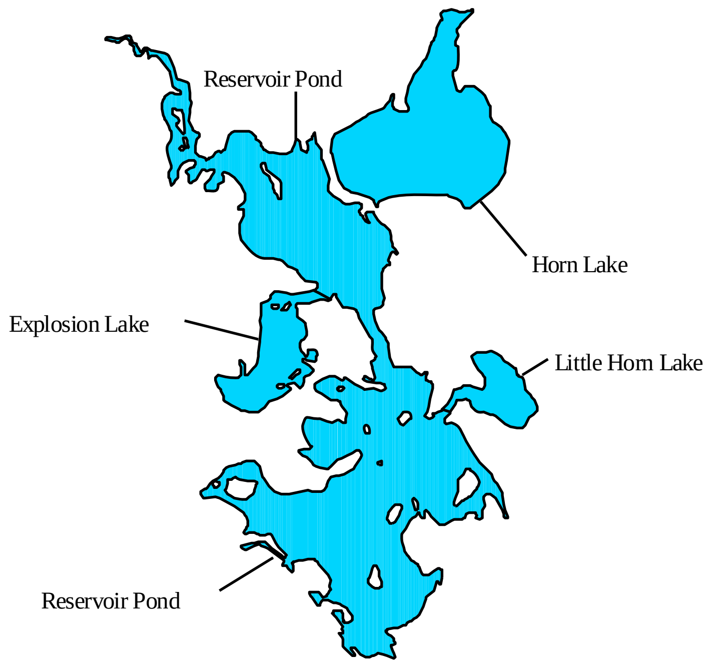
Inland Lakes Protection and Rehabilitation District #1, Townsend, Wisconsin

Aquatic Plant Management Plan 2006 - 2009



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Introduction

The Inland Lakes Protection and Rehabilitation District No. 1 is located within the Nicolet National Forest, near the Village of Townsend (**Figure 1**). The District boundary includes four lakes: Reservoir Pond, Explosion Lake, Horn Lake, and Little Horn Lake as well as a portion of the McCaslin Brook above Reservoir Pond and below the dam leading to Townsend Flowage (**Figure 2**). Reservoir Pond was created in 1888 when the Holt Lumber Company dammed McCaslin Brook. Explosion, Horn and Little Horn Lakes are natural lake basins that are directly connected to Reservoir Pond through surface water. The four lakes within the District support a fishery of walleye, northern pike, largemouth bass, and panfish (WNDR 2001). Waters within the District encompass more than 600 surface acres. **Table 1** presents the physical characteristics of the four lakes within the District.

Table 1. Characteristics of lakes within the Inland Lakes Protection and Rehabilitation District No. 1.

Lake Name	Size (acre)	Maximum depth (ft)	Average depth (ft)	Lake Type*
Explosion	31	27	--	SP
Horn	134	11	6	SP
Little Horn	24	22	--	SP
Reservoir	417	16	5	DG

* SP = Spring Lake
  DG = Drainage Lake

Excessive weed growth has been a major issue for The District for a number of years. Since 1976 the District has managed nuisance aquatic plants with a mechanical weed harvesting program. Although harvesting occurs in all four lakes, it is most intensive in Reservoir Pond where weed growth has become most significant. The Wisconsin Department of Natural Resources has required the Inland Lakes Protection and Rehabilitation District No. 1 to develop an aquatic plant management plan prior to renewal of their weed harvesting permit which expired in 2005. In response, The District retained Wisconsin Lake & Pond Resource, LLC to conduct aquatic plant surveys of the lakes and to develop an aquatic plant management plan. This report is the result of these efforts.

Project Goals

The primary goals of this project were 1) to address excessive weed growth through the development of an Aquatic Plant Management Plan for the Inland Lakes Protection and Rehabilitation District, No. 1, 2) to identify and prioritize management concerns including harvesting, shoreline treatments, and navigation lanes, 3) to gather additional information needed to develop a long-range management plan, and 4) to develop contingency plans for the possible invasion of exotic species.

Methods

Aquatic Plant Surveys

Point intercept survey of four lake basins

The aquatic plant survey conducted on the four lake basins during August 2005 utilized a sampling protocol designed by the WDNR. This protocol involved plotting a series of grid points approximately 100 m. apart from one another across the lakes (**Figure 3**). Where grid lines intercept, aquatic plant samples were collected from an anchored boat. Rake tows were made at each point intercept. Approximately 294 points were sampled in the survey. These included 195 points in Reservoir Pond, 22 in Explosion Lake, 67 in Horn Lake, and 10 in Little Horn Lake. The rake used consisted of a short-toothed garden rake head attached to a 15 foot telescoping pole. Where depths were too great to collect samples with the telescoping pole, a double rake head attached to a rope was thrown from the boat. At each sample point, the rake was dragged along bottom for approximately 2.5 feet to collect plants. All plant samples collected were identified to *genus* and *species* whenever possible, and recorded. An abundance rating of 1 to 4 was given for each species collected in each rake tow. Using these reproducible methods will allow for accurate assessment of any future changes to the aquatic plant community.

Survey of McCaslin Brook

During 1999, Northern Lake Service conducted a macrophyte survey of McCaslin Brook from below the dam to the district boundary. These same survey methods were used again in 2005 as follows: the stream was divided into six sections and data were recorded separately for each section. Rake tows and surface observations of the aquatic plant community were made in each section of the brook. Again all plant samples collected will be identified to *genus* and *species* whenever possible, and recorded. An abundance rating of 1 to 4 was given for each species observed.

Exotic plant survey and mapping

In August 2005, considerable effort was made to thoroughly search all lake basins and McCaslin Brook for the presence in invasive exotic plants. Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), and purple loosestrife (*Lythrum salicaria*) were the species of primary concern. Where found, the extent and location of plant beds were plotted and measured using GPS technology. Minimum and maximum depths of beds were noted, and the locations of the beds were drawn on lake contour maps. Bed area measurements conducted in the field were later verified using modified acreage grid analysis.

Emergent plant community mapping

Because emergent and floating-leaf plant communities are abundant on District lakes, and because they are important natural resources, another effort was made to map their distribution. The extent and location of emergent plant beds were plotted using GPS technology drawn on lake contour maps. Results were used to develop weed harvesting guidelines.

Water Quality Assessment

Concurrently with the aquatic plant survey, a water chemistry and limnology analysis was conducted in all four lakes. These analyses included:

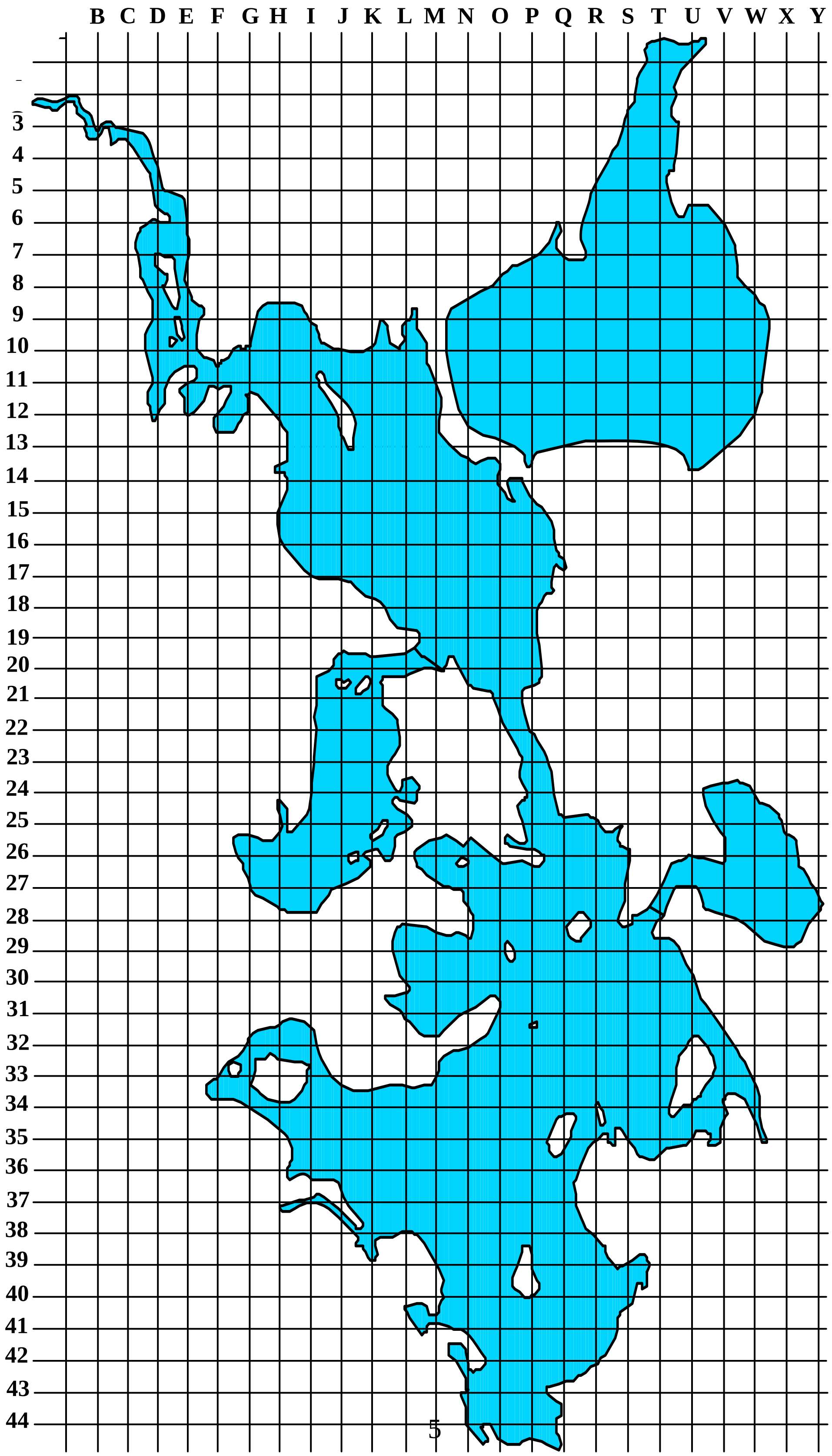
- pH
- Dissolved oxygen profile
- Temperature profile
- Secchi depth

Dissolved oxygen, temperature and pH data were collected with an electronic meter at the deepest portion of each lake basin. Data collected was used to assess the general water quality and health of the lakes.

Literature Review

The review of available literature was another component of this survey. The literature review included previous studies conducted on the four lakes, characteristics of native aquatic plant found and exotic plant management options.

Figure 3. Aquatic plant survey map for Reservoir Pond and Horn, Little Horn, and Explosion Lakes, Oconto County.



Results and Discussion

Aquatic plant community characteristics

Reservoir Pond contained a very diverse aquatic plant community with a total of 23 species. Reservoir Pond was also the most diverse of the four lakes. Northern Lake Service, Inc conducted a limnological survey of the lakes and upper brook from 1975-1976. While quantitative data on the aquatic plant community was not collected, the survey did note that bushy pondweed (*Najas flexilis*) was the most abundant plant species in the lakes. Bushy pondweed was also the most abundant plant in Reservoir Pond during the 2005 survey. Northern watermilfoil (*Myriophyllum sibericum*), Flatstem pondweed (*Potamogeton zosteriformis*), common waterweed (*elodea*) and coontail (*Ceratophyllum demersum*) were also very abundant in 2005 (**Table 2**). Eurasian watermilfoil, an invasive exotic plant, was found in the north basin of Reservoir Pond at 2.4% frequency.

