (CLP) and purple loosestrife (PL). As previously discussed, EWM is present in all three lakes. CLP was not observed during the June and July plants survey. PL was also not observed during either survey.

Eurasian Water Milfoil *(Myriophyllum spicatum)*

EWM is the most common AIS found in Wisconsin lakes. EWM was first discovered in southeast Wisconsin in the 1960's. During the 1980's, EWM began to spread to other lakes in southern Wisconsin and by 1993 it was common in 39 Wisconsin counties. EWM continues to spread across Wisconsin and is now found in the far northern portion of the state including Vilas and Oneida Counties.

Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, or bait buckets, and can stay alive for weeks if kept moist http://www.dnr.state.wi.us/invasives/

Once established in an aquatic community, EWM reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, EWM is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl. http://www.dnr.state.wi.us/invasives/

Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms of infested lakes. http://www.dnr.state.wi.us/invasives/

Curly leaf pondweed *(Potamogeton crispus)*

The leaves of curly-leaf pondweed (CLP) are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early July.

CLP spreads through burr-like winter buds (turions), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making CLP one of the first nuisance aquatic plants to emerge in the spring.

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. CLP may form surface mats that interfere with aquatic recreation. http://www.dnr.state.wi.us/invasives/

Purple Loosestrife (*Lythrum salicaria*)

Purple loosestrife is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta; possess 5-6 petals aggregated into numerous long spikes, and bloom from July to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers. Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. http://www.dnr.state.wi.us/invasives/

4.3 Floristic Quality Index

FQI varies around the state of Wisconsin and ranges from 3.0 to 44.6 with the average FQI of 22.2 (Aquatic Plant Management in Wisconsin - Draft, 2005). FQI is used to help compare lakes around the state and to assess the lake over time. Higher FQI numbers indicate better lake quality. During July, the FQI of Crooked Lake was 33.5. The FQI of Gilkey Lake was 26.9. The FQI of Bass Lake was 26.6. These FQI values average 29, a value slightly above Wisconsin's median of 22.2. This FQI value suggests that the Lakes have above average water quality when using aquatic plants as an indicator of lake health (Appendix B).

4.4 Shoreline Characterization

Emergent and floating leaved plants identified along the shoreline outside of grid sample points included arrowhead, bulrushes, cattails, white water lily, spatterdock, and watershield. The locations of these plant communities are illustrated in Figure 7. Figure 8 depicts the undeveloped and developed shoreline of each lake.

5.0 CONCLUSIONS AND MANAGEMENT ALTERNATIVES

5.1 Conclusions

The Lakes have historically been perceived as lakes with good water quality, and abundant aquatic macrophytes. Water quality data collected between 1993 and 2006 indicate a mesotrophic to olgiotrophic lake system. Nutrients from both within the lake and from land uses within the watershed are likely contributing nutrients to enhance aquatic plant growth. The lake is a popular recreational boating lake. An aquatic plant harvester helps manage dense aquatic plant growth for boating navigation.

During the July 2006 aquatic plant survey, 32 aquatic plant species were found; an indicator of a moderately diverse aquatic plant community. CLP was not observed during the June reconnaissance survey. EWM was observed during the June reconnaissance survey and the July formal aquatic plant survey. The most abundant aquatic plant was fern pondweed *(Potamogeton robbinsii)* in Bass and Crooked Lake. White water lily *(Nymphaea odorata)* was the most abundant plant in Gilkey Lake.

5.2 Management Alternatives

Some areas of the Lakes exhibit aquatic plant growth that interferes with swimming and recreational boating. Dense aquatic plants tangle boat props and the riparian landowners report problems getting their boats from their piers to open water areas. Lake users have also reported problems with dense plant growth at the boat landings on Bass and Crooked Lake. As such, the District has operated an aquatic plant harvesting program. Historically, the harvesting activities were often largely un-regulated. The WDNR promulgated NR 109, Wis. Adm. Code requiring development of APM Plans in order to obtain an aquatic plant management permit for harvesting activities. The NR 109 program is intended to allow management for nuisance conditions but protect aquatic plant communities from improper management. NR 109 requires that an applicant review all available aquatic plant management techniques before selecting a management strategy.

