# Management Plan for Mud Lake, Lake Mills

# 2011

Jefferson County Land and
Water Conservation Department

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# INTRODUCTION

Mud Lake is a 95 acre lake located in the Town of Lake Mills in Jefferson County. The 8.3 square mile watershed is located both in the Town of Lake Mills and the Town of Oakland.

This document was developed by the Jefferson County Land and Water Conservation Department with the assistance of Underwater Habitat Investigations LCC who was hired to lead the field work portion of the project. A Lake Planning grant from the Wisconsin Department of Natural Resources helped to fund the project. The Land and Water Conservation Department contributed staff time for the required local match for the grant money.

# CHARACTERISTICS OF MUD LAKE AND ITS WATERSHED

Mud Lake is a 95 acre drainage lake located in the Town of Lake Mills in Jefferson County (Appendix A). Mud Lake's outlet stream, Rock Creek, drains to Rock Lake. Physical characteristics of the lake are contained in Table 1. The map showing the depth contours of the lake is contained in Appendix A.

Table 1. Physical Characteristics of Mud Lake

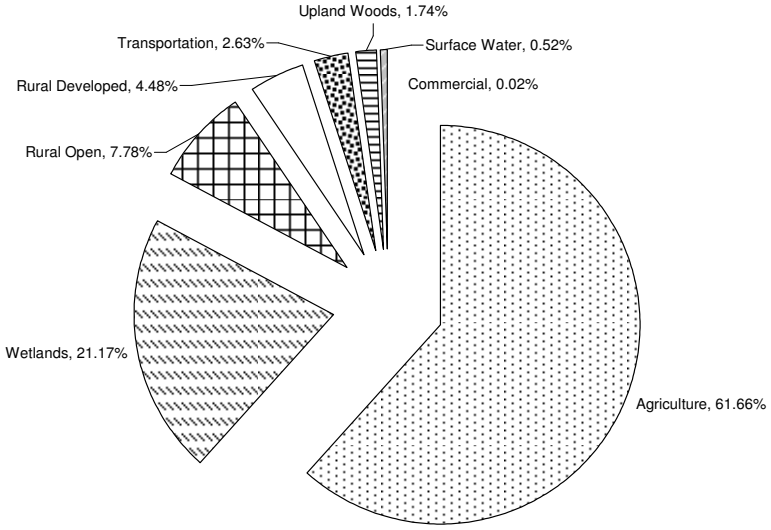
| Watershed Area ($mi^2$) | Lake Area (acres) | Maximum Depth (ft) | Mean Depth (ft) | Volume (acre feet) | Shoreline Length (miles) |
|---|---|---|---|---|---|
| 8.3 | 95 | 22 | 7.4 | 710.8 | 1.67 |

A boat launch provides access via a dredged navigation channel on the east side of the lake at the Sandhill Station State Campground owned and maintained by the Department of Natural Resources (DNR). As set forth by a Town of Lake Mills ordinance, motors are not allowed on boats using the lake. Therefore, the lake is a slow-no-wake lake. Adjacent to the boat ramp is a boardwalk that provides pedestrian access to the lake.

## Land Uses

Chart 1 displays the land uses in the Mud Lake watershed. Agriculture is the main land use in the watershed covering more than half of the land area in the watershed. The next dominant land use is wetlands representing almost a quarter of the total watershed area. Except for the northern shoreline of Mud Lake, the majority of the shoreline lies within the State's Lake Mills Wildlife Area. A map showing the location of the different land uses in the watershed is contained in Appendix A.

Chart 1. Land Uses in the Mud Lake Watershed



## Water Quality

Mud Lake has not received extensive chemical or biological sampling. General water quality conditions were assessed in 1996 during planning for the Rock Lake Priority Lake Project. At that time, the water quality was characterized as poor. Furthermore, the problems identified were excessive phosphorus loading and wetlands reduction.

Because Mud Lake is located upstream from Rock Lake, watershed modeling done in the mid-1990s included Mud Lake as part of a chain of lakes effect on phosphorus trapping and transport. Essentially, Mud Lake acts as a sediment trap for Rock Lake. Therefore, less sediment is transported into Rock Lake than would otherwise because of the existence of Mud Lake. Over time, lakes that act as sediment traps reach their capacity and more sediment and nutrients will be discharged from the lake. While the chain of lakes effect has benefited Rock Lake, further decline in the water quality of Mud Lake may have occurred since 1996 and it may ultimately become a source of phosphorus as well as sediment.

### Watershed-to-Lake Ratio

The watershed-to-lake size ratio is used as a measure of the potential nutrient and pollutant loading to a lake from its watershed. If there are two lakes with the same surface acreage but one has a much larger watershed, then there is greater likelihood that the lake with the larger watershed will have more nutrient and pollutant loading from runoff. Runoff occurs when rainwater and snowmelt transport nutrients, sediment, and other pollutants to water. Lakes with watershed-to-lake size ratios greater than 10:1 are known to more often experience water quality problems when compared to lakes with smaller ratios.

The watershed-to-lake size ratio for Mud Lake is 56:1. This is a large ratio and likely indicates water quality problems. However, the large amount of wetlands in Mud Lake's watershed probably helps reduce some water quality impacts from sediment and phosphorus runoff in the watershed.

### Stratification

Thermal stratification occurs during the summer in lakes that are more than 20 feet deep. The stratification is characterized by three distinct horizontal layers based on temperature and water densities. The upper layer, called the epilimnion, is characterized by warmer, lighter surface water. The cold, dense bottom water is called the hypolimnion. Separating these two layers is the thermocline characterized by a temperature gradient.

Lakes that are deep enough to sustain their stratification in the summer typically have two times during the year when the lake water fully mixes: spring and fall. In the fall, the upper water will cool until it is similar to the temperature of the lower layer and mixing will occur. Over the winter, another stratification occurs that is characterized by

a water temperature under the ice at about 32 degrees and 39 degrees near the bottom of the lake. Mixing does not occur because the ice shields the water from the wind. In the spring when the ice melts, the temperature and density of the water is consistent which allows the water to mix.