A total of 14 species were found in Horn Lake (**Table 3**). Horn Lake was also dominated by bushy pondweed, but had a different plant community composition than Reservoir Pond. Illinois pondweed (*Potamogeton illinoiensis*) and musk grass (*Chara spp*.) were very abundant while Flatstem pondweed and common waterweed were sparse. Coontail was absent. Eurasian watermilfoil was found in Horn Lake at a 4.5% frequency.

A total of nine species were found in Explosion Lake (**Table 4**). Bushy pondweed, musk grass and white water lily (*Nymphaea odorata*) were most abundant. Only six species were found in Little Horn Lake (**Table 5**), which contained an abundance of northern watermilfoil, musk grass and bushy pondweed. No exotic plants were found in either Explosion of Little Horn Lakes.

A study done by Northern Lake Service, Inc. in 1999 focused on McCaslin Brook from below the dam to the district boundary. It included a visual survey of six arbitrary sections along the brook and found coontail (*Ceratophyllum demersum*) and water stargrass (*Heteranthera dubia*) to be the most abundant species. The McCaslin Brook plant community appears to have changed by the time of the 2005 survey. In 2005, bur-reed (*Sparganium americanum*), Flatstem pondweed, large-leaf pondweed (*P. amplifolius*) and white water lily were most abundant, having been found in all six stream sections (**Table 6**). Coontail was also abundant, but water stargrass was not found in any stream sections. In all, McCaslin Brook contained a very diverse and healthy aquatic plant community comprised of 21 species. One invasive exotic species, purple loosestrife, was found near the road bridge crossing. All purple loosestrife plants found were hand pulled by Wisconsin Lake & Pond Resource staff at the time of the survey.

Emergent plant bed distribution

District lakes contained an abundance of emergent and floating-leaf plants. While significant beds were found in all four lakes, the north basin of Reservoir Pond contained the most extensive beds (**Figure 4**). This basin was dominated by bog communities and water lily beds.

Table 2. Results of the aquatic plant survey conducted on Reservoir Pond in August 2005.

Plant Species		Percent	Percent
Common name	**Scientific name**	**Frequency**	**Composition**
Bushy pondweed	*Najas flexilis*	58.6	16.0
Northern water milfoil	*Myriophyllum sibericum*	56.8	15.5
Flat-stem pondweed	*Potamogeton zosteriformis*	49.7	13.6
Common waterweed	*Elodea canadensis*	47.3	12.9
Coontail	*Ceratophyllum demersum*	46.1	12.6
Muskgrasses	*Chara spp.*	21.3	5.8
Illinois pondweed	*Potamogeton illinoensis*	19.5	5.3
Spatterdock	*Nuphar variegata*	16.0	4.4
Large-leaf pondweed	*Potamogeton amplifolius*	13.6	3.7
White water lily	*Nymphaea odorata*	11.8	3.2
Small pondweed	*Potamogeton pusillus*	8.3	2.3
Floating-leaf pondweed	*Potamogeton natans*	4.1	1.1
Bladderwort	*Utricularia vulgaris*	3.6	1.0
Star duckweed	*Lemna trisulca*	2.4	0.6
Eurasian water milfoil	*Myriophyllum spicatum*	2.4	0.6
Ribbon-leaf pondweed	*Potamogeton epihydrus*	1.2	0.3
Watershield	*Brasenia schreberi*	1.1	0.3
Sago pondweed	*Stuckenia pectinata*	1.1	0.3
Water stargrass	*Zosterella dubia*	0.6	0.2
variable pondweed	*Potamogeton grammineus*	0.6	0.2
Nitella	*Nitella spp.*	0.6	0.2
Clasping-leaf pondweed	*Potamogeton richardsonni*	0.6	0.2
Bottlebrush sedge	*Carex comosa*	0.6	0.2

Table 3. Results of the aquatic plant survey conducted on Horn Lake in August 2005.

Plant Species		Percent Frequency	Percent Composition
Common name	**Scientific name**		
Bushy pondweed	*Najas flexilis*	37.9	34.2
Illinois pondweed	*Potamogeton illinoensis*	16.7	15.1
Muskgrasses	*Chara*	16.7	15.1
Northern water milfoil	*Myriophyllum sibericum*	7.6	6.9
White water lily	*Nymphaea odorata*	7.6	6.9
Eurasian water milfoil	*Myriophyllum spicatum*	4.5	4.1
Common waterweed	*Elodea canadensis*	3.0	2.7
Flat-stem pondweed	*Potamogeton zosteriformis*	3.0	2.7
Floating-leaf pondweed	*Potamogeton natans*	3.0	2.7
Spatterdock	*Nuphar variegata*	3.0	2.7
Watershield	*Brasenia schreberi*	3.0	2.7
Large-leaf pondweed	*Potamogeton amplifolius*	1.5	1.4
Sago pondweed	*Stuckenia pectinata*	1.5	1.4
Small pondweed	*Potamogeton pusillus*	1.5	1.4
No Plants Found		33.3	

Table 4. Results of the aquatic plant survey conducted on Explosion Lake in August 2005.

Plant Species		Percent Frequency	Percent Composition
Common name	**Scientific name**		
Bushy pondweed	*Najas flexilis*	37.5	21.4
Muskgrasses	*Chara spp.*	31.3	17.9
White water lily	*Nymphaea odorata*	25.0	14.3
Northern water milfoil	*Myriophyllum sibericum*	18.8	10.7
Illinois pondweed	*Potamogeton illinoensis*	18.8	10.7
Floating-leaf pondweed	*Potamogeton natans*	18.8	10.7
Spatterdock	*Nuphar variegata*	12.5	7.1
Water smartweed	*Polygonum amphibium*	6.3	3.6
Flat-stem pondweed	*Potamogeton zosteriformis*	6.3	3.6

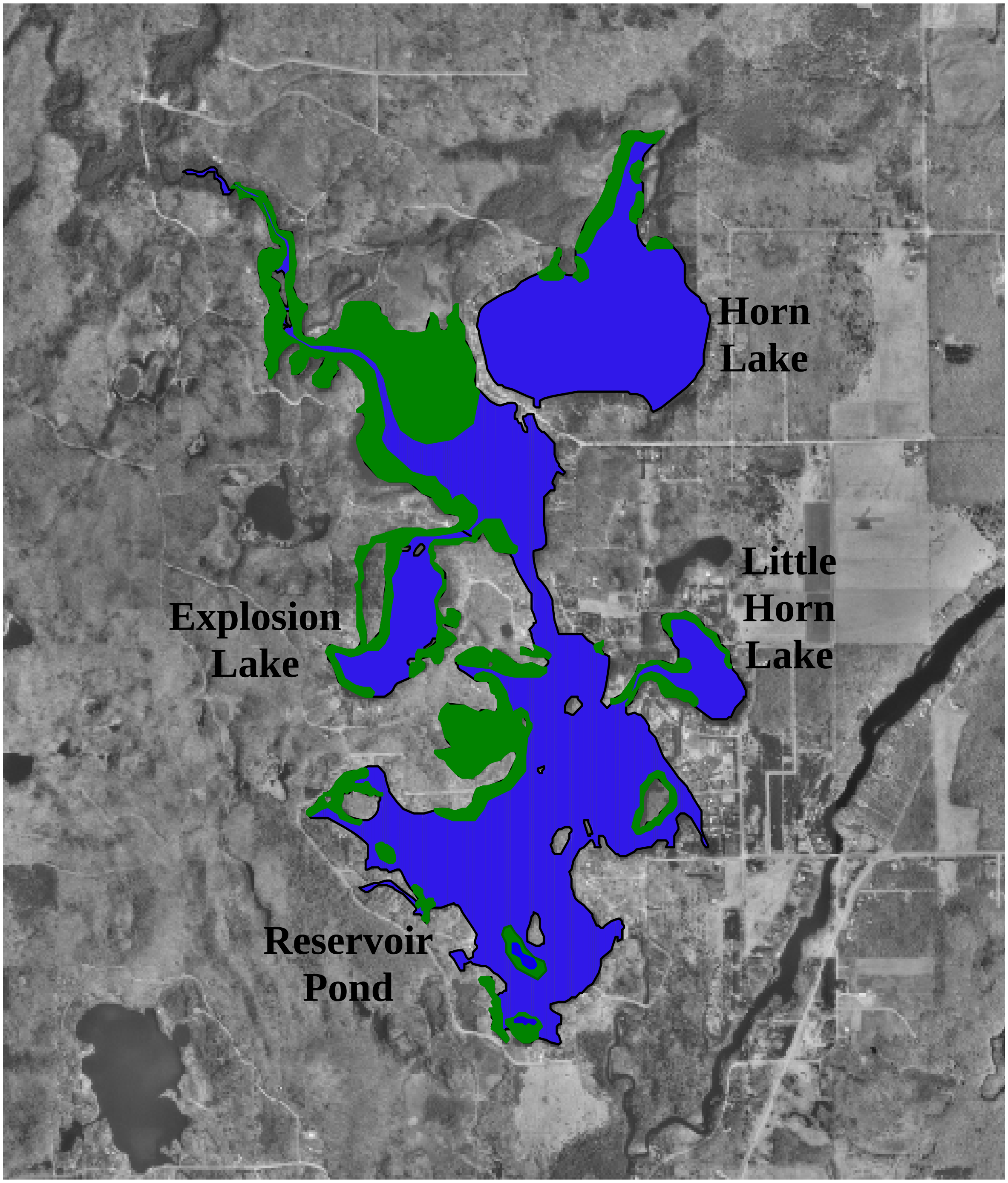
Table 5. Results of the aquatic plant survey conducted on Little Horn Lake in August 2005.

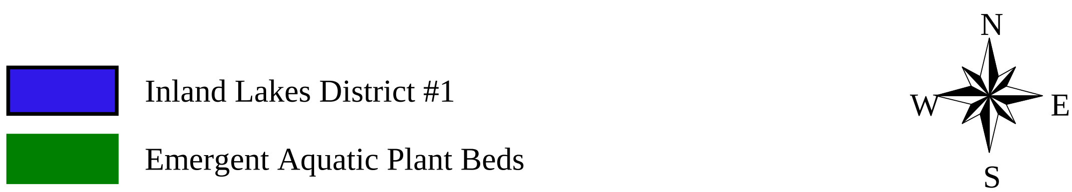
Plant Species		Percent	Percent
Common name	**Scientific name**	**Frequency**	**Composition**
Northern water milfoil	*Myriophyllum sibericum*	85.7	30.0
Muskgrasses	*Chara spp.*	57.1	20.0
Bushy pondweed	*Najas flexilis*	57.1	20.0
Flat-stem pondweed	*Potamogeton zosteriformis*	42.9	15.0
Illinois pondweed	*Potamogeton illinoensis*	28.6	10.0
Large-leaf pondweed	*Potamogeton amplifolius*	14.3	5.0

Table 6. Results of the aquatic plant survey conducted on McCaslin Brook in August 2005.