In addition to addressing native plant concerns, the District conducted chemical treatment on EWM in an effort to prevent its spread to other parts of the Lakes. NR 107 regulates the application of aquatic herbicides to Waters of the State. NR 107 requires detailed information of a lakes' aquatic plant community and watershed prior to issuing a permit for treatment areas over 10 acres.

Existing physical, biological, and chemical management techniques and current available research were reviewed in detail. A comprehensive comparision of APM techniques, including descriptions about the technology, benefits, drawbacks, and costs are included in Appendix C. Based on these comparisons and the specific aquatic plant problems on the Lakes, the following potential management strategies were considered.

5.2.1 Manual Removal

Hand raking or hand pulling can be completed to remove aquatic plants from the water. Benefits include low costs, and the drawbacks are the labor intensive nature of this option. Manual removal by individual landowners can be completed to a maximum width of 30 feet to provide pier or swimming raft access. A permit is not required for hand pulling or raking if the maximum width cleared does not exceed 30 feet. Manual removal of native aquatic plants exceeding 30 feet in width requires a permit from the WDNR. No permit is necessary if the manual removal is limited to AIS species such as EWM and CLP.

Hand pulling of new infestations of EWM can be completed in shallow water or by a scuba diver in deeper water. Due to the labor intensive nature and the cost of hiring a scuba diver, this method is only recommended for new areas (≤ .10 acres) in size. Careful consideration must be given to removing the entire plant, including stems and fragments; thus preventing the spread of EWM.

5.2.2 Mechanical Harvesting

Aquatic plant harvesting 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 and at multiple times of the year "as needed". Disadvantages of this method include the limited depth of operation in shallow areas, high initial equipment costs, disposal site requirements, and a need for trained staff to operate the harvester. An additional disadvantage is EWM is easily spread by fragmentation and the method of picking up plant fragments with the harvester is imperfect. Harvesting in areas of EWM can contribute to the spread of EWM throughout the lakes. A full discussion about harvesting is included in Appendix C.

The District currently operates one aquatic plant harvester and a shore conveyer. The District implements the harvesting programs on an "as needed" basis. Areas of harvesting operation include high traffic areas such as boat landings and navigation channels. Figure 8 depicts areas of current and suggested mechanical harvesting.

5.2.3 Aquatic Herbicide Treatment

Use of an aquatic herbicide was considered as a potential management option for the control of EWM. A suitable herbicide applied at an appropriate dose by an experienced licensed pesticide applicator can target a problem aquatic plant species. Advantages of chemical herbicides include selectivity for problem AIS and better control in confined areas (e.g. around docks) than harvesters can achieve. Disadvantages include the potential to affect non-target plant species (if not applied at an appropriate application rate and/or time of year). After an application, water use restrictions may be necessary. Additional disadvantages include the high cost of chemical treatment (approximately $500.00/acre) and potential controversy over using chemicals in water.

Chemical treatments are discussed at length in Appendix C.

5.2.4 Biological Control

Biological control was considered to control EWM. *Eurhychiopsis lecontei*, an herbivorous weevil native to North America, has been found to feed on EWM. Adult weevils feed on the stems and leaves, and females lay their eggs on the apical meristem (top-growing tip); larvae bore into stems and cause extensive damage to plant tissue before pupating and emerging from the stem. Three generations of weevils hatch each summer, with females laying up to two eggs per day. It is believed that these insects are causing substantial decline in some milfoil populations. Because this weevil prefers EWM, other native aquatic plant species, including northern water milfoil, are not at risk from the weevil's introduction.