Lake stratification is important because water quality and fisheries can be impacted by the extent of stratification. During the summer in stratified lakes, algae, plant debris, and other organic material will fall to the bottom of the lake and decay. If the lake produces too much of this organic material, then the decaying process can deplete the oxygen in the bottom waters causing unsuitable conditions for fish. If the oxygen is totally depleted, then phosphorus bound to sediment particles can be released into the water. Then when the lake mixes in the fall, algae blooms can occur due to the increase of phosphorus. Algae blooms also can occur when the lake mixes in the spring.

The degree to which lakes stratify can be determined by the stratification factor:

$$\text{Stratification Factor} = \frac{\text{Maximum Depth (ft)} + 4.5}{\text{Log of surface area (acres)}}$$

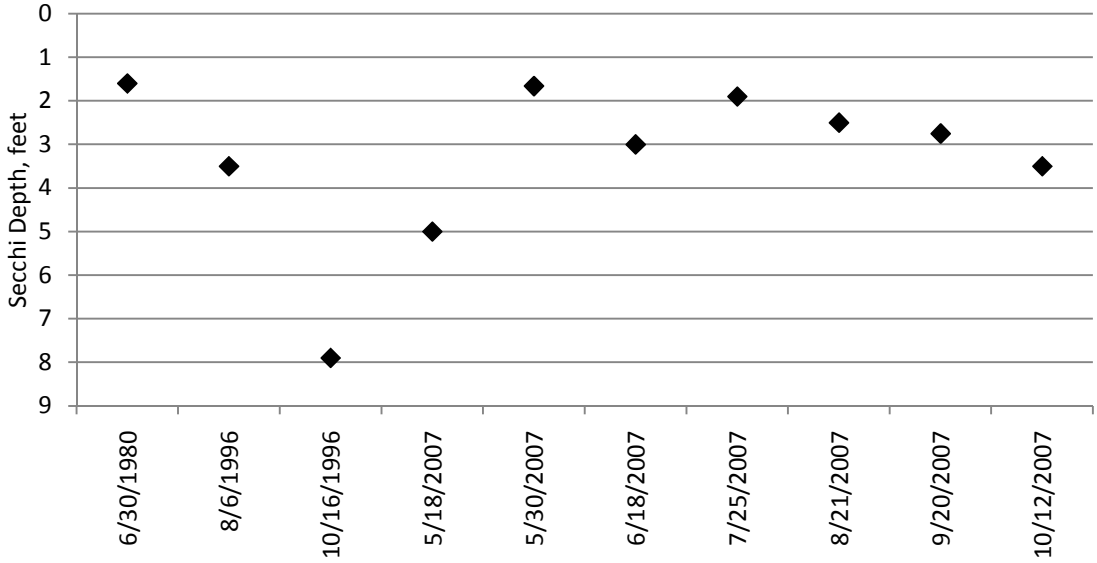
Higher ratios indicate more stratification, with ratios of 13.5 and higher being more strongly stratified. Lake that are more strongly stratified are more sensitive to additional nutrient inputs than lakes that do not sustain stratification. The stratification factor for Mud Lake is 13.4.

During the 2007 sampling period, temperature and dissolved oxygen profiles indicate that Mud Lake stratifies. The lake was mixing during the October 2007 sampling date.

Water Clarity

A Secchi disc is an 8-inch disc that is painted black and white. It is lowered into the water until it disappears from sight, then raised until it becomes visible – that depth is recorded as the water clarity reading. Materials suspended (especially algae) and dissolved in the water will impact the water clarity of a lake. Water clarity measurements can indicate the overall water quality of a lake. Chart 2 displays the water clarity readings from all sampling efforts on the lake.

Chart 2. Water Clarity Measurements in Mud Lake




Trophic State

By determining a lake's trophic state, its water quality can be characterized as eutrophic, mesotrophic, or oligotrophic. These trophic states are based on water clarity, total phosphorus concentration, and chlorophyll *a* concentration.

Oligotrophic lakes are clear, deep, and free of weeds or large algae blooms. They contain low amounts of nutrients and therefore do not support large fish populations. However, they can develop a food chain capable of sustaining a desirable fishery of large game fish.

Mesotrophic lakes have moderately clear water. They can have deep waters that are low in dissolved oxygen during the summer, and as a consequence, can limit cold water fish and cause phosphorus release from the bottom sediments.

Eutrophic lakes are high in nutrients and support a large biomass that include weeds, or frequent algae blooms, or both. Rough fish are often common in eutrophic lakes. A natural aging process occurs in all lakes to shallower and more eutrophic lakes. It is important to point out that this aging process is accelerated by human activities that increase sediment and nutrient delivery to our lakes. Some of the activities include agriculture, existing and new development, fertilizers, storm drains, etc.

The Trophic State Index (TSI) is determined using mathematical formulas that convert water clarity, total phosphorus, and chlorophyll *a* measurements into a TSI score on a scale of 0 to 110. Lakes that are less fertile have a low TSI. The scale is described in Table 2.

Table 2. Description of the Trophic State Index Scale

| TSI Score | Description |
|---|---|
| TSI < 30 | Classical oligotrophic: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality. |
| TSI 30-40 | Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer. |
| TSI 40-50 | Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer. |
| TSI 50-60 | Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only. |
| TSI 60-70 | Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible. |
| TSI 70-80 | Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae blocks sunlight). |
| TSI > 80 | Algal scums, summer fish kills, few plants, rough fish dominant. Very poor water quality. |

The average summer (July-August) water clarity for Mud Lake during 2007 was 2.2 feet and for all of the summer sampling events is 2.6 feet. This translates into a TSI of 63 for water clarity.

Chlorophyll *a* is the photosynthetic pigment found in plants. When filtered from lake water, it will signify the lake's algae biomass with higher concentrations indicating algal blooms. For most Wisconsin lakes, concentrations less than 7 µg/l indicate good water quality. Mud Lake's average summer (July-August) chlorophyll *a* concentration for 2007 was 28.95 µg/l. The summer average of all the data on the lake is 41.2 µg/l. This translates to a TSI for chlorophyll of 63. Table 3 displays all of the chlorophyll *a* data available for the lake.