Plant Species		Percent	Percent
Common name	**Scientific name**	**Frequency**	**Composition**
American bur-reed	*Sparganium americanum*	100.0	8.0
Flat-stem pondweed	*Potamogeton zosteriformis*	100.0	8.0
Large-leaf pondweed	*Potamogeton amplifolius*	100.0	8.0
White water lily	*Nymphaea odorata*	100.0	8.0
Common waterweed	*Elodea canadensis*	85.7	6.8
Coontail	*Ceratophyllum demersum*	85.7	6.8
Northern watermilfoil	*Myriophyllum sibericum*	85.7	6.8
Spatterdock	*Nuphar variegata*	71.4	5.7
Wild celery	*Vallisneria americana*	71.4	5.7
Blue flag iris	*Iris versicolor*	57.1	4.5
Clasping-leaf pondweed	*Potamogeton richardsonii*	57.1	4.5
Floating-leaf pondweed	*Potamogeton natans*	57.1	4.5
Ribbon-leaf pondweed	*Potamogeton epihydrus*	57.1	4.5
Softstem bulrush	*Scirpus validus*	57.1	4.5
Illinois pondweed	*Potamogeton illinoensis*	42.9	3.4
Fern pondweed	*Potamogeton robbinsii*	28.6	2.3
Sago pondweed	*Stuckenia pectinata*	28.6	2.3
Broad-leaved cattail	*Typha latifolia*	14.3	1.1
Common bladderwort	*Utricularia vulgaris*	14.3	1.1
Purple loosestrife	*Lythrum salicaria*	14.3	1.1
Small duckweed	*Lemna minor*	14.3	1.1

Figure 4. Distribution of emergent and floating-leaf aquatic vegetation in the Inland Lakes Protection and Rehabilitation District No. 1, Oconto County, Wisconsin.





Historical data comparisons

The 1975-76 survey conducted by Northern Lake Service found a diverse aquatic plant community in the four lakes. However it was noted that 95% of the aquatic plant community was comprised of naiad or bushy pondweed. **Table 7** lists the plant species found during the 2005 survey of District Lakes and McCaslin Brook. **Table 8** lists the plant species found in District Lakes during the 1975-76 survey (note: McCaslin Brook was not included in this survey). **Table 9** lists the plant species found during the 1999 survey of McCaslin Brook. It appears that little has change in the aquatic plant community of District waters in terms of diversity and abundance. Among the lakes however, it is evident that a better balance of plant species was found in 2005. The reason why the plant community was 95% bushy pondweed in 1975-76 was not clear. Bushy pondweed is an annual plant and is very opportunistic – often one of the first species to recolonize disturbed areas. Environmental conditions at the time of the survey may have suppressed other plants and encouraged bushy pondweed. Another notable change is the presence of Eurasian watermilfoil and purple loosestrife in the 2005 survey. These two exotic plants are thought to have recently invaded district waters. Another exotic plant, curly-leaf pondweed, listed in the 1975-76 survey results, but was not found in 2005, despite an extensive effort to locate exotic plants. It is possible that clasping leaf pondweed, a similar looking plant that was found in 2005, was misidentified as curly-leaf pondweed in the earlier survey.

Table 7. Aquatic plants found in Inland Lakes Protection and Rehabilitation District # 1 during the August 2005 survey.

SUBMERGENT SPECIES

Bladderwort
Bushy pondweed
Clasping-leaf pondweed
Common waterweed
Coontail
Eurasian watermilfoil
Fern pondweed
Flat-stem pondweed
Illinois pondweed
Large-leaf pondweed
Muskgrasses
Nitella
Northern watermilfoil
Ribbon-leaf pondweed
Sago pondweed
Small pondweed
Variable pondweed
Water stargrass
Wild celery

EMERGENT SPECIES

American bur-reed
Blue flag iris
Bottlebrush sedge
Broad-leaved cattail
Purple loosestrife
Softstem bulrush

FLOATING-LEAF SPECIES

Spatterdock
Watershield
White water lily
Floating-leaf pondweed
Water smartweed

FREE-FLOATING SPECIES

Small duckweed
Star duckweed

Table 8. Aquatic plants found in Inland Lakes Protection and Rehabilitation District lakes during the 1975-76 survey.

SUBMERGENT SPECIES	**EMERGENT SPECIES**
American pondweed	Arrowhead
Bladderwort	Bulrush sp.
Bushy pondweed	Cattail sp.
Common waterweed (Elodea)	Three-way sedge
Coontail	
Curly-leaf pondweed	
Flatstem pondweed	
Robbins (Fern) pondweed	
Leafy pondweed	**FLOATING-LEAF SPECIES**
Large-leaf pondweed	Spatterdock
Muskgrasses (Chara)	Watershield
Northern watermilfoil	White water lily
Ribbon-leaf pondweed	Floating-leaf pondweed
Sago pondweed	Water smartweed
Small pondweed	Yellow pond lily
Variable pondweed	
Waterthread pondweed	**FREE-FLOATING SPECIES**
Wild celery	Duckweed sp.

Table 9. Aquatic plants found in McCaslin Brook during the 1999 survey.

SUBMERGENT SPECIES	EMERGENT SPECIES
Bladderwort	American bur-reed
Clasping-leaf (Richardson's) pondweed	Broad-leaved cattail
Common waterweed	
Coontail	**FLOATING-LEAF SPECIES**
Flat-stem pondweed	Spatterdock
Large-leaf pondweed	Watershield
Northern watermilfoil	White water lily
Ribbon-leaf pondweed	Floating-leaf pondweed
Sago pondweed	Water smartweed
Various leaved watermilfoil	Yellow pond lily
Water stargrass	
Whitestem pondweed	**FREE-FLOATING SPECIES**
Wild celery (eelgrass)	Small duckweed
	Star duckweed

Importance and Ecological Value of Native Plants

Aquatic plants serve an important purpose in the aquatic environment. They play an instrumental role in maintaining ecological balance in ponds, lakes, wetlands, rivers, and streams. Native aquatic plants have many values. They serve as important buffers against nutrient loading and toxic chemicals, they act as filters that capture runoff-borne sediments, they stabilize lake bed sediments, they protect shorelines from erosion, and they provide critical fish and wildlife habitat. Therefore, it is essential that the native aquatic plant community in the District Lakes be protected. The following is a list of native aquatic plants that were commonly found during the 2005 survey. Ecological values and a description are given for each plant. Plant information was gathered from Borman et. al. (1997), Eggers (1997), Fink (2000), and Whitley et. al.(1999).

Submersed Plants (Plants that tend to grow with their leaves under water.)

Bushy Pondweed (*Najas flexilis*) has a finely branched stem that grows from a rootstock. Leaves are short (1-4 cm), pointed and grow in pairs. Bushy pondweed is an annual and must grow from seed each year. It tends to establish well in disturbed areas. Bushy pondweed is a favorite food of waterfowl and is considered very important. Seeds, leaves and stems are relished by waterfowl, marsh birds, and muskrats. Bushy pondweed stabilizes bottom sediment and offers cover for fish.

Clasping-leaf Pondweed (*Potamogeton richardsonii*) has winding stems that emerge from a spreading rhizome. The heart shaped base of each leaf wraps around most of the stem. No floating leaves are produced. The fruit of this plant is a locally important food source for several waterfowl and mammal species. Leaves provide habitat for invertebrates, and it turn, foraging opportunities for fish.

Common waterweed or **Elodea** (*Elodea canadensis*) is made up of slender stems with small, lance shaped leaves that attach directly to the stem. Leaves are in whorls of 2 or 3 and are more crowded toward the stem tip. Elodea serves as cover for fish and is home to many invertebrates that fish feed upon. Elodea is grazed by waterfowl and muskrats. Studies revealed that elodea can filter toxic chemicals, including turbine oil.

Coontail *(Ceratophyllum demersum)* produces whorls of narrow, toothed leaves on a long trailing stem that often resembles the tail of a raccoon. The leaves tend to be more crowded toward the tip. Coontail blankets the bottom, which helps to stabilize bottom sediments. Tolerant to nutrient rich environments, coontail filters a high amount of phosphorus out of the water column. Coontail provides a home for invertebrates and juvenile fish. Seeds are consumed by waterfowl, but are not of high preference.

Fern Pondweed (*Potamogeton robbinsii*) has thick stems that emerge from a spreading rhizome. Its leaves are fern-like in appearance with fine serrations along the margin. Leaves of the plant offer habitat for invertebrates and foraging opportunities for waterfowl and fish, especially northern pike.

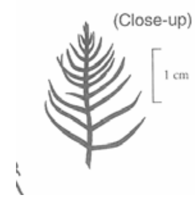
Flat-stem Pondweed (*Potamogeton zosteriformis*) emerges from a rhizome, and has strongly flattened stems. The leaves are narrow and grow 4-8 inches long. Leaves contain a prominent mid-vein and many fine parallel veins. Ecologically, flat-stem pondweed provides a home for fish and invertebrates, and is grazed by waterfowl and muskrats.

Illinois Pondweed (*Potamogeton illinoiensis*) and **Variable Pondweed** (*P. gramineus*) are very similar-looking perennial herbs that emerge from a rhizome. Their stout stems support lance-shaped leaves that come to a sharp point. Both of these pondweeds provide excellent cover for fish and invertebrates. Ducks, geese, muskrats, and beaver find most parts of these plants to be a tasty meal.

Large-Leaf Pondweed (*Potamogeton amplifolius*) also referred to by fisherman as cabbage weed, is a perennial herb that emerges from a ridged black rhizome. This pondweed is the largest of all pondweeds. The sturdy stem supports large broad leaves that are numerously veined (25-37). Growing upright throughout most of the water column, Large-leaf pondweed provides excellent shade, shelter, and foraging habitat for fish. Producing a large number of nutlets, cabbage weed is also valued by waterfowl.

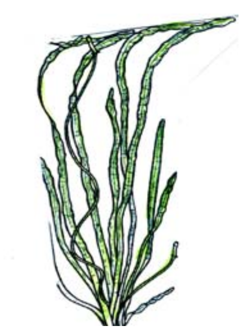
Musk grass (*Chara spp*.) and **Stonewort** (*Nitella*) are complex algae that resemble higher plants. Musk grass is identified by its pungent, skunk-like odor and whorls of toothed branched leaves. Stonewort looks nearly identical, but lacks the strong odor. Ecologically, these plants provide shelter for juvenile fish and are associated with black crappie spawning sites. Waterfowl love to feast on *Chara* when the plant bears its seed-like oogonia. These two species serve an important role in stabilizing bottom sediments, tying up nutrients in the water column, and maintaining water clarity.

Northern Watermilfoil (*Myriophyllum spicatum*) produces whorls of feather-like leaflets from a fairly stout stem. Northern watermilfoil is identified by its 5 to 12 pairs of leaflets that become progressively longer near the base of the leaf – giving the leaf a candelabra-like appearance. The leaves and fruit of this plant are eaten by a variety of waterfowl. Its finely divided leaves are habitat for numerous invertebrates that fish feed upon. Northern watermilfoil is an indicator of good water quality, as the plant seldom survives in more eutrophic environments.



Sago Pondweed (*Potamogeton pectinatus*) is a perennial herb that emerges from a slender rhizome that contains many starchy tubers. Leaves are sharp, thin, and resemble a pine needle. Reddish nutlets (seeds) that resemble beads on a string rise to the water surface in mid-summer. Sago pondweed produces a large crop of seeds and tubers that are valued by waterfowl. Juvenile fish and invertebrates utilize sago pondweed for cover.

Water Celery (*Valisneria americana*) also known as **Wild Celery** or **eelgrass** has long ribbon-like leaves that emerge in clusters. Leaves have a prominent central stripe and leaf tips tend to float gracefully at the water's surface. In the fall, a vegetative portion of the rhizome will break free and float to other locations. Water Celery is considered one of the best all natural waterfall foods. The entire plant is relished by waterfowl, especially canvasbacks. Eelgrass beds serve as an important food source for sea ducks, marsh birds, and shore birds. Fish also find water celery as a popular hiding spot.