The disadvantage of using weevils includes several un-controllable factors. The first of these factors includes the density of weevils required to significantly damage a population of EWM. Even if high levels of seasonal weevil damage are achieved, it does not always translate into long-term EWM declines. This is due to fact that the weevils move out of the water and onto the nearby shorelines in winter. In order for the weevils to survive, these shorelines must be relatively undeveloped and have an abundance of leaf litter and other herbaceous vegetation present. Developed shorelines are not suitable overwintering habitat due to shoreline structures such as riprap, seawalls, and mowed grass. In addition to these habitat requirements, the weevils may not significantly damage EWM populations (biomass or plant height due to recovery EWM after adult weevils move to shore for overwintering. (Hairston and Johnson, 2001). http://www.dcnr.state.pa.us/forestry/invasivetutorial/Eurasian_water_milfoil_M_C.htm

6.0 RECOMMENDED ACTION PLAN

Consistent with the goals of the APM Plan and AIS Prevention and Control Plan, and the feasible aquatic plant management alternatives discussed in Section 5.2, the District has prepared a comprehensive APM plan and AIS plan that integrates aquatic plant management techniques for nuisance native plant growth and AIS on the Lakes. These techniques and other important components of the comprehensive APM Plan are discussed in the following sections. The District should periodically update this APM Plan to reflect current aquatic plant problems, and the most recent acceptable APM methods. Information is available from the WDNR website: http://dnr.wi.gov/org/water/fhp/lakes/aquaplan.htm or from Northern Environmental upon request.

6.1 Manual Removal

Individual property owners can manually remove nuisance aquatic plants in the lake offshore from their property. Manual removal can be completed to a maximum width of 30 feet to provide pier or swimming raft access. A permit is not required for hand pulling or raking if the maximum width cleared does not exceed 30 feet. Manual removal exceeding 30 feet in width requires a permit from the WDNR. Requests to exceed 30 foot removal width should be brought to the District’s attention and alternative management could be considered (e.g. harvesting).

New infestations of EWM (≤.10 acres) can be controlled via manual removal. If the water depth allows for easy removal, individual property owners, District members and lake users can remove the EWM by hand. Care must be taken to remove the entire plan, including the root, and to remove any stems and fragments that may have become dislodged. In areas of deeper water, scuba divers may be used to manually remove EWM. This method is both thorough and selective but is also labor intensive. Careful consideration must be given to disposal locations. Near-shore areas and wetlands should be avoided to reduce the risk of spreading EWM to new locations. Large amounts of decaying vegetation can cause unpleasant odors and is unsightly. Aquatic vegetation can contain high levels of nutrients, including phosphorus and nitrogen, two common nutrients found in fertilizers removed aquatic vegetation can be used to fertilize gardens.

6.2 Mechanical Harvesting

The District will continue mechanical harvesting for navigation purposes using District-owned harvesting equipment. The WDNR reguates mechanical harvesting under Chapter NR109 of the Wisconsin Administrative Code (NR 109 Wis. Adm. Code). The District must comply with the conditions of a WDNR-issued harvesting permit. A copy of the current harvesting permit and NR 109 Wis. Adm. Code is included in Appendix D. Harvesting for aesthetic reasons is not allowed. Harvesting is allowed to provide nuisance relief for navigation subject to the following restrictions.

Areas

Aquatic plant harvesting will be completed on the Lakes for navigation purposes only within the permitted area illustrated on Figure 8. Harvester operators shall target nuisance areas of dense native submergent aquatic plant growth that interferes with swimming, significant boat traffic or other recreation within this area. The operator shall not harvest emergent (e.g. bulrushes) or floating leaved plants (e.g. water lilies), or areas of EWM or other AIS. The harvesting map (Figure 9) illustrates approximately where aquatic plants may potentially be harvested. The area illustrated is between 3 and 15 feet of water depth minus areas where floating leaved vegetation is present or shoreline areas that are not developed. The nuisance aquatic plants within the mapped area are only harvested for pier access, swimming areas and boat navigation lanes. Furthermore, the harvester is not operated in less than 3 feet of water depth. Harvesting may occur at half the water column depth and aquatic plants growing to 15 feet are only cut to the 4 foot harvester cutter head depth.