Table 3. Chlorophyll *a* Concentrations

| Date | Chlorophyll *a* (µg/l) |
|---|---|
| June 30, 1980 | 118 |
| February 14, 1996 | 4.8 |
| June 13, 1996 | 42.8 |
| August 6, 1996 | 65.6 |
| October 16, 1996 | 58.7 |
| July 25, 2007 | 23.5 |
| August 21, 2007 | 34.4 |
| September 20, 2007 | 62.2 |
| October 12, 2007 | 46.5 |

Phosphorus is a nutrient that is often referred to as the “limiting nutrient” because its concentration in the water will affect the amount of algae and plant growth more than nitrogen. One pound of phosphorus delivered to a lake can produce up to 500 pounds of algae. Sources of phosphorus include runoff from farmland, animal lots, lawns, and construction sites, as well as shoreline erosion.

Phosphorus mostly is held in insoluble particles with calcium, iron, and aluminum. Phosphorus is released from particle form when the water is anoxic (has no oxygen). Anoxic conditions occur in the bottom waters of deep lakes during the summer when dead plant and animal matter uses up the oxygen during decomposition. During the summer, the phosphorus released from the sediments is held in the bottom waters and only enters the upper waters during strong winds that can mix the upper waters with the bottom waters. When the lake’s water mixes in the fall, the phosphorus that had been contained in the bottom waters will mix with the surface water and cause fall algal blooms. Mud Lake’s total phosphorus in the first 6 feet of the lake was sampled throughout 2007. Those results and all previous data are shown in Table 4.

Table 4. Total Phosphorus in Mud Lake

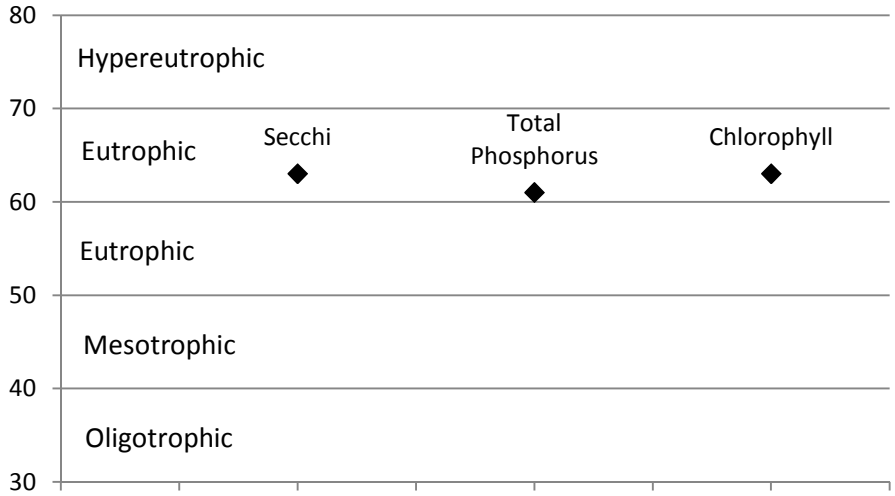
| Date | Total Phosphorus (µg/l) |
|---|---|
| February 14, 1996 | 84 |
| June 13, 1996 | 108 |
| August 6, 1996 | 104 |
| October 16, 1996 | 83 |
| May 18, 2007 | 60 |
| July 25, 2007 | 48 |
| August 21, 2007 | 69 |
| September 20, 2007 | 23.8 |
| October 12, 2007 | 111 |

The average 2007 summer phosphorus concentration in Mud Lake was 58.5 µg/l. The average summer phosphorus concentration for all the sampling data is 73.7 µg/l. This translates to a TSI for phosphorus of 61.

The total phosphorus in the bottom of the lake was measured on August 21, 2007 and was found to be 114 µg/l. The bottom waters of the lake were also anoxic at the same time and under these conditions, phosphorus is released from the sediments. That is why the phosphorus in the bottom of the lake exceeds the phosphorus at the surface of the lake. In October, the lake was undergoing fall mixing, and the phosphorus in the bottom of the lake was mixed with the surface waters. That is why the total phosphorus of the surface water was its highest in October.

The Trophic State Index for Mud Lake is displayed in Chart 3. It represents all average July and August measurements of water clarity, total phosphorus, and chlorophyll. Mud Lake is characterized as a eutrophic lake.

Chart 3. Trophic State Index for Mud Lake (Note: This chart does not contain the entire Trophic State Index scale. Not shown is classic oligotrophic of 0-30 and eutrophic scales greater than 80.)




A water quality index was developed for Wisconsin lakes using data collected in July and August (Lillie and Mason 1983). Table 4 shows this index and contains the average of all the July and August data on Mud Lake.

Table 4. Water Quality Index for Wisconsin Lakes with Mud Lake Summer Averages Indicated (adapted from Lillie and Mason 1983)

| **Water Quality Index** | **Secchi Depth (feet)** | **Chlorophyll a (ug/l)** | **Total Phosphorus (ug/l)** |
|---|---|---|---|
| Excellent | > 19.7 | < 1 | < 1 |
| Very Good | 9.8-19.7 | 1-5 | 1-10 |
| Good | 6.6-9.8 | 5-10 | 10-30 |
| Fair | 4.9-6.6 | 10-15 | 30-50 |
| Poor | 3.3-4.9 | 15-30 | 50-150<br>Mud Lake = 73.7 |
| Very Poor | < 3.3<br>Mud Lake = 2.6 | > 30<br>Mud Lake = 41.2 | > 150 |

pH

Hydrogen ion concentrations are measured as pH. During the summer of 2007, the pH of Mud Lake ranged from 7.03 to 8.94 and falls on the alkaline side of the scale (with neutral being a pH of 7). These measurements are common for southeastern Wisconsin and indicate that the system is buffered from acidification.