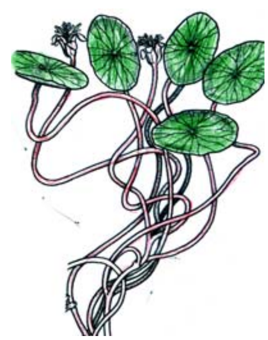
Water Stargrass *(Heteranthera dubia)* resembles some of the narrow-leaved pondweeds. It is dark green to brown with thread-like leaves scattered on flexible stems. A close examination of the leaves will show that they have several veins but no obvious mid-vein. It reproduces from plant fragments. Water stargrass usually becomes abundant in late summer. It settles to the bottom in late autumn where it forms a decaying mat in the winter that provides habitat to many small aquatic animals. Water stargrass provides valuable habitat for fish and serves as habitat for macro-invertebrates fish feed upon.

Floating Leaf Plants (Plants that are rooted into the bottom and have leaves that float at the water's surface.)

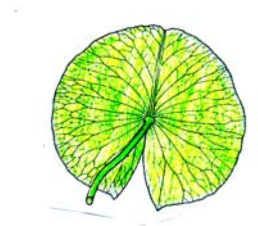
Floating Leaf Pondweed (*Potamogeton natans*) is a perennial that emerges from a red-spotted rhizome. Leaves that rest at the waters surface are heart shaped. Submerged leaves tend to be longer and skinnier than floating leaves. Fish find this pondweed to be useful for foraging opportunities and shelter. Growing upright in the water column, floating leaf pondweed attracts many aquatic invertebrates. Muskrats, ducks, and geese all graze on the plant.

Spatterdock (*Nuphar variegata*) is a perennial herb that produces yellow, rounded flowers. Large (4-10 inches) long, heart-shaped leaves float at the waters surface. Leaf stalks have flattened wings and emerge from a buried spongy rhizome. With large buried rhizomes, spatterdock helps stabilize bottom sediment. The large leaves also help buffer the impact of wave action on the shoreline. Like lilies, spatterdock offers excellent fish habitat. Seeds are eaten by waterfowl; leaves, rhizomes, and flowers are relished by muskrats, beaver, moose, and deer.

Watershield (*Brasenia schreberi)* as its name implies has leaves shaped like a small shield that floats at the water's surface. This perennial has leaves that are green on the upper side and purple on the underside. The pinkish stem is elastic and attaches to the middle of the leaf. Submersed parts of this plant are covered with a thick gelatinous slime. Under favorable conditions watershield can form huge colonies. Ecologically, waterfowl consume most portions of this plant. The stems and floating leaves offer cover for fish and invertebrates.



White Water Lily (*Nymphaea odorata*) emerges from a buried rhizome. Durable round stalks grow up from the rhizome. This perennial herb supports large round leaves (4-10 inches) wide that float at the water's surface. Leaves appear waxy green on top and reddish-purple on their undersides. At mid-summer, showy white flowers float at the water's surface. Lilies serve as important fish cover, especially for largemouth bass. White water lily seeds are eaten by waterfowl. Rhizomes, flowers, and leaves are consumed by muskrats, beaver, deer, and moose. With large broad leaves, lilies also help prevent shoreline erosion by slowing wave action.



<u>**Emergent Plants** (Plants that are rooted into the bottom and have leaves that emerge above the water's surface.)</u>

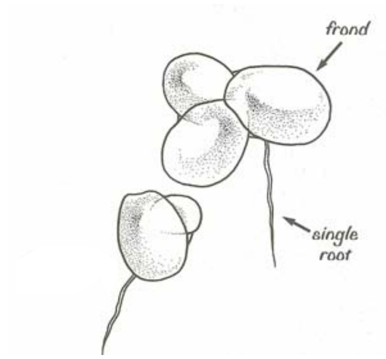
Bulrushes (*Scirpus spp.*) are perennial herbs that prefer growing on hard bottom substrates. Olive-green stems emerge above the water's surface. Stems grow 3-9 ft., and can grow in water up to 6 ft. deep. Bulrushes provide important spawning, nursery, and foraging habitat for fish, especially northern pike. Seeds are feasted on by a variety of waterfowl. They also provide food and shelter for muskrats. Bulrushes offer important cover and nesting opportunities for marsh birds. Bulrushes are second only to pondweeds in the number of animal users. Bulrushes also play an important role in improving water quality. They are known for their ability at up-taking excessive nutrients and stabilizing both shoreline and bottom sediment.

Sedges (*Carex spp.*) are perennial herbs that appear grass-like and have triangular solid stems. Sedges contain a perigynium, a sac-like structure that covers the ovary and nutlet. The perigynium distinguishes sedges from all other plants. Sedges provide important nesting cover and food for a wide variety of songbirds, upland game birds, shore birds, and waterfowl. Amphibians, including frogs and salamanders utilize *Carex* for feeding, shade, and protection. Sedges also serve as important buffer species against nutrient loading and shoreline erosion.

Broad-Leaved Cattail (*Typha latifolia*) emerges from a robust spreading rhizome. This perennial herb has pale green, sword-like leaves that grow up to 9 ft. tall. The male and female flowers grow on the same spike and there's no gap between them. Cattails provide cover and or food for a variety of wildlife including muskrats, black birds, marsh wrens, and waterfowl. Deer and pheasants also seek cattail stands for winter cover. Cattails serve as a home to many invertebrates and are an important spawning habitat for fish. With a network of large rhizomes, cattails also are sturdy shoreline stabilizers.

<u>**Free -Floating f Plants (**Plants that are not be rooted to the bottom but float freely at the water's surface.)</u>

Duckweeds are is among the world's smallest vascular plants. Individual plants are tiny, round, and bright green disks, with or without roots. In lakes, they are found scattered among emergent plants or massed together in floating mats. Duckweeds are also commonly found in stagnant waters. Duckweed can occur as single plants or as small colonies of connected plants. They provide food for fish and waterfowl and habitat for aquatic invertebrates.



Managing native aquatic plants

Manual Removal

Lakefront property owners can manage aquatic plant along their own frontages using hand pulling, cutting or raking. State statutes currently allow removal of aquatic vegetation to a maximum width of 30 feet per property to provide necessary access for boating or swimming without a permit. Removal may be done as far as necessary into the lake to provide access. (Note: if only exotic aquatic plants are targeted these restrictions do not apply.) If individuals wish to remove aquatic vegetation in an area exceeding the 30-foot width, a permit from the WDNR will be required. Advantages of manual removal include precision control, low cost and the ability to do so without obtaining a permit. The main disadvantage of manual removal is that the method is often labor intensive. Disposal of harvested plant matter may be another disadvantage.

Removal of plants along a lakeshore – by any means – can be disruptive to lake ecology. Much important habitat has been lost or degraded in Wisconsin lakes due to removal of aquatic vegetation by lakefront property owners. Poorer quality fisheries, loss of wildlife and reduced water quality are often the result of these activities. There is also evidence to suggest that removal of native vegetation can encourage the spread of harmful exotic plants. Therefore lakefront property owners are discouraged from removing native vegetation from their lakefronts. If removal is required, it should be limited to only what is necessary.

Mechanical harvesting

Mechanical harvesting involves cutting of plants from a boat- or barge-mounted device. Modern harvesters utilize cutting, retrieval, storage and transportation mechanisms. Mechanical weed harvesting is the most widely used method for large-scale management of native aquatic plants. Both navigation lanes and large open water areas can be cut. The advantages of mechanical harvesting are that aquatic plants are only mowed, not killed, which allows aquatic plant communities and the ecological values they provide to remain intact. There are perhaps no other options for large-scale management of native plants that offer this important feature. The primary disadvantage of this method is that it is very labor intensive and costly. Other disadvantages of this method are that it is not suitable for use in confined areas such as around docks, that substantial numbers of fish, reptiles, amphibians and invertebrates are killed, that cut plant fragments can cause a nuisance if not carefully collected, and that it is not suitable for management of Eurasian watermilfoil. Management plans, permits and reporting are requirements of mechanical harvesting programs.

Herbicides

Application of aquatic herbicides is a common method for control of unwanted aquatic plants around docks and swim areas and in certain navigation lanes. Use of aquatic herbicides for large-scale control of native plants is seldom used, however. Native plants have many important values in a lake environment. Large-scale removal of native plants may cause a shift to undesirable algae or exotic plants, or may encourage resuspension of bottom sediments. WDNR permits are required for all aquatic herbicide applications. Treatments are generally restricted to 50 foot wide X 150 deep areas along individual frontages, or to designated navigation lanes.

The use of herbicides to control nuisance plants around docks and swimming areas is popular because it is an effective, practical and readily available method. Further, most approved aquatic herbicides are biodegradable and pose little direct risk to humans or the environment. A major drawback of aquatic herbicides is that they are less precise than other methods, such as manual removal. Herbicide drift is a problem with aquatic applications. Herbicide drift can negatively affect plant communities outside of target areas. This is most likely to occur when multiple adjacent property owners are conducting treatments. Because of this factor, great discretion should be used with this method. Precise application methods, and formulations or adjuvants that retard drift should also be used whenever possible.

Again, removal of plants along a lakeshore – by any means – can be disruptive to lake ecology. Nearshore aquatic plant communities are often the most important to lake ecology. They are also the most vulnerable of lake habitats. Therefore lakefront property owners are discouraged from removing native vegetation from their lakefronts. If removal is required, it should be limited to only what is necessary.

Benthic Barriers

Benthic barriers are synthetic blankets that are placed over the lakebed to smother plants. This method is only practical for small areas. Benthic barriers must be regularly removed, cleaned and replaced or else plants will growth through them or on top of them in a relatively short period of time. Barriers must also be securely anchored or wave energy will displace them. Because use of benthic barriers is so labor intensive, they are seldom used properly and, therefore, are seldom effective. WNDR permits are required to place benthic barriers, or any other structure or material upon the lakebed.

Eurasian watermilfoil

Life history

Eurasian Watermilfoil (*Myriophyllum spicatum*) produces long spaghetti-like stems that often grow up to the water's surface. Leaves are feather-like and resemble bones on a fish. 3-5 leaves are arranged in whorls around the stem, and each leaf contains 12-21 pairs of leaflets. At mid-summer small reddish flower spikes may emerge above the water's surface. Perhaps the most distinguishing characteristic though, is the plant's ability to form dense, impenetrable beds that, inhibiting boating, swimming, fishing, and hunting.

Eurasian watermilfoil is native to Europe, Asia and Northern Africa. Of the eight milfoil (*Myriophyllum*) species found in Wisconsin, Eurasian watermilfoil is the only exotic. The plant was first introduced into U.S. waters in 1940. By 1960, it had reached Wisconsin's lakes. Since then, its expansion has been exponential (Brakken, 2000).

Threats to our lakes

Eurasian watermilfoil begins growing earlier than native plants, giving it a competitive advantage. The dense surface mats formed by the plant block sunlight and have been found to displace nearly all native submergent plants. Over 200 studies link declines in native plants with increases in Eurasian watermilfoil (Madsen, 2001). The resultant loss of plant diversity degrades fishery habitat (Pullman, 1993), and reduces foraging opportunities for waterfowl and aquatic mammals. Eurasian watermilfoil has been found to reduce predatory success of fish such as largemouth bass (Engle, 1987), and spawning success for trout (*Salmonidae spp.*) (Newroth, 1985).

The continued spread of Eurasian watermilfoil can produce significant economic consequences. In the Truckee River Watershed below Lake Tahoe, located in western Nevada and northeastern California, economic damages caused by Eurasian watermilfoil to the recreation industry have been projected at $30 to $45 million annually (Eiswerth, et. al., 2003). In Tennessee Valley Authority Reservoirs, Eurasian watermilfoil was found to depress real estate values, stop recreational activities, clog municipal and industrial water intakes and increase mosquito breeding (Smith, 1971).