Depth

The harvester operator shall not operate the harvester in less than 3 feet of water depth to prevent disruption of the bottom sediments, turbidity, and/or damage to the cutting head. If any sediments are encountered, the cutter head will be raised immediately. Harvesters will cut approved harvesting areas at half the water column depth. Full cutter depth (4 feet) is only operated at water depths of 10 feet or greater. Mechanical harvesting should not be conducted in areas of documented EWM.

Operators

Prior to each harvesting season, each operator will be required to review the APM and AIS Prevention and Control Plan and conditions of the harvesting permit. Harvester operators will be trained to know the limitations of harvesting (areas and depths). The approved harvesting area map (Figure 9), a copy of the DNR harvesting permit, and the harvesting restrictions listed above will be included in a harvester guidance binder on the aquatic plant harvester. Operators will be trained to identify EWM and other AIS species. Operators will collect plant samples thought to be an AIS. The samples will be submitted to the WDNR Aquatic Plant Manager for identification.

Timing

Timing of aquatic plant harvesting is a useful tool in selective management and therefore is considered an important component of the APM Program activities. Aquatic plant harvesting activities will normally begin after June 15th. This date is protective of April and May fish spawning seasons and if necessary, will provide nuisance relief near boat landings prior to the July 4th weekend.

Record Keeping

The District will maintain detailed records including harvesting dates, harvesting areas, types, and amounts of aquatic plants harvested. A sample record keeping form is included in Appendix D.

Additional specific information about the Lakes harvesting program (completed WDNR harvesting worksheet) is included in Appendix D.

6.3 Chemical Control

Chemical controls of EWM can be effective, however, long term eradication of larger infestations is unlikely and chemical controls can be expensive and may need to be repeated every one to four years. Generally, the aim is for selective control, to reduce EWM but retain a native plant community. Thus, systemic herbicides, which are taken up by the plant and will kill the entire plant, are preferable to contact herbicides which will knock down the plant, but do not affect the roots and prevent regrowth. The most commonly used herbicide for milfoil control in Wisconsin is 2-4-D, which is selective for dicots. Control is most effective with spring or fall applications and some damage to other dicots (e.g., coontail, water lilies) can be expected, but minimized by suitable application rates and timing.

Chemical control of AIS will be implemented in a phased approach. The goals of any aquatic herbicide application will be to reduce the number of acres with EWM, reduce the frequency and density of EWM and to re-establish native plant communities in area of the Lakes now dominated by EWM.

Phase 1

Phase 1 will be to conduct a large-scale chemical treatment of all areas of the Lakes with EWM (Figure 6). A selective herbicide such as 2,4-d will be used in accordance with the label requirements and WDNR permit. Phase 1 should be completed in spring or early summer when the water temperatures are approximately 60ºF. Conducting chemical treatment for EWM at this time of year provides selective control for EWM for two reasons. The first reason is the selectivity of the recommended chemical, 2,4-d. 2,4-d has been shown to be selective for dicots, such as EWM and native milfoils. Based on the 2006 plant survey, where EWM is present in the Lakes, it is the dominant plant. Where EWM has the highest densities, it was the only plant present so the risk of harming native plants is low. In addition to the chemical selectivity, the recommended treatment time allows for increased selectivity. EWM tends to get an early start in the spring in cooler water. Native aquatic plants require higher water temperatures to begin actively growing. By treating EWM early in the growing season, the District would be giving the native plants in these areas the opportunity to re-establish a healthy native plant community.

Phase 1 also includes follow-up monitoring of areas where EWM was treated. The monitoring will include documenting the size of EWM beds, the density of EWM within those beds and documentation of any new infestations in the Lakes. In addition to documenting new infestations, any re-growth in the treated areas should be documented and photographed. This monitoring should be conducted throughout the growing season, including late fall when EWM is suspected to produce winter buds. In addition to monitoring for re-growth, location and frequency of EWM in late fall, the locations should be documented with GPS coordinates. Based on these coordinates and locations, a subsequent permit application can be filed during the winter months for chemical treatment during the following spring in Phase 2.

The goal of Phase 1 will be a documented 50% reduction in the occurrence and density of EWM. The reductions will be documented during the follow-up monitoring as described above. A follow-up plant survey of the 2006 documented EWM locations should be conducted in July 2007.