Conductivity

Conductivity measurements indicate the total dissolved solids (such as calcium, magnesium, potassium, bicarbonate, sulfate, and chloride) in the water. The higher the concentration of the dissolved solids, the higher the conductivity. In Southern Wisconsin, a conductivity of greater than 500 umhos/cm is an indicator of high groundwater inputs because of the presence of limestone bedrock. In July 2007, conductivity in the upper waters of Mud Lake averaged 478 umhos/cm and 633 umhos/cm in the bottom of the lake.

## Aquatic Plants

Aquatic plants are a vital part of a healthy lake ecosystem. In fact, 90% of a lake's ecosystem depends on what happens in the vegetated shallow areas. Some valuable characteristics of aquatic plants are the following:

- Aquatic plants create a thriving habitat supplying food, shade, and shelter for a large variety of aquatic and terrestrial animals.
- Fruits and tubers of aquatic plants provide food for mammals, waterfowl, insects and fish.
- Aquatic plants are essential to the spawning success of many fish species.
- Aquatic plants photosynthesize, creating oxygen for the animals that live in the shallow area.
- Aquatic plants filter runoff from uplands to protect lake water quality.
- Plant roots create networks that stabilize sediments at the water's edge where waves might otherwise erode the lakeshore.
- Submersed plants absorb phosphorus and nitrogen over their leaf surface and through their roots.
- Plant use nutrients, making them less available for nuisance algae.
- Native aquatic plants can limit growth of exotic plants.

Aquatic plants can reveal a lot about the quality of a lake. The aquatic plant communities were sampled in Mud Lake by use of the point intercept method developed by Jen Hauxwell (DNR). Details of the procedure can be found in Aquatic Plant Management in Wisconsin (DNR & UWEX). Sampling was conducted on July 23, 2007. The sampling points that were surveyed are shown in a map in Appendix B. Herbarium specimens were collected and submitted to the UW Madison Herbarium.

The species found in the survey are listed in Table 5. There were a total of 19 plant species (either surveyed or visually identified) in Mud Lake. Only one invasive species was found in the lake: curly-leaf pondweed. Maps of the location of the dominant plant species are located in Appendix B.

Table 5. Ecological Significance and Coefficient of Conservatism for Aquatic Plants in Mud Lake, 2007

| **Aquatic Plant** *Species name* Common name | **Plant Type** | **Coefficient of Conservatism** | **Ecological Significance** |
|---|---|---|---|
| *Chara* Muskgrass | S | 7 | Excellent producer of fish and waterfowl food, stabilizes bottom sediments, has a softening effect on water by removing lime and carbon dioxide. |
| *Decodon verticillatus* Swamp loosestrife | E | 7 | Seeds grazed by waterfowl, important source of food and cover for muskrats. |
| *Utricularia vulgaris* Common bladderwort | S | 7 | Provides food and cover for fish. |
| *Nuphar variegate* Spatterdock | FL | 6 | Provides shade and shelter for fish and habitat for invertebrates. Seeds are eaten by a variety of waterfowl. Leaves, stems, and flowers are eaten by deer. Rhizomes eaten by muskrat, beaver, and porcupine. |
| *Nymphaea odorata* White water lily | FL | 6 | Provides shade and cover for fish and invertebrates. A food source for waterfowl, muskrat, and beaver. |
| *Potamogeton illinoensis* Illinois pondweed | S | 6 | Provides cover for panfish; nesting ground for bluegills, largemouth bass, northern pike. Supports insects valuable as food for fish and waterfowl, fruit is also eaten. |
| *Potamogeton foliosus* Leafy pondweed | S | 6 | Early season nutlets provide important food source for waterfowl. Leaves and stems are grazed by muskrat and beaver. |
| *Potamogeton zosteriformis* Flatstem pondweed | S | 6 | Food source for waterfowl and wetland mammals. Provides cover for fish and invertebrates. Supports insects valuable as food source for fish and waterfowl. |
| *Polygonum amphibium* Water smartweed | T/E | 5 | Fruits provide some food for waterfowl, stems and leaves provided limited cover for fish and insects. |
| *Spirodela polyrhiza* Large duckweed | FF | 5 | Important food source for a variety of wildlife, capable of satisfying most dietary needs of ducks and geese. Provides essential shade and cover for fish and insects. |
| *Lemmna minor* Small duckweed | FF | 4 | Important food source for ducks and geese. Consumed by muskrats, beaver, and fish. Provides shade and cover for fish and invertebrates. Extensive mats of duckweed can inhibit mosquito breeding. |

| **Aquatic Plant**<br>*Species name*<br>Common name | **Plant Type** | **Coefficient of Conservatism** | **Ecological Significance** |
|---|---|---|---|
| *Schoenoplectus tabernaemontani*<br>Softstem bulrush | E | 4 | Important nesting habitat and cover for wide variety of wetland birds and waterfowl. Shoots are grazed by muskrats. Provides fish spawning habitat and cover for juvenile fish. |
| *Ceratophyllum demersum*<br>Coontail | S | 3 | Provides good shelter for young fish, supports insects valuable as food for fish and ducklings, and fruits are eaten by waterfowl. |
| *Sagittaria latifolia*<br>Common arrowhead | E | 3 | Tubers and seeds are eaten by waterfowl. Provides cover for young fish. |
| *Stuckenia pectinata*<br>Sago Pondweed | S | 3 | Fruits and tubers are a very important food source for a variety of waterfowl. Supports insects that are eaten by game fish. Provides cover for young game fish. |
| *Typha latifolia*<br>Broad-leaved cattail | E | 1 | Provides nesting habitat for waterfowl and wetland birds. Roots and shoots are eaten by muskrats and beaver. Provides spawning habitat for some game fish. |
| *Najas marina*<br>Spiny naiad | S | | Naturalized exotic, provides food and cover for fish as well as food for ducks. |
| *Potamogeton crispus*<br>Curly-leaf pondweed<br>- Invasive Species - | S | | Provides winter and spring habitat for fish and invertebrates. Mid-summer die-off releases nutrients which may trigger algae blooms and create turbid water conditions. |
| *Typha angustifolia*<br>Narrow-leaved cattail | E | | Naturalized exotic, provides nesting habitat for waterfowl and wetland birds. Roots and shoots are often eaten by muskrats and beaver. Provides spawning habitat for some game fish. |

Key:

E = Emergent – plants with leaves that extend above the water surface
FL = Floating Leaf – plants with leaves that float on the water surface
FF = Free Floating – plants that float freely on the water surface
S = Submersed – plants with most of their leaves growing below the water surface
T/E = Terrestrial/Emergent plants

**Coefficient of Conservatism:** A number on a scale from 0 to 10 that represents an estimated probability that a plant species is likely to occur in a lake unaltered from what is believed to be pre-settlement conditions. A Coefficient of 10 indicates the plant is almost certain to be found only in an undegraded natural community, and a Coefficient of 0 indicates the probability is almost 0. Introduced plants were not part of the pre-settlement flora, so no coefficient is assigned to them.