Eurasian watermilfoil has been found to reduce water quality in lake by several means. Dense mats of Eurasian watermilfoil have been found to alter temperature and oxygen profiles – producing anoxic conditions in bottom water layers (Unmuth, et. al., 2000). These anoxic conditions can cause localized die-offs of mollusks and other invertebrates. Eurasian watermilfoil has also been found to increase phosphorus concentration in lakes through accelerated internal nutrient cycling (Smith and Adams, 1986). Increased phosphorus concentrations caused by Eurasian watermilfoil have been linked to algae blooms and reduced water clarity.

Distribution

Eurasian watermilfoil was found in the north basin of Reservoir Pond and in Horn Lake during the August 2005 survey. In Reservoir Pond it was scattered over an 8.2 acre area adjoining the channel to Horn Lake and in the area where the weed harvesters were docked. Eurasian watermilfoil was found in three locations in Horn Lake. These beds were denser and ranged in size from 0.4 acres to 3.2 acres (**Figure 5**). These milfoil colonies appeared to be young, pioneering stands, and were likely recent arrivals to the system.

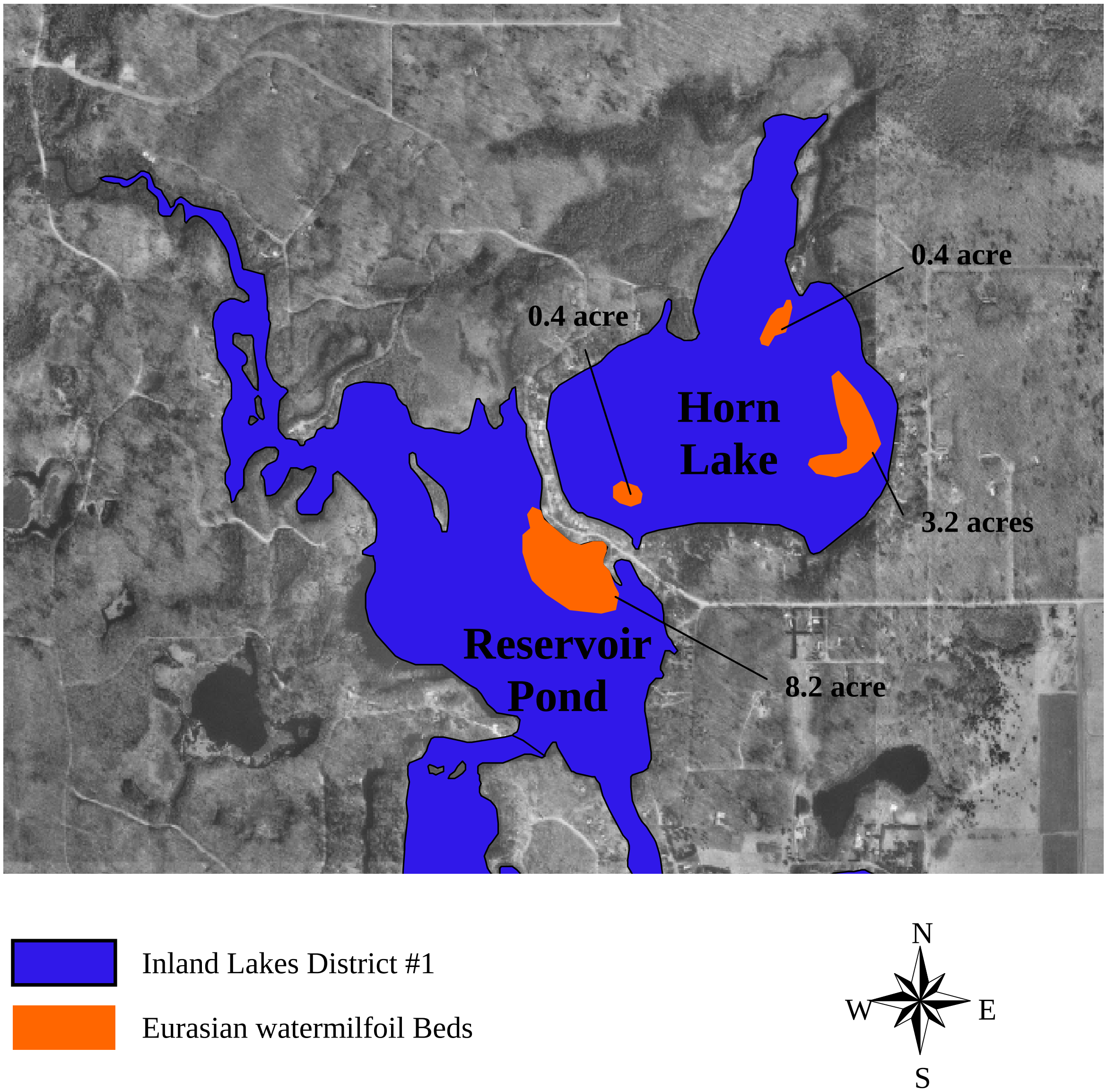
Management Alternatives

Historically, management of Eurasian watermilfoil has included mechanical, biological, and chemical means. It is important to consider each of these control measures before implementing a management program. After weighing the pros and cons of each option, the wisest course of action should be chosen.

Hand pulling

Hand pulling of Eurasian watermilfoil is a useful tool when the plant occurs at very low frequencies. For this method to be successful, care must be taken to remove the entire root mass along with the plant or else it will quickly regenerate. Given the current distribution of Eurasian watermilfoil in Reservoir Pond and Horn Lake, this method would not be practical as a control option. However, if other management options are successful in reducing Eurasian watermilfoil to a sparse distribution, this option should be reconsidered. This is still an alternative for riparian property owners. Without obtaining a permit, individuals can hand pull all aquatic plants in a 30-foot wide strip along their shoreline, and extending out as far as necessary. If exotic plants are singled out for hand removal, there are no restrictions on the extent of hand-pulling. If large amounts of milfoil are present, it will be labor intensive. If individuals choose to hand pull, care should be taken to properly identify Eurasian watermilfoil and to minimize its fragmentation.

Figure 5. Distribution of Eurasian watermilfoil in Reservoir Pond and Horn Lake, Inland Lakes Protection and Rehabilitation District No. 1, Oconto County,WI.



Drawdown

Some recent management efforts in Wisconsin indicate that water level drawdown may be an effective management alternative for controlling Eurasian watermilfoil and restoring native plant communities. If water levels are drawn down in late summer to the depths where Eurasian watermilfoil is found and left exposed for the fall and winter, then allowed to refill in spring, Eurasian watermilfoil plants will die from desiccation or freezing. If the Eurasian watermilfoil has not produced seed, it is possible that it will not regenerate. Heavy winter snow cover, however, may prevent Eurasian watermilfoil from freezing and will allow plants to survive. Drawbacks of this method are that it is often unpopular with lake users, and that fish spawning may be unsuccessful.

Since District Lakes are impounded some drawdown of water levels is possible. However, it would not be possible to draw down Horn Lake to a level where Eurasian watermilfoil would be exposed. Thus this method could not be effective in providing system-wide control of Eurasian watermilfoil.

Mechanical harvesting

Mechanical control methods include hand cutters and boat-mounted mechanical weed harvesters (Nichols, 1974). While these methods provide temporary nuisance relief, they are rarely recommended as control methods for Eurasian watermilfoil. Eurasian watermilfoil can reproduce effectively through fragmentation (Borman et al. 1997). Free-floating plant matter left from cutting operations can spread quickly and encourage additional infestations within the lake or in neighboring lakes. Although harvesting does remove plant matter, and therefore nutrients, from the lake, it is unlikely that harvesting will induce a shift back to a native plant-dominated community. Therefore attempting to control Eurasian watermilfoil through mechanical harvesting would be a poor choice for the Lake District.

Milfoil weevils

There has been considerable research on biological vectors, such as insects, and their ability to affect a decline in Eurasian watermilfoil populations. Of these, the milfoil weevil (*Euhrychiopsis lecontei*) has received the most attention. *Native* milfoil weevil populations have been associated with declines in Eurasian watermilfoil in natural lakes in Vermont (Creed and Sheldon, 1995), New York (Johnson et al., 2000) and Wisconsin (Lilie, 2000). While numerous lake groups have attempted to augment native milfoil weevil populations through stocking - in hopes of controlling milfoil in a more natural manner - this method has not proven successful in Wisconsin. A twelve-lake study called "The Wisconsin Milfoil Weevil Project" (Jester et al. 1999) conducted by the University of Wisconsin, Stevens Point in conjunction with the WDNR, researched the efficacy of weevil stocking. This report concluded that milfoil weevil densities were not elevated, and that Eurasian watermilfoil was unaffected by weevil stocking in any of the study lakes. Until more evidence that suggests weevil stocking is an effective control agent for Eurasian watermilfoil, this method should be discouraged as control option.

Herbicides

Herbicides have been the most widely used and most successful tools for controlling Eurasian watermilfoil. The two herbicide groups most commonly employed are fluridone (Avast®, Sonar®) and 2,4-D (Aquacide®, Aquakleen®, Navigate®, and Weedar 64®). Whole-lake Sonar® treatments have been conducted on several Wisconsin Lakes. While initial results were encouraging (species selectivity, 95-100% initial control), continued monitoring found that desired long-term control was not achieved (Cason, 2002). Another drawback is that it may take fluridone 60 to 90 days to achieve full control of Eurasian watermilfoil. This may mean that plant matter will be dying off and decomposing during the warmest part of summer – a factor that may contribute to algae blooms and poor water quality. Further, because fluridone is applied as a liquid, this option is impractical in a flow-through lake system such as Reservoir Pond and Horn Lake.

Granular 2,4-D herbicides, on the other hand, have been very effective at controlling Eurasian watermilfoil in hundreds of Wisconsin lakes. Granular formulations produce localized control and are therefore effective for both large and small area treatments, as well as treatments in moving water. 2,4-D herbicides also offer a high degree of species selectivity (the ability to single out Eurasian watermilfoil for control), and have few water use restrictions. Treatment of Eurasian watermilfoil using granular 2,4-D will be the most practical and economical option for the District.

Herbicide Facts

While 2,4-D may be the most practical and widely used method for controlling Eurasian watermilfoil, a number of concerns should be addressed before this type of control program is implemented by the Lake District.

Is this herbicide safe for humans? The Environmental Protection Agency (EPA) lists 2,4-D as a Class D herbicide. This classification means that there is insufficient data to suggest that either compound causes cancer or is harmful to humans. The University of Michigan School of Public Health recently concluded a review of more than 160 toxicological and epidemiological studies on 2,4-D and concluded that there was not adequate evidence to link 2,4-D exposure to any forms of cancer. (Garabrant and Philbert, 2002) Nor does 2,4-D from treated lakes appear to be able to contaminate well water. The Michigan Department of Environmental Quality recently released results of a 4-year study of drinking water wells surrounding twelve lakes heavily treated with 2,4-D. To date, no traces of 2,4-D have been found in any of the test wells (Bondra, 2002).

The EPA product label lists no water use restrictions for swimming or fish consumption following treatment with 2,4-D. While it is not possible to guarantee that any herbicide is 100% safe, the overwhelming body of evidence suggests that 2,4-D herbicides, when properly used, pose minimal risks to humans.