Phase 2

Phase 2 includes a chemical treatment of EWM during 2008. Based on the assumption that Phase 1 achieved a 50% reduction in occurrence and density of EWM, the goals of Phase 2 will be 30% reduction of the remaining EWM. The chemical treatment regime should follow the methods outlined above in Phase 1.

Phase 3

Phase 3 includes spot treatments for remaining EWM beds and new infestations.

Assuming the goals of Phase 1 & 2 are achieved, an 80% reduction in EWM can be achieved. This correlates to 20 acres of EWM eradicated or controlled to a minimal existence level. If 80% reduction is achieved that correlates to only 5 acres of EWM present in the Lakes or about 2%. This assumes that EWM does not spread in any considerable acreage during the next 3-5 years.

Phase 3 should include continued monitoring as described in Phase 1.

6.4 Biological Control

At this time, biological control of EWM is not recommended. This is due to the fact the weevils have not been proven to provide large-scale control of EWM. Weevil damage may contribute to plant damage and fewer nuisance problems but will not kill the plant. If the goals include reducing the amount of EWM in the Lakes, biological control can only supplement other management strategies such as manual and/or chemical control.

6.5 Sensitive Areas

WDNR often will designate sensitive areas on Wisconsin Lakes. Sensitive Areas are defined as "areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or lifestage requirements, or offering water quality or erosion control benefits to the body of water". Sensitive areas are often located where there is little to no shoreline development. Shoreline features (developed areas and undeveloped areas) are illustrated on Figure 8. WDNR has not conducted any sensitive area surveys on the Lakes. If such surveys are completed, additional restrictions to the harvesting program or APM in general may be required. Information about sensitive areas is included in Appendix E.

6.6 AIS Prevention and Control Plan

A component of the APM plan is the AIS Prevention and Control Plan (AIS Plan). The current AIS on the Lakes is EWM. To date other common AIS (curly-leaf pondweed, purple loosestrife, zebra mussels, rusty crayfish, etc.) have not been found in the Lakes. AIS aquatic plants were discussed in Section 4.2.5. Additional AIS are briefly discussed here.

Zebra mussels (*Dreissena polymorpha*) are a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

http://www.dnr.state.wi.us/invasives/fact/zebra.html


photo by Jeff Gunderson, MN Sea Grant

Rusty crayfish (*Orconectes rusticus*) have invaded portions of Minnesota, Wisconsin, Ontario, and many other areas. Although native to parts of some Great Lakes states, rusty crayfish have spread to many northern lakes and streams where they cause a variety of ecological problems. Rusty crayfish were probably spread by non-resident anglers who brought them north to use as fishing bait. As rusty crayfish populations increased, they were harvested for the regional bait market and for biological supply companies. Such activities probably helped spread the species further. Invading rusty crayfish frequently displace native crayfish, reduce the amount and kinds of aquatic plants and invertebrates, and reduce some fish populations. Environmentally-sound ways to eradicate or control introduced populations of rusty crayfish have not been developed, and none are likely in the near future. The best way to prevent further ecological problems is to prevent or slow their spread into new waters.

http://www.seagrant.umn.edu/exotics/rusty.html

In order to address the current AIS and prevent new infestations, the AIS plan includes the following components.

6.7 Watercraft Inspection

The District should continue the already established watercraft inspection program, Clean Boats, Clean Waters (CBCW). This is extremely important to prevent the introductions of other AIS and to prevent the spread of EWM into other nearby lakes from transient boaters using the Lake. CLP, rusty crayfish and zebra mussels are present in other area lakes and rivers and preventing their introduction into the Lakes should be a high priority component of this AIS Plan.