Other plants that were identified in the shoreland area during the aquatic plant survey included the following:

Catnip
Jewelweed
Marsh milkweed
Nightshade
Reed canary grass (invasive species)

The summary of statistics from the plant sampling is contained in Table 6.

Table 6. Summary of Plant Sampling Statistics for Mud Lake

| | |
|---|---|
| Total number of points sampled | 132 |
| Total number of sites with vegetation | 33 |
| Total number of sites shallower than maximum depth of plants | 113 |
| Maximum depth of plants | 5.4 feet |
| Average number of all species per site (shallower than max depth) | 0.51 |
| Average number of all species per site (veg. sites only) | 1.76 |
| Average number of native species per site (shallower than max depth) | 0.48 |
| Average number of native species per site (veg. sites only) | 1.73 |

There are several ways to analyze aquatic plant data for a lake. These include the coefficient of conservatism, the floristic quality index, the frequency of occurrence, the relative frequency of occurrence, and the Simpson Diversity Index.

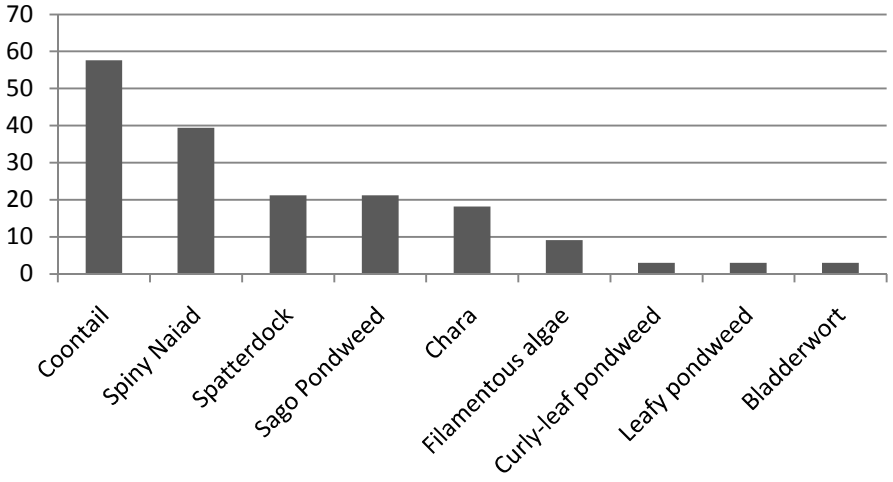
The Coefficient of Conservatism is a number on a scale from 0 to 10 that represents an estimated probability that a plant species is likely to occur in a lake unaltered from what is believed to be pre-settlement conditions. A coefficient of 10 indicates the plant is almost certain to be found only in an undegraded natural community, and a coefficient of 0 indicates the probability is almost 0. Introduced plants were not part of the pre-settlement flora, so no coefficient is assigned to them. Table 5 lists the species from highest coefficient to lowest. The average Coefficient of Conservatism for Mud Lake is 3.95.

The floristic quality index (FQI) is used to assess a lake's quality using the aquatic plants that live in it. Developed by Stan Nichols (WI Geological and Natural History Survey), the floristic quality index is the average coefficient of conservatism multiplied by the square root of the number of plants in the lake. The FQI varies around Wisconsin but ranges from 3.0 to 44.6 with a median of 22.2. Generally, higher FQI numbers mean better lake quality. The floristic quality index for Mud Lake is 17.7.

The frequency of occurrence for a plant species is the number of times a species is observed, divided by the total number of sampling points contained within the area shallower than the maximum depth of plants in a lake. The maximum rooting depth of Mud Lake is 5.4 feet. The frequency of occurrence is expressed as a percentage and the results from the 2007 survey are displayed in Chart 4. The Frequency of

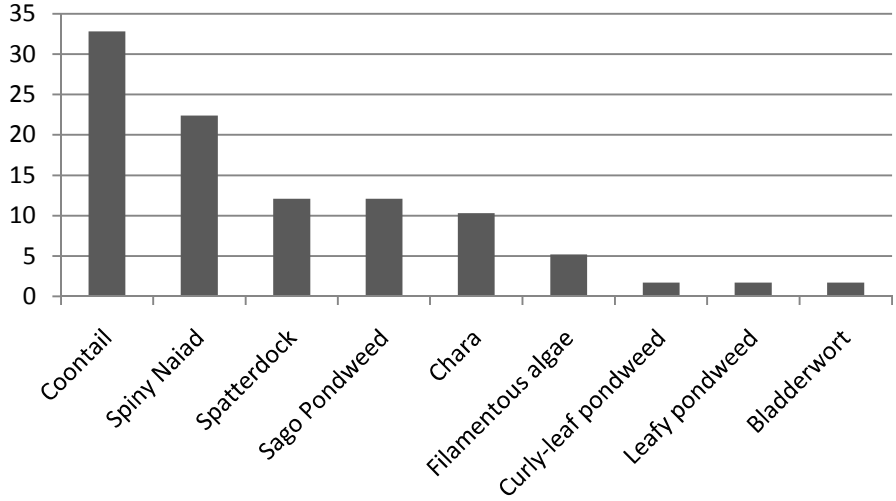
Occurrence does not factor in plant species that were visually noted in the survey and not sampled with the rake.