Is this herbicide safe for the environment? 2,4-D is organic in nature and biodegrades quickly in aquatic environments. In three separate field studies, 2,4-D concentrations were non-detectable 14 days after treatments done at 100 lbs./acre. 2,4-D does not bioaccumulate. For example, even if fish consume 2,4-D pellets, the chemical is quickly excreted without entering muscle tissues. For these reasons, there are no label restrictions on fish consumption.

Will this herbicide affect desirable plants? Applied correctly at prescribed rates (100-150 lbs/acre), 2,4-D is highly selective to Eurasian watermilfoil. According to the product label, water stargrass and watermilfoils are susceptible to 2,4-D applied at 100-200 lbs/acre. Coontail, watershield and water lilies are slightly to moderately resistant to 2,4-D at higher rates (150-200 lbs/acre). At lower rates these and other native plants respond positively to treatments, and the resulting decreases in Eurasian watermilfoil occurrences.

Is it effective? 2,4-D herbicides have been used on thousands of lakes throughout North America. To date 2,4-D treatments have been the single most effective Eurasian watermilfoil control method. In fact, the number of lakes in Michigan having Eurasian watermilfoil problems has actually declined as a result of 2,4-D use (Pullman, 1993).

Is it economical? While no control method could be considered cheap, herbicide treatments are among the least costly of methods. This is in part due to the relatively low labor costs in comparison to measures such as hand-pulling, mechanical harvesting, etc. Perhaps the greatest consideration is that these herbicides typically produce long-term control of exotics. This means that lake management units seldom need to spend as much in the long-term as they do for the initial treatments. Once the target species are brought under control, the costs of annual maintenance treatments, if needed, are minimal.

What are the disadvantages? The greatest disadvantage of herbicide treatments is that they rarely produce 100% control in a single application. In most cases, herbicides tend to work only where applied. This is more the case with granular formulations. Unnoticed and untreated plants may eventually grow to dense beds if left unchecked. Factors such as pH and plant maturity may also reduce treatment efficacy. Several follow-up treatments, whether in-season or in subsequent years, may be needed to reduce exotic species to target levels.

Purple Loosestrife

Life History

Purple Loosestrife (*Lythrum salicaria*) forms bright purple flowers in a spike atop stems that reach 2 to 7 feet in height. Lance-shaped leaves are arranged oppositely along the stem. Purple loosestrife can be found in a wide variety of habitats from shallow water to moist soils. Like Eurasian watermilfoil it is a very aggressive plant that can displace many native wetland plants including cattails (*Typha spp.*). Purple loosestrife plants produce hundreds of thousands of tiny seeds. When purple loosestrife is cut, seeds stick to mowing equipment and are spread to new locations. This invasive plant causes significant economic damage by clogging waterways and irrigation canals. Unlike cattails, purple loosestrife has little food or cover value for wildlife (Borman, et. al. 1997). When food and cover disappear, so do the species that depend on it.

Management options

There are several methods that are commonly used for purple loosestrife control: digging and hand pulling, cutting, herbicide treatments and biological controls. Digging and hand pulling are most effective for small infestations. Individual property owners are encouraged to use this method if they are able. Cutting involves removal and destruction of flowers and seed heads to inhibit plant propagation. Since cut plants tend to re-grow and since seeds present in the soils can sprout new plants, this method will need to be done for a number of years before desired control is achieved. Herbicide treatments are the easiest and most economical of methods. The preferred herbicide is glyphosate (Eagre®, Rodeo®). This product rapidly biodegrades upon contact with soil or water. There are no water use restrictions following treatment. Because it is non-selective, each individual plant must be sprayed, as opposed to broadcast applications. Glyphosate is extremely effective in controlling purple loosestrife. It is also a very low cost treatment. The biggest disadvantage is that seeds in the soil will sprout new plants, requiring annual treatments for a number of years before desired control is achieved. Biological controls using several species of beetles and a weevil from Europe, by far show the most promise for long-term control of purple loosestrife (WDNR PUB-WT-276 2001). However this method is generally not recommended for small infestations as was found on McCaslin Brook because of the labor, time and expense involved.

Water Quality

Dissolved Oxygen and Temperature Profiles

Oxygen concentration is one of the greatest limiting factors in aquatic ecosystems. Because water is capable of holding relatively low levels of oxygen relative to air, oxygen is easily depleted by respiration and decomposition unless continually replenished. Atmospheric diffusion and photosynthesis are the main sources of dissolved oxygen. However, photosynthesized oxygen concentrations vary considerably. In fact, very productive lakes may experience periodic anoxic conditions.

Dissolved oxygen and temperature data for District Lakes were used to develop profile graphs for each lake basin (**Figure 6**). Generally, the levels of dissolved oxygen throughout each lake were sufficient to support a healthy aquatic ecosystem. Only Little Horn Lake experienced significant oxygen depletion, but this was confined to depths below 20 feet.

It is important to understand the relationship between dissolved oxygen and temperature. As a rule, colder water can hold more oxygen than warmer water (Shaw, et al. 1998). The percent saturation column in **Table 10** illustrate this point.

Table 10. Oxygen solubility in water at different temperatures (from Shaw, et al. 1998).

Temperature ºC	ºF	Oxygen solubility (mg/L)
0	32	15
5	41	13
10	50	11
15	59	10
20	68	9
25	77	8

Percent saturation is a measure of how much oxygen is present in the water in comparison to the solubility of oxygen at the given temperature (Mitchell, et al. 2000). Percent saturation values over 80% reflect excellent water quality, while values in the mid to upper 70's indicate good water quality. In the case of District Lakes, dissolved oxygen readings do not appear to follow the solubility rules for oxygen and temperature. In general dissolved oxygen concentrations decrease with temperature as depths increase. This occurs when decomposition of organic matter creates a higher biological oxygen demand in the deeper portions of the lake. A substantial drop in the concentration of dissolved oxygen in lake is often seen at or just above the sediment layer. Microbial activity in the sediment consumes oxygen resulting in an oxygen depleted zone. Often the extent of oxygen depletion can reach well above the lakebed into the water column. When anaerobic conditions like this occur, nutrients, otherwise tied up in the sediments, become soluble and are released into the water column where they can feed excessive plant and algal growth. Once these conditions become established, a continual cycle of nutrient release can occur causing a dramatic decrease in the water quality of a lake. In lakes with high oxygen levels throughout the water column, this magnitude of nutrient release from sediment is not seen.

Secchi Disc Depth

In addition to measuring the water clarity of a lake, Secchi discs are also used to gauge water quality and productivity of a lake. There is an inverse relationship between Secchi depth and the amount of suspended matter, including algae, in the water column. The less suspended matter, the deeper the Secchi disc is visible.

During the time of sampling, Secchi disc depths were 13.9 feet for Explosion Lake, 12.5 feet for Little Horn Lake, 10.0 feet for Reservoir Pond and 6.0 feet for Horn Lake. **Figure 7** shows the ranking of District Lakes on the Secchi disc water quality index. Explosion, Little Horn and Reservoir all rank in the "good" water quality range, while Horn Lake ranks in the "fair" water quality range.

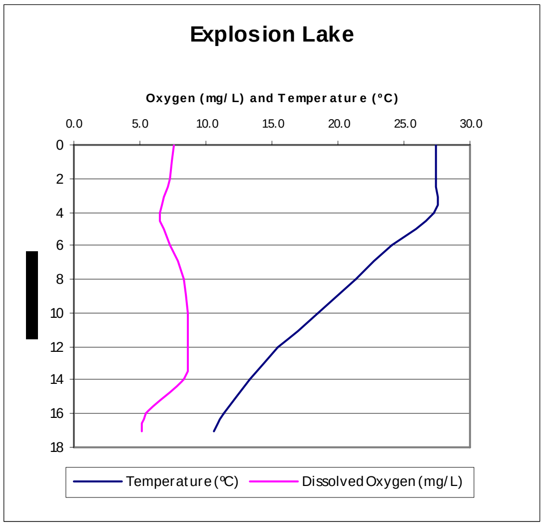
pH

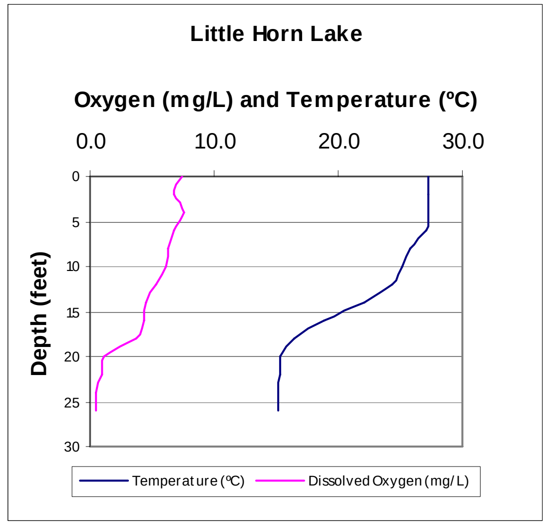
pH is the negative logarithm of the H+ (hydrogen ion) concentration. The product of H+ and OH- (hydroxyl) ions present in water is a constant. This constant is known as the dissociation constant of water. Theoretically, pure water has equal concentrations of H+ and OH- and is neutral in reaction. Neutral water has a pH of 7. When OH- becomes greater than H+, pH rises and water is considered basic or alkaline. When H+ becomes greater than OH-, water is considered acidic. Since pH is a logarithmic scale, an increase of 1.0 in pH equals a ten-fold increase in OH- concentration. Thus water with a pH of 9 is 100 times more alkaline than water with a pH of 7.

The pH of lakes is affected by many factors. Rainwater is acidic and can lower pH. However this reaction is often buffered by calcium bicarbonate. Plant productivity will raise pH. Calcium bicarbonate is actively broken down by plants in the reactions of photosynthesis. The release of OH- from this reaction raises pH (Ruttner, 1953).

Extremes in pH can have negative effects on aquatic life. In Wisconsin, most pH – related problems with lakes are due to low pH. Low pH can inhibit fish spawning and even cause fish kills. Low pH can also lead to the precipitation of mercury, zinc and aluminum from bedrock. These metals can cause health problems for fish and animals that feed upon them, notably: loons, eagles and humans (Shaw, et. al., 2000). Fortunately the pH found District Lakes are relatively high, and these are not concerns. The high pH found in District Lakes are predominantly the result of local geology, as area lakes tend to be alkaline, but are also partly the result of plant productivity.

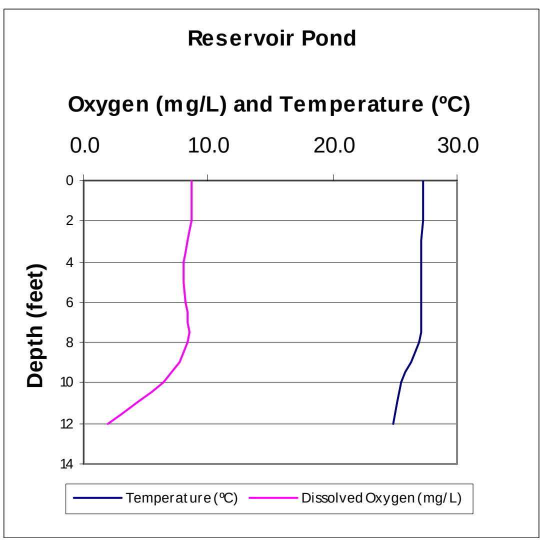
Figure 6. Water quality data for the Inland Lakes Protection and Rehabilitation District No. 1, Oconto County, Wisconsin, August 4, 2005.