The watercraft inspection effort in Wisconsin involves providing information to lake users about what invasive species look like and what precautions they should take to avoid spreading them. It also involves visual inspection of boats to make sure they are "clean" and demonstration to the public of how to take the proper steps to clean their boats and trailers. Watercraft inspectors also install signs at boat landings informing boaters of infestation status, state law, and steps to prevent spreading AIS. The CBCW Program is sponsored by the DNR, UW Extension, and the Wisconsin Association of Lakes and offers training to volunteers on how to organize a watercraft inspection program. For more information see the following website: http://www.uwsp.edu/cnr/uwexlakes/CBCW/default.asp or contact Laura Felda- Marquardt, Volunteer Coordinator for the Invasive Species Program, UW Extension-Lakes Program at (715) 346-3366 or (715) 365-2659 for details. If any of the above hyperlinks to web addresses become inactive, please contact Northern Environmental for appropriate program and contact information.

6.7.1 Monitoring

In addition to monitoring boat launches, volunteers should establish a lake monitoring program. As described in section 6.2, Phase 1 of the chemical control calls for monitoring of the EWM treatment areas and additional monitoring of the Lakes to identify any new infestations of EWM. An organized volunteer monitoring group should be established to closely observe the aquatic plant community of the Lakes and document any changes on a weekly basis. Close attention should be paid to existing EWM locations. Volunteers should be trained to identify EWM and CLP and the common native species found in the Lakes.

The District should either contract for annual AIS monitoring or have a volunteer trained to complete the AIS monitoring through the WDNR self help program. At a minimum the harvester operator should be trained to recognize AIS such as EWM and curly leaf pondweed, Additional information about these exotic aquatic plants is available in the educational materials in Appendix G. Additional information is also available from the WDNR website http://dnr.wi.gov/invasives/aquatic.htm or from Northern Environmental upon request. The operator shall report any new AIS to a District Commissioner immediately. The District should complete periodic monitoring for AIS such as EWM and Curly leaf pondweed. Grants may be available to help fund hiring professionals to complete these monitoring efforts or local lake enthusiasts can become trained in the WDNR self-help citizen monitoring program. For more information on having volunteers provide AIS monitoring, please visit the following website:

http://dnr.wi.gov/org/water/fhp/lakes/selfhelp/shlmhowto.htm

Or contact your local lake coordinator from the list at:

http://www.dnr.state.wi.us/org/water/fhp/lakes/selfhelp/shlmcont.asp

If any of the above hyperlinks to web addresses become inactive, please contact Northern Environmental for appropriate program and contact information.

Northern Environmental also recommends completing lake wide aquatic macrophyte surveys every 5 to 10 years to monitor changes in the aquatic plant community and the effects of the APM activities. Aquatic plant communities may change with varying water levels, water clarity, nutrient levels, and aquatic plant management. These formal surveys should duplicate the 2006 point intercept survey.

6.7.2 APM & AIS EDUCATION

Education is the key to understanding the impact of AIS, identifying AIS and preventing the spread both in the Lakes and to nearby lakes. The District should establish an organized education effort focusing on AIS Prevention and Control. The following approaches should be implemented to address education concerns;

1) Develop a District Newsletter-The District does not currently have a newsletter. A newsletter is an excellent way to reach a large audience and share information. A small-scale WDNR lake management planning grant can be obtained to assist the District with the initial start-up, printing and distribution of a newsletter.
2) Annual meeting-the District currently holds an annual meeting during Memorial Day weekend. This meeting can also serve as an annual education opportunity. Topics focusing on AIS issues can include a summary of the previous year's efforts and successes and samples of EWM, CLP and purple loosestrife
3) Conduct a "Clean Sweep" Lake Day-the District should coordinate a day in late July or early August where property owners observe their shoreline for all plant species present. Any unknown or suspicious plants should be identified by trained volunteers or WDNR staff to document the spread of EWM and the presence of native plants. In addition to the shoreline, known areas of EWM should be re-visited to document presence/absence of AIS species.
4) Purchase plastic buckets to be used by residents and transient boaters alike at the boat landings to place any plant fragments.

In addition to informing the Crooked Lake community, the District should publish an article in the local newspaper detailing the efforts the District is taking to address AIS on the Lakes. The article should information on how the CBCW program on the Lakes is preventing the spread of AIS to other Oconto County Lakes.