Chart 4. Frequency of Occurrence of Plants in Mud Lake, 2007




The relative frequency of occurrence gives an indication of how the plants occur throughout a lake in relation to each other. It is the frequency of a species divided by the sum of the frequencies of all species. The sum of the relative frequencies should be equal to 100%. The data from the 2007 survey is displayed in Chart 5.

Chart 5. Relative Frequency of Plants in Mud Lake, 2007




Based on the Simpson Diversity Index (one minus the sum of the relative frequencies squared) for the community, the closer the index value is to one, the greater the diversity within the lake. The Simpson Diversity Index for Mud Lake is 0.80.

## Fish

The Surface Water Resources of Jefferson County (DNR 1968) reported the presence of northern pike, largemouth bass, bluegills, black crappies, and bullheads.

During the summer of 2007, a variety of fish sampling was performed and a total of 13 species were identified (Table 7). The fish sampling include the following gear types: dip nets, minnow traps, and seines. Dip nets were used in the navigation channel between the boat launch and the lake, and also in the outlet stream. Minnow traps (with and without bait) were set in Mud Lake on 3 different occasions for a period of approximately 24 hours. Except for one trap, the sampling attempt did not result in any fish. Two different seines were used: a 20 foot long seine with 1/8 inch mesh size and a 30 foot long seine, with a 6 foot by 6 foot bag, and a 3/16 inch mesh size.

Table 7. Fish of Mud Lake

| Fish Species | Importance |
|---|---|
| Blackchin shiner, *Notropis heterodon* | gamefish food |
| Bluegill, *Lepomis macrochirus* | popular panfish |
| Bowfin, *Amia calva* | "living fossil", ecological balance |
| Brook silverside, *Labidesthes sicculus* | gamefish food |
| *Common carp, *Cyprinus carpio* | destroys habitat |
| Black crappie, *Pomoxis nigromaculatus* | popular panfish |
| Golden shiner, *Notemigonus crysoleucas* | gamefish food |
| Johnny darter, *Etheostoma nigrum* | gamefish food, |
| Largemouth bass, *Micropterus salmoides* | popular gamefish |
| Longnose gar, *Lepisosteus osseus* | "living fossil", ecological balance |
| Mudminnow, *Umbra limi* | gamefish food |
| Northern pike, *Esox lucius* | popular gamefish |
| Yellow perch, *Perca flavescens* | popular panfish |

*nonnative species

A nonnative fish, the common carp, was found in the lake. Two fish found in Mud Lake, the longnose gar and the bowfin, are considered "living fossils." These fish possess characteristics found in their 200 million year old relatives which include functional lungs. The species offer ecosystem stability by preying on the invasive carp and over populated panfish.

## Wildlife

Wildlife observed on or adjacent to the lake during the 2007 surveys were documented. In addition, crawfish traps were deployed in the lake. They were set in the lake for 24 hours with bait. No crawfish were found in the traps.

The following is the list of wildlife species observed in and around Mud Lake;

Blanding's Turtle
Painted Turtle
Snapping Turtle
Green Frog
Leopard Frog
American Toad
Northern Water Snake
Giant Water Bug
Sandhill Crane
Canada Geese
Gull

The Blanding's turtle is a Wisconsin Threatened Species. This species is on the threatened species list because of habitat loss and fragmentation due to draining of wetlands, heavy nest predation, highway mortality, and low nesting frequency.

The Blanding's turtle can be identified by the underside of its neck which is bright yellow. The head, tail, and limbs are blue-black and the underside of its shell is yellow with brown or black splotches. The upper shell is usually black speckled with yellow, or horn colored and mottled with brown. The Blanding's turtle is semi-aquatic. It prefers open, grassy marshes containing shallow water.

The Wisconsin Department of Natural Resources indicates that predator exclosures may effectively reduce predation where Blanding's turtle nesting is concentrated. In addition, barriers along roadways have proven effective in reducing adult turtle mortality.

## Natural Areas

Mud Lake is almost totally surrounded by the Lake Mills Wildlife Area, except for the north shore of the lake. The Lake Mills Wildlife Area is owned and managed by the Department of Natural Resources. The area contains a diverse variety of habitat types, including:

- open water marsh
- wet prairie
- lowland hardwoods with tamaraks
- oak savanna uplands

The Glacial Heritage Area Plan (DNR, 2009) contains a number of objectives for the wildlife area. One that pertains to the lake is to maintain the boardwalk from the boat landing to Mud Lake.

# PUBLIC INPUT

During the course of the project, the public's input on Mud Lake was obtained in a variety of ways. Project managers talked to boaters on the lake during the times when they were sampling. In addition, the project was brought up by a project manager at a meeting of the Rock Lake Improvement Association. Finally, a public meeting was held on Monday, June 27, 2011 at the Town Hall of the Town of Lake Mills.

Citizens shared the types of fish they caught in the lake and their impressions of the lake. A common concern was the navigability of the channel where it meets the lake. Someone noted that money is needed to dredge the end of the channel.

Citizens also were concerned about the amount of carp in the lake. One fisherman had an idea of a carp spearing event at night. This event would involve boats with motors and generators with lights. This activity would require a special permit from the Town of Lake Mills to allow motors on the lake for the event. In addition, the end of the channel might have to be fixed prior to the event to make sure the boats could gain access.

# FACTORS IMPACTING MUD LAKE AND ITS WATERSHED

## Nonpoint Source Pollution

Nonpoint Source Pollution is defined as pollution that enters water bodies via overland flow from areas including lawns, streets, paved areas, rooftops, and farm fields. As water flows over land, it picks up nutrients, sediment, salt, pesticides, fertilizers, oil, grease, leaves, litter, and many other pollutants.

A pollutant of concern to lakes is phosphorus because excess phosphorus in a lake can cause rapid and excessive growth of algae and aquatic plants. This in turn can deteriorate water quality and impair recreational enjoyment.