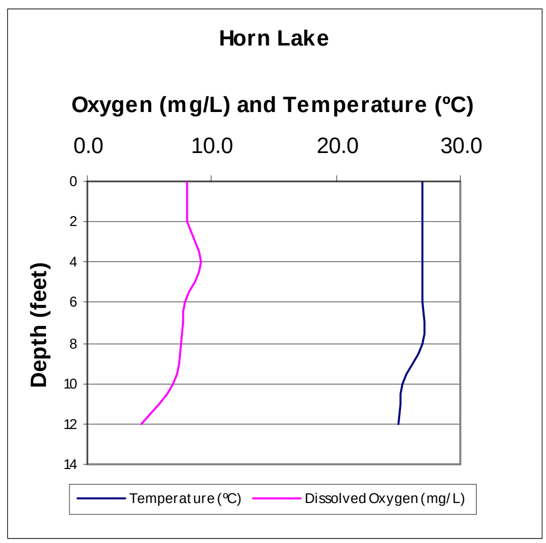




pH = 7.87 Secchi = 13.9

pH = 8.29 Secchi = 12.5

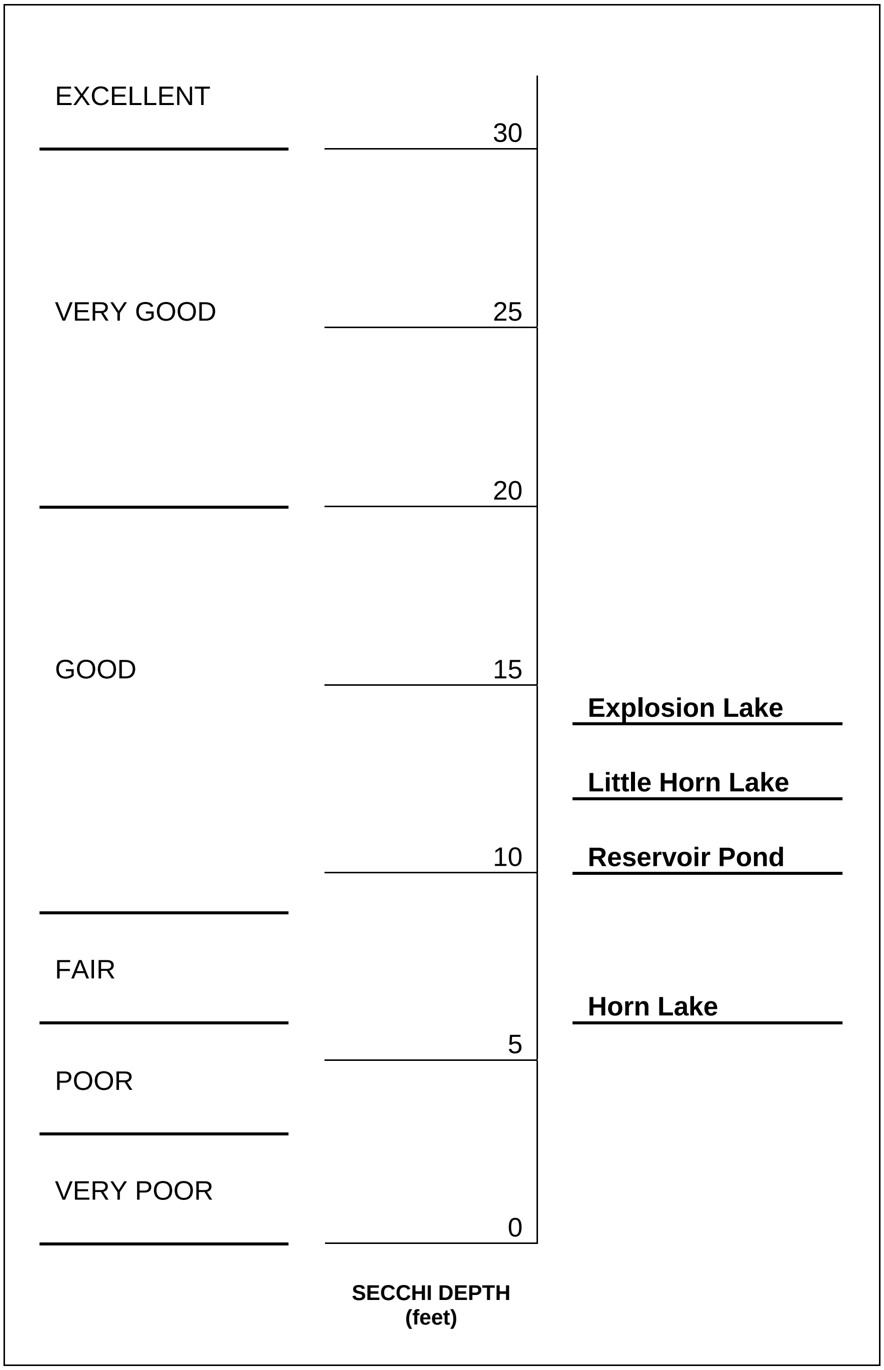




pH = 8.70 Secchi = 10.0

pH = 8.84 Secchi = 6.0

Figure 7. Secchi disc depth water quality index.



Adapted from Shaw, et. al. (2000).

Water Quality Improvement Practices

Elevated nutrient inputs from human activities around lakes can adversely affect both water clarity and water quality. This may directly affect the plant community by encouraging nuisance growth of both native and nonnative species. It can also negatively impact the lake's fishery, by reducing or eliminating conditions needed for survival of certain fish species. Therefore protecting lake water quality is essential to maintaining and enhancing the entire biotic community of District Lakes. The following list describes activities individual lakefront property owners can undertake to improve water quality.

Vegetative buffer zones

There are beneficial alternatives to the traditional mowed lawn. The best alternative is to protect the natural shoreline and leave it undisturbed. If clearing is necessary to access and view the lake, consider very selective removal of vegetation. Restoring a vegetative buffer zone is also an important alternative.

A recommended buffer zone consists of native vegetation that may extent from 25 – 100 feet or more from the water's edge onto land, and 25 – 50 feet into the water. A buffer should cover at least 50%, and preferably 75% of the shoreline frontage (Henderson et al., 1998). In most cases this still allows plenty of room for a dock, swimming area, and lawn. Buffer zones are made up of a mixture of native trees, shrubs, upland plants, and aquatic plants.

Shoreline vegetation serves as an important filter against nutrient loading and trapping loose sediment. The buffer provides excellent fish and wildlife habitat, including nesting sites for birds, and spawning habitat for fish. Properly vegetated shorelines also play a key role in bank stabilization. Wisconsin Lake and Pond Resource, LLC can provide a number of native shoreline plant species and assist property owners in creating beneficial buffer zones.

Lawn care practices

Mowed grass up to the water's edge is a poor choice for the well being of the lake. Studies show that a mowed lawn can cause 7 times the amount of phosphorus and 18 times the amount of sediment to enter a water body (Korth and Dudiak, 2003). Lawn grasses also tend to have shallow root systems that cannot protect the shoreline as well as deeper-rooted native vegetation (Henderson et al., 1998).

Landowners living in close proximity to the water should be discouraged from using lawn fertilizers. Fertilizers contain nutrients, including phosphorus and nitrogen can wash directly into the lake. While elevated levels of phosphorus can cause unsightly algae blooms, nitrogen inputs have been shown to increase weed growth. Landowners are encouraged to perform a soil test before fertilizing. A soil test will help determine if you need to fertilize, and give you direction on fertilizing. For assistance in having your soil tested, contact your county UW-Extension office. If there is a need to fertilize your lawn, use a fertilizer that does not include phosphorus. Most lawns in Wisconsin don't need additional phosphorus. The numbers on a bag of fertilizer are the percentages of available nitrogen, phosphorus and potassium found in the bag. Phosphorus free fertilizers will have a 0 for the middle number (e.g. 10-0-3).

To further reduce nutrient loading, avoid raking twigs, leaves, and grass clippings into the lake. They contain nitrogen and phosphorus. The best disposal for organic matter, like leaves and grass clippings is to compost them. Composted material can then be used for gardening.

Septic system maintenance

It is the responsibility of lakeshore property owners to ensure that septic systems, if present, are properly functioning. A failing septic system can contaminate both surface and ground water. If located in a groundwater discharge area, failing septic systems can be a major cause of nutrient loading in lakes. Systems should be professionally inspected every 3 years, and pumped every 2-5 years depending on operating circumstances (EPA, 2002). Avoid flushing toxic chemicals into the system. This can harm important bacteria that live in your tank and naturally break down wastes. Avoid planting trees in the drain field, compacting soil within the drain field, and directing additional surface runoff on top of the drain field.

Erosion control

Erosion is a natural process, but it's for the benefit of the landowner and health of the lake that erosion control practices be carried out to slow the process as much as possible. Sedimentation into the lake causes nutrient pollution, turbid water conditions, eliminates fish spawning habitat, and increases eutrophication. Shoreline owners are encouraged to leave existing vegetation, which is a great shore stabilizer. The placement of logs, brush mats, and rock riprap are also options against erosion. When riprap is used it is recommended that desirable shrubs and aquatic plants be planted within the riprap. The plantings serve as nutrient filters and habitat. Before any shoreline stabilization project is initiated, it is recommended that property owners contact the local DNR office for project approval and to obtain any necessary permits.

Rainfall is one of the most powerful things on earth (Holdren et al., 2001). When a rain event occurs loose sediment can be washed directly into the lake or into inlets that drain into the lake. Disturbed areas with loose soil, including plowed farm fields, pastures, and construction sites, should all be areas of concern. Precautions in disturbed areas need to be addressed. The use of silt fencing is a popular tool designed to help control erosion on construction sites.

Emergent plant restoration

Shoreline vegetation can benefit lake ecology tremendously. A properly vegetated shoreline provides habitat for a variety of birds, furbearers, amphibians, and reptiles. Benefits to lake water quality, fishery and wildlife can be achieved by restoring emergent plants. Lakefront habitat improvement is often done on a property-by-property basis. In recent years many new techniques have been developed for restoring lakefronts. This type of work often incorporates many attractive flowering plants and adds a great deal of aesthetic appeal to lakefronts as well.

Informational resources for shoreline restoration

Lakescaping for Wildlife and Water Quality. This 180-page booklet contains numerous color photos and diagrams. Many consider it the bible of shoreline restoration. It is available from the Minnesota Bookstore (651-297-3000) for $19.95.

Woodworking for Wildlife: Homes for Birds and Mammals. by Carrol L. Henderson. 112 pages. Recommended for anyone wishing to construct homes to attract wildlife and enhance habitat. It is available from the Minnesota Bookstore (651-297-3000) for $9.95.

The Living Shore. This video describes buffer zone construction and gives information on selecting and establishing plants. May be available at local library, or order from the Wisconsin Association of Lakes (800-542-LAKE) for $17.00.

A Fresh Look at Shoreland Restoration. A four-page pamphlet that describes shoreland restorations options. Available from UW Extension (#GWQ027) or WDNR (#DNR-FH-055).

What is a Shoreland Buffer? A pamphlet that discusses both ecological and legal issues pertaining to riparian buffer zones. Available from UW Extension (#GWQ028) or WDNR (#DNR-FH-223).

Life on the Edge…Owning Waterfront Property. A guide to maintaining shorelands for lakefront property owners. Available from UW Extension-Lakes Program, College of Natural Resources, University of Wisconsin, Stevens Point, WI 54481, for $4.50.

The Water's Edge. A guide to improving fish and wildlife habitat on your waterfront property. Available from WDNR (#PUB-FH-428-00).