Northern Environmental will present information about aquatic plants and aquatic plant management to attendees during the 2007 annual meeting. The presentation will include a hands on look at aquatic plant specimens collected from the Lakes. Information presented will emphasize:

- The values that aquatic plants provide
- The importance of keeping excessive nutrients out of a lake
- The importance of preventing and controlling AIS on the Lakes

Several WDNR and UW Extension fact sheets about aquatic plants and aquatic plant management will be distributed to attendees of t the meeting. A copy of the materials to be distributed is provided in Appendix F. The District can order copies of WDNR and UW Extension publications by visiting the following website:http://www.uwsp.edu/cnr/uwexlakes/publications/

If the above hyperlinks to web addresses become inactive, please contact Northern Environmental for appropriate program and contact information. Public education should continue with emphasis on the above topics. If you need additional public education materials, contact your WDNR lake coordinator, local UW Extension agent, or Northern Environmental for more information.

6.7.3 APM Technologies

The APM technologies listed in Appendix C should be re-visited periodically to evaluate if new or improved technologies are available. The professional environmental science community includes universities, state natural resource regulatory agencies (e.g. WDNR), and federal regulatory agencies (e.g. USFWS, USACE, EPA, and USGS). The District is encouraged to "stay current" with this research as the knowledge gained from these endeavors may prove useful for APM activities or overall aquatic ecosystem management in the future.

6.7.4 Public

The District should assess the public's perception of APM on the Lakes. Periodic questionnaires (similar to Appendix G) should be solicited in District mailings to evaluate the opinions of lake users about aquatic plants and management on the Lakes.

6.7.5 Water Quality

The District is currently conducting water quality studies through the Wisconsin Citizen Lake Monitoring Program to better understand the water quality conditions of the Lakes. This sampling should continue to be conducted by volunteers. This information is vital to evaluate the condition of the Lakes today and in the future. The aquatic plant community does not tell the entire story of what is happening on a lake so good water quality data over a long period of time can tell more the story.

6.8 Nutrient Controls

The District may also consider encouraging landowners to install a natural shoreline buffer on their property. Offering lakeshore residents within the District who complete such a project a tax credit is one idea. In addition to the near-shore areas, tributary sampling and groundwater monitoring may be conducted to monitor in-flows into the Lakes. This sampling may be completed by applying for additional WDNR grants and/or working with the Oconto County Land & Water Conservation Department. In addition to tributary sampling, landowners may have their soil from their lawn sampled to determine the appropriate level, if any, fertilizer is required.

If a fertilizer is required, a non-phosphorus fertilizer is recommended.

7.0 SCHEDULE OF EVENTS

The following table describes a schedule of required activities for the EWM treatment program on the Lake.

Activity	Frequency	Date
Mapping of EWM or post-treatment survey	Annually	No later than September 30th
Prepare NR 107 Permit Application (*for grant purposes*)	Every 3 years	December 1st
Prepare DRAFT WDNR AIS Control Grant Application	Every 3 years	January 1st
Submit WNDR AIS Control Grant Application	Annually	February 1st
Pre-treatment Survey	Annually	May 30th
Submit *Amended* NR 107 Permit Application	Annually	Within 2 weeks of Pre-treatment survey completion
EWM treatment	Annually	*June 30th
Lake District Budget Voting	Annually	??
Town Budget Voting	Annually	??
Lake wide Aquatic Plant Survey	Every 5 years	July 30th 2011
Update APM Plan	Every 5 years	December 1, 2011

* = Activity will not be completed until water temperature reaches 60 degrees Fahrenheit.

7.1 Designation of Responsibility

The following table assigns responsibility for the EWM treatment program events listed above. When the Town or District is identified as a responsible party, these entities should identify which individual, or committee should complete the specified activity. For example, the Town of Riverview may elect to form a committee to review District authored grant applications and submit grant applications to the WDNR.