In order to estimate the amount of nonpoint source phosphorus inputs into Mud Lake, the Wisconsin Lake Modeling Suite (WiLMS) was used. For Mud Lake, the "most likely" estimated phosphorus loading is 3,209 lbs/year. It is important to note that this is an estimate and might not accurately reflect the actual loading from year to year. The range of possible phosphorus loading given by the WiLMS model is 1,724.8 lbs/yr to 9,334.9 lbs/yr.

In 1997, modeling of the Mud Lake watershed was done in conjunction with the Rock Lake Priority Watershed Project. The WINHUSLE model was used and there was a significant inventory of the watershed that was performed to try to ensure that the model inputs were the most accurate they could be. This model estimated the phosphorus loading to Mud Lake as 1,613.2 lbs/year.

### Agricultural Nonpoint Source Pollution

Agricultural nonpoint source pollution results from both cropland soil erosion and runoff from animal lots, farm fields, and faulty manure storage. Nearly 62% of Mud Lake's watershed is in agricultural production. The majority of this agricultural land is farmed according to conservation plans whose purpose it is to keep the soil on the land. Many of these agricultural lands also have nutrient management plans that not only detail the fertilizer and manure applications, but also identify spreading restrictions that work to protect water quality.

From 1999 to 2005, the Rock Lake Priority Lake Project assisted farmers and landowners with the design, implementation, and partial costs of implementing conservation practices on agricultural land. Some of these practices (nutrient management plans, closure of a leaking manure storage structure, wetland restoration, no-till farming, etc) were implemented in the Mud Lake subwatershed.

A survey of the watershed was performed to identify critical sites experiencing erosion or manure problems. There were no critical sites identified in the survey of the watershed.

Shoreland Erosion

A survey of the shoreland area did not find any shoreland erosion. There is not development on the shoreline because the vast majority of the shoreline is part of the Lake Mills Wildlife area, and the entire shoreline is wetlands. Approximately 1,890 feet of shoreline (21% of shoreline) is owned by someone other than the Department of Natural Resources.

Construction Site Erosion

Erosion from construction sites can be a significant sediment and phosphorus source to water resources. One estimate is that one acre under construction with no erosion control delivers, on average, as much sediment to local waterways as 75 acres of cropland.

As the majority of the Mud Lake's watershed is in agricultural production, in wetlands, and not very close to incorporated areas, there is likely very low potential for large areas of development. Some agricultural parcels could construct additional farm buildings or create residential lots. Therefore, there is some potential for future construction site erosion concerns in the watershed.

## Wetlands

There are 1,109.93 acres of wetlands in the Mud Lake watershed representing just over 21% of the land uses. These wetlands not only surround the entire shoreline of the lake, but they also surround Rock Creek which is the major tributary to the lake. Much of the wetland areas are owned and managed by the Wisconsin Department of Natural Resources as part of the Lake Mills Wildlife Area.

Wetlands have many functions that contribute several ecological, social, and economic benefits including:

- Filter pollutants, nutrients, and sediment from water before it enters the lake
- Store runoff to reduce flood potential and damage
- Provide habitat (feeding, breeding, resting, nesting, escape cover, and travel corridors) for many animals and spawning areas for fish
- Protect shorelines from erosion

Degradation or reduction of the wetlands in the watershed could likely cause a negative impact on Mud Lake.

## Recreation

There is a boat launch located on the east side of the lake that is part of the Lake Mills Wildlife Area, and also part of Sandhill Station Campground. The boat launch is located on a dredged channel that leads out to the lake. Next to the boat launch, there is also a raised wooden walkway that leads to the lake. The platform by the lake is used for lake

viewing and fishing. The Town of Lake Mills has an ordinance that does not allow motors of any kind on the lake.

All of the sampling for this project was done during the weekdays between 8 am and 4:30 pm. At these times the boat traffic was very minimal: sometimes we were the only boat on the lake, other times there were 1-2 other boats on the lake. It is not known what the boat usage is on the weekends. During the survey, we saw several people fishing from the boardwalk.

## Institutional Framework

Boating rules and the County's shoreland zoning ordinance were reviewed to determine if any improvements would benefit the lake.

As the Town of Lake Mills has a no-motor ordinance for Mud Lake, the boating rules are adequate for the lake. However, if sensitive areas are designated in the future, the Town should consider placing buoys to mark the site(s).

The entire shoreline of Mud Lake is wetland areas that have not been disturbed. These areas have some protections because of the presence of the wetlands and therefore are not likely to be disturbed in the future. The Jefferson County Zoning Department has not yet adopted the new State minimum zoning rules. This is set to happen by February 2012. These rules should be adequate to protect the lake.

# GOALS AND RECOMMENDATIONS

## Problem Identification

There were a few problems identified during the study on Mud Lake in 2007.

Nonpoint Source Pollution

Agricultural nonpoint source pollution is a concern for Mud Lake because the majority of the watershed (nearly 62%) is in agriculture. Though conservation practices were installed in the Mud Lake watershed from 1999 to 2005 through the Rock Lake Priority Lake Project, more work should to be done to address potential agricultural nonpoint source pollution.

A potential for future farm expansions and residential development could impact the lake through erosion from construction sites.

Low Dissolved Oxygen

Low dissolved oxygen is a concern for aquatic life. Fish need adequate dissolved oxygen to live in the lake – a minimal amount is 5 mg/l.

The dissolved oxygen levels in the bottom waters of Mud Lake become anoxic in the summer. This is typical for lakes that are stratified during the summer. However, in August of 2007, the surface waters (above the thermocline) at the deepest point of the lake had extremely low dissolved oxygen that ranged from 4.03 mg/l to 4.3 mg/l.

Aquatic Exotic Plants

There was one invasive plant not native to Wisconsin found in Mud Lake: curly-leaf pondweed. Out of the 33 vegetated sampling sites, only one site was found to contain curly-leaf pondweed. However, there is possibly more curly-leaf pondweed in the lake because this plant typically dies off in late June or early July, and the plant survey was conducted in late July.

In lakes with abundant curly-leaf pondweed, the die off will release phosphorus into the water that triggers algae blooms and sometimes decreases in dissolved oxygen. The result for the lake is water quality, wildlife, and recreational impairments.