Conclusions and Recommendations

Eurasian watermilfoil control strategies

Eurasian watermilfoil represents the greatest threat to District Lakes and should be the primary concern of the Inland Lakes Protection and Rehabilitation District #1. Because so much of the District Lakes are capable of supporting dense growths of aquatic plants, the potential for expansion of Eurasian watermilfoil is extreme. Because Eurasian watermilfoil spreads so quickly, steps should be taken immediately to control the plant.

Treatment plan

The District should apply for a WDNR permit to chemically treat Eurasian watermilfoil in Reservoir Pond and Horn Lake, and should contract with a licensed aquatic applicator to conduct treatments as soon as possible in 2006. Treatments should be made with granular 2,4D herbicide at rates of 100 – 150 lbs./acre. The initial treatment should target all Eurasian watermilfoil beds at once. If post treatment monitoring efforts find survival or regrowth of Eurasian watermilfoil, these plants should also be spot treated with granular 2,4D herbicide at rates of 100 – 150 lbs./acre. The initial treatment should take place in spring or early summer while plants are actively growing – typically when water temperatures are between 55 - 70° F. Mechanical harvesting operations should be suspended in all areas where Eurasian watermilfoil has been found until it has been deemed to be eradicated. The District should be prepared each year thereafter to monitor and spot treat any recurring Eurasian watermilfoil using the same methods. Using this strategy, the District should be successful in preventing Eurasian watermilfoil from having a negative influence on District Lakes.

Prevention strategies

Improved public awareness is one of the most important prevention strategies and is a key component of an effective exotic plant species control program. By becoming knowledgeable about the conditions of it’s waters, The District can learn what practices are necessary to restore the plant community and keep the lakes in good health. There are number of activities that volunteers and individuals can carry out to improve lake users’ awareness of the challenges facing The District.

It is important that all access points to the lake be posted with exotic species prevention signs available through the DNR. It is recommended that these signs encourage boaters, whether entering or leaving the lake remove any plant material from their watercrafts before continuing. Several other prevention and educational awareness activities should be planned. This can include public notices regarding exotic species, distribution of DNR educational literature to public lake users, and conducting watercraft inspections. These volunteer efforts should focus on preventing the spread of Eurasian watermilfoil and other exotic plants. See **Appendix 2** for information on the DNR’s Clean Boats Clean Waters program.

Harvesting guidelines

Recommended harvesting areas are shown in **Figure 8.** Harvest areas are based on historical need and recommendations of operators. Intrusions into emergent and floating-leaf plant communities should be limited to historic navigation lanes, and should not exceed 25 feet in width.

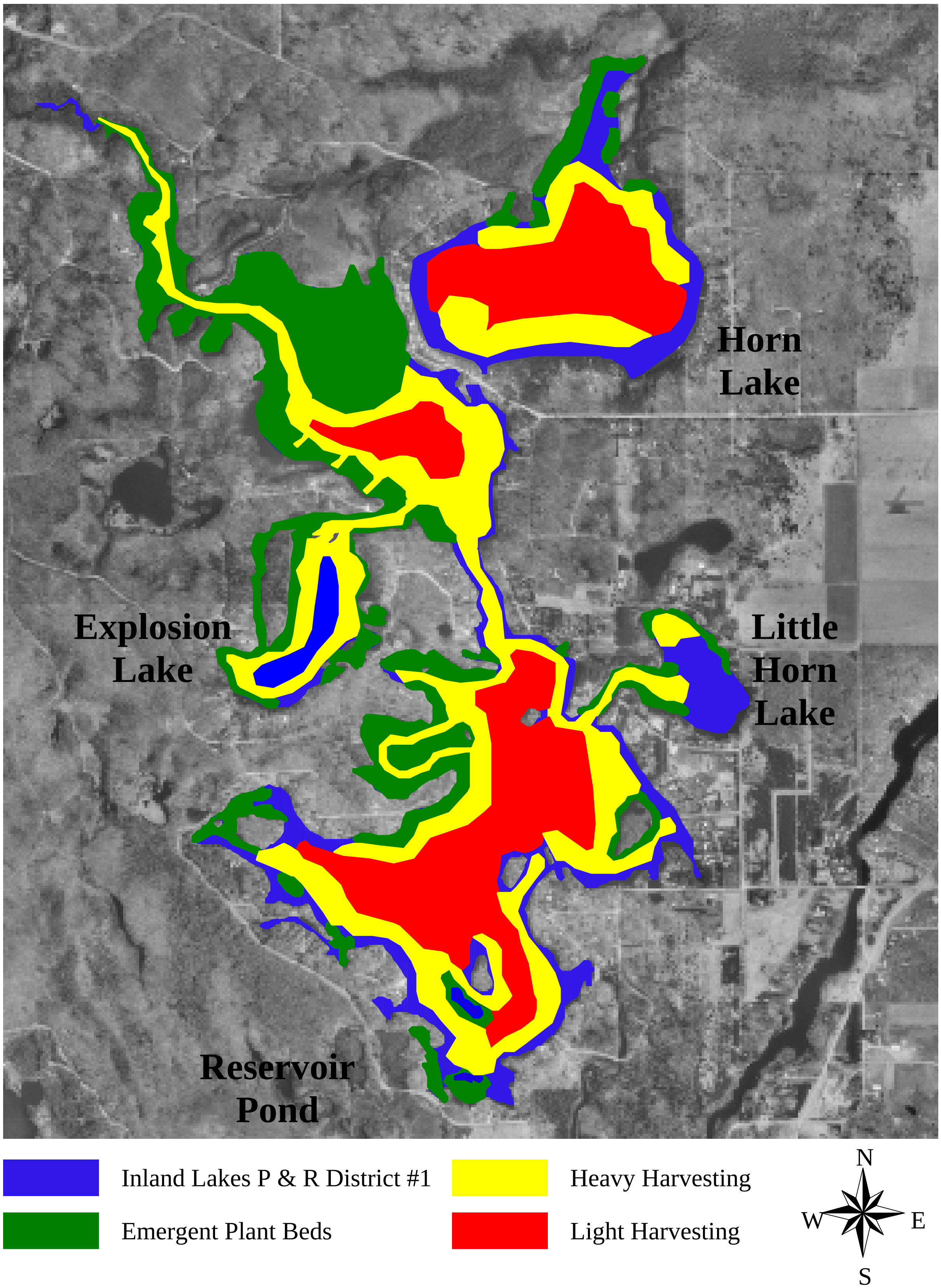
The following guidelines have been established by the Inland Lakes Protection and Rehabilitation District #1 for mechanical harvesting operations on District waters:

1. District will maintain a current DNR permit for harvesting
2. Harvesters will strive to collect and remove all cut material
3. Cutting in emergent plant beds will be limited to historic navigation lanes
4. No other cutting of emergent or floating-leaf plants will be allowed
5. Cutting depth will not exceed ½ of total depth at any location
6. No cutting will be done in depths less of than 2 feet
7. Sediment dredging and bog removal will not be allowed
8. Cutting will be limited to areas shown in Figure 3.
9. Harvester operators will learn to identify Eurasian watermilfoil and other exotic plants
10. No cutting will be done in known Eurasian watermilfoil beds.
11. No cutting will be done before June 1st to protect spawning fish
12. Operators will avoid cutting in or near active fish spawning beds
13. Operators will cease cutting if excessive numbers of fish are being caught

Management of aquatic plants along individual frontages

The District should discourage manipulation of native aquatic plants along shorelines by individual property owners. If removal of native plants is necessary, The District should encourage manual removal methods. The District should not support large-scale treatment of native aquatic plants with non-selective herbicides, unless such treatments are part of an approved habitat improvement project.

Figure 8. Aquatic plant harvesting map for the Inland Lakes Protection and Rehabilitation District No. 1, Oconto County, Wisconsin.



Long-term Lake Monitoring

An important component of any exotic plant control effort is the continual monitoring of the plant community. It is recommended that exotic species mapping efforts, such as those conducted in the 2005 survey, be conducted annually. These surveys will be necessary to assess the status of invasive aquatic plants in District Lakes, and to evaluate the success of control efforts. A detailed point intercept aquatic plant survey should be conducted every five years in order to quantify responses by the native plant community to the District's management efforts. All future aquatic plant surveys should also utilize previous sampling protocols so that data comparisons can be made.

Financial Assistance

The Inland Lakes Protection & Rehabilitation District #1 will be eligible for several grants that can provide financial assistance for lake management activities. The District should be eligible for the DNR's Aquatic Invasive Species – Rapid Response Grant. This grant could be used to help fund control of Eurasian watermilfoil in 2006. Other grant programs, such as the DNR's Lake Management Planning Grant may be used for activities such as future plant surveys and management plans. See **Appendix 1** for more details.

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Appendix 1. Grants for Lake Groups

State grant programs

A number of State-funded grants are available to qualified lake organizations and local units of government for a variety of lake management and improvement projects. These include: the Lake Management Planning and Protection grants, the Aquatic Invasive Species Control grants, and the Recreational Boating Facilities grant.

Lake Planning Grants

This program has been established for the purpose of assisting with lake management. Qualified organizations are eligible to apply for funding to collect and analyze information needed to protect and restore lakes and their watersheds. Small and large-scale grants are available. This program funds up to 75% of the cost of the project. Grant awards cannot exceed $10,000 per grant for large-scale projects and $3,000 per grant for small-scale projects.

Lake Protection Grants

As with the Planning Grant programs, Protection Grant awards may fund up to 75 percent of project costs with a maximum grant amount of $200,000. Eligible projects include the purchase of land or conservation easements, restoration of wetlands and shorelands, development of local regulations or ordinances to protect lakes, and lake management plan implementation projects.

Recreational Boating Facilities Grants

The DNR's Waterways Commission provides grant money for a variety of projects designed to improve recreation on Wisconsin lakes. The DNR provides cost sharing of up to 50 percent for eligible costs. Organizations and management units can apply for funds to provide safe recreational boating facilities, conduct feasibility studies, purchase aquatic weed harvesting equipment, purchase navigation aids, dredge waterways, and chemically treat Eurasian watermilfoil.

Aquatic Invasive Species (AIS) Control Grants

This grant program is designed to assist management units in the control aquatic invasive species. The WDNR awards cost-sharing grants for up to 50% of the costs of projects to control invasive species. These funds are available to units of local government and are broken down into three major categories:

1. Education, Prevention and Planning
2. Early Detection and Rapid Response
3. Controlling Established Infestations

For more details on each of these and other grant programs, visit the DNR's grant program website at http://www.dnr.state.wi.us/org/caer/cfa/grants/index.html.

Appendix 2. Volunteer Programs

Clean Boats, Clean Waters

The Wisconsin DNR in cooperation with the EW-Extension Lakes Program have developed a volunteer watercraft inspection program designed to educate motivated lake organizations in preventing the spread of exotic plant and animal species in Wisconsin lakes. Through the Clean Boats, Clean Waters program volunteers are trained to organize and conduct boater education programs.

For more information contact:
Laura Felda-Marquardt
Clean Boats, Clean Waters Program Coordinator
Wisconsin Invasive Species Program
Ph: 715-365-2659 (Rhinelander)
Ph: 715-346-3366 (Stevens Point)

To download a printable brochure regarding the Clean Boats, Clean Waters program go to http://www.uwsp.edu/cnr/uwexlakes/CBCW/Pubs/CBCW_brochure.pdf.

Volunteers should also take the opportunity to educate themselves and assist in identifying and mapping exotic species found in the lake. An ongoing effort should be initiated by numerous individuals to located and record the locations of invasive species throughout the lake. This information can then used to aid in lake management activities, and will serve as a foundation for a long-term monitoring program.