Activity	Responsible Party
Mapping of EWM or post-treatment EWM survey	Aquatic Plant Professional or Licensed Applicator
Prepare NR 107 Permit Application (*for grant purposes*)	Licensed Applicator
Prepare DRAFT WDNR AIS Control Grant Application	Lake District and Town
Submit WDNR AIS Control Grant Application	District and/or Town (acts as grant sponsor)
Pre-treatment EWM Survey	Aquatic Plant Professional or Licensed Applicator
Submit *Amended* NR 107 Permit Application	Licensed Applicator

EWM treatment	Licensed Applicator
Lake District Budget Voting	Lake District
Town Budget Voting	Town
Lake wide Aquatic Plant Survey	Aquatic Plant Professional hired by Lake District or Town
Update APM Plan	Aquatic Plant Professional hired by Lake District or Town

* Local units of government receive preference in AIS Control grant projects and should act as project sponsor

8.0 REFERENCES

While not all references are specifically cited, the following references were used in preparation of this report.

Borman, Susan, Robert Korth, and Jo Temte, *Through the Looking Glass, A Field Guide to Aquatic Plants*, Wisconsin Lakes Partnership, 1997.

Fassett, Norman C., *A Manual of Aquatic Plants*, The University of Wisconsin Press, Madison, Wisconsin, 1975.

Foth and Van Dyke, *The Lakes Management Plan,* 1992.

Getsinger, Kurt D., and H.E. Westerdahl, *Aquatic Plant Identification and Herbicide Use Guide, Volume II Aquatic Plants and Susceptibility to Herbicides*, U.S. Army Corps of Engineers Waterways Experiments Station, Technical Report A-88-9, 1988.

Hotchkiss, Neil, *Common Marsh, Underwater and Floating-Leafed Plants of the United States and Canada,* Dover Publication, Inc., New York, 1972.

Madsen, John, *Point Intercept and Line Intercept Methods for Aquatic Plant Management, Aquatic Plant Control Technicla Note MI-02*, February 1999.

Nichols, Stanley A. *Distribution and habitat descriptions of Wisconsin lake plants*, Wisconsin Geological and Natural History Survey Bulletin 96, 1999.

North America Lake Management Society of Aquatic Plant Management Society (NALMS), *Aquatic Plant Management in Lakes and Reservoirs,* 1997.

Prescott, G.W., *How to Know the Aquatic Plants,* Wm. C. Brown Publishers, Dubuque, Iowa, 1980.

United States Department of Agriculture, *Soil Survey of Calumet and Manitowoc Counties, Wisconsin,* 1980.

United States Geological Survey, *School Hill, Wisconsin Quadrangle, 7.5 minute (Topographic) Series*, 1992.

Welsh, Jeff, *Guide to Wisconsin Aquatic Plants,* Wisconsin Department of Natural Resources Publication WR 173, 1992 revised.

Wetzel, Robert G., *Limnology*, 1983

Wisconsin Department of Natural Resources, *ECorrespondence/Memorandum, Subject: The Lakes Comprehensive Survey report, by Steve Hogler, Fisheries Biologist,* 1997.

Wisconsin Department of Natural Resources, *Eurasian Watermilfoil in Wisconsin as of December 2004* (fact sheet from WDNR website), 2004.

Wisconsin Department of Natural Resources, *Aquatic Plant Management in Wisconsin DRAFT (not for distribution),* April 25 2006.

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APPENDIX A

2006 AQUATIC PLANT SURVEY DATA

APPENDIX B

FLORISTIC QUALITY INDEX

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APPENDIX C

SUMMARY OF AQUATIC PLANT MANAGEMENT ALTERNATIVES

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APPENDIX D

HARVESTING INFORMATION

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APPENDIX E

SENSITIVE AREA INFORMATION

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APPENDIX F

PUBLIC EDUCATION MATERIALS

APPENDIX G

PUBLIC QUESTIONNAIRE EXAMPLES

AQUATIC PLANT MANAGEMENT PLAN

AQUATIC INVASIVE SPECIES
PREVENTION & CONTROL PLAN

CROOKED, BASS & GILKEY LAKES
OCONTO COUNTY, WISCONSIN

January 10, 2007