Eurasian water milfoil was not found during the plant survey on Mud Lake. This invasive plant is common in lakes in Southern Wisconsin. Because of the close proximity of other lakes in the area that contain Eurasian water milfoil (including Rock Lake, Hope Lake, and Lake Ripley), there is a significant risk of it being transported via boats or fishing gear to Mud Lake.

Carp

The fish surveys performed on Mud Lake identified Common Carp, an invasive fish. These fish feed on submerged vegetation and in the process uproot plants, muddy the waters and destroy vegetative food and cover needed by other fish. The low aquatic plant coverage on the lake could potentially be related to the presence of Carp in the lake.

Lake Access and Recreation

To gain access to Mud Lake, boaters must navigate through a dug channel from the boat launch to the lake. Depending on the water level, it is sometimes difficult to navigate to the lake because it is extremely shallow where the channel meets the lake.

Currently the lake is a no-motor lake. The use of motor on Mud Lake could potentially add to the suspension of sediment into the water column, especially in shallow areas.

## Goals

The goals for the management of Mud Lake are as follows:

- Collect water clarity and water quality data through the Citizen Lake Monitoring Network.
- Enhance the water quality of the lake by reducing nonpoint source pollution to the lake and watershed.
- Determine the extent of the carp and curly-leaf pondweed populations in the lake.
- Enhance and protect the aquatic plant community in the lake.
- Prevent the invasion and spread of exotic species.

## Recommendations

Rock Lake Watershed Recommendations and Lake Association

The Rock Lake Improvement Association (RLIA) has historically been an association that takes a watershed approach toward protection of Rock Lake. As Mud Lake is in the Rock Lake watershed, and Mud Lake acts as a sediment trap preventing some sediment from traveling to Rock Lake, the RLIA should be involved in the protection of Mud Lake.

In 2006, the Management Plan for Rock Lake was developed by the Rock Lake Improvement Association, the Joint Rock Lake Committee, and a volunteer citizen advisory committee. The following recommendations were made that pertain to Mud Lake:

- Stop construction site erosion.
- Conduct a study to determine the quality of the wetlands in the Rock Lake watershed because the large wetland complex is one of the main reasons that

Rock Lake has good water quality. The study could define the steps to take to protect and enhance the wetlands.
- Initiate water quality monitoring at key locations within the Rock Lake watershed. This list included Mud Lake.
- Make direct, personalized contact with every farm and lakeshore owner in the Rock Lake watershed to communicate with them about conservation practices that are available to address erosion or pollution issues that may exist on the property.
- Educate landowners about the availability of federal, state, and county money to help defray the costs of implementing conservation practices to prevent pollution and erosion.
- Reduce the Canada geese population. Continue to collect population information on Canada geese during molting season.
- Investigate the possible migration of fish between Marsh Lake and Mud Lake. Determine if it would be beneficial to improve the migration route (perhaps through clearing the channel) so that fish can migrate to any spawning beds in Mud Lake.

Nonpoint Source Pollution Reduction

The Management Plan for Rock Lake contained a few recommendations that pertain to reducing both agricultural nonpoint source pollution and construction site erosion. These should be followed. In addition, the goal of 50% reduction of sediment and phosphorus in the watershed that was first established with the Rock Lake Priority Watershed Project should be continued.

The Town of Lake Mills and the Town of Oakland both have jurisdiction over construction sites in the Mud Lake watershed. Each Town should understand the importance of erosion control rules for construction sites. It is important that they communicate to their contracted building inspectors that erosion control measures should be followed by builders and contractors. This includes installing erosion control prior to land disturbance and maintaining the control measures until the disturbed site is vegetated. *Implementers: Towns of Lake Mills & Oakland; Timeframe: ongoing; Funding: not needed.*

The Jefferson County Land and Water Conservation Department (LWCD) works with farmers throughout the county. Their work includes assisting farmers with installing conservation practices on their land to reduce erosion and pollution. In addition, the LWCD is responsible for ensuring that agricultural performance standards are followed. They should continue to do this work in the Mud Lake watershed. *Implementers: Jefferson County LWCD; Timeframe: ongoing; Funding: state and county cost-share funds.*

Exotic Species Monitoring, Control, and Prevention

The population of curly-leaf pondweed in Mud Lake should be further investigated. An assessment of the lake should be completed in early June to get a better understanding of the extent of curly-leaf pondweed in the lake. If a small population exists, then

options for control could include hand pulling and/or spot treatment with an herbicide. A sustained control effort is required for curly-leaf pondweed because the turions (dormant shoot of the plant) fall to the sediment when the plant starts dying and can remain dormant for years. *Implementer: Jefferson County LWCD; Timeframe: lake assessment 2012, then every 3 years, possible control 2012-future as needed; Funding: county staff time, DNR grant for any future control.*

Eurasian water milfoil has not yet been found in Mud Lake. As it would probably be introduced via boats or fishing gear, surveys at the boat launch and at the end of the boardwalk should be done periodically to look for the plant. If a small infestation is found, hand pulling and/or spot treatment with an herbicide could be pursued. *Implementer: Jefferson County LWCD; Timeframe: lake assessment 2012, then every 3 years, possible control 2012-future as needed; Funding: county staff time, DNR grant for any future control.*

The DNR should be consulted for guidance in terms of aquatic plant control and permit requirements. Herbicides, mechanical removal, and in some instances hand removal of plants require a permit. In addition, DNR Rapid Response grants are available throughout the year to combat new discoveries of invasive species in a lake.

Education is imperative to preventing the spread of invasive exotic species. The signage present at the Mud Lake boat launch should be determined. A new aquatic invasive species sign is now available and should be posted at the launch if it is not already there. The DNR should be contacted for permission to install this sign. *Implementers: Jefferson County LWCD, Town of Lake Mills, DNR; Timeframe: 2011; Funding: not needed.*

The public should be educated about the following steps because it is against the law to transport aquatic invasive species. Before launching and before leaving a boat launch, everyone must:

- Inspect boats, trailers, and equipment
- Remove all attached aquatic plants and animals
- Drain all water from boats, vehicles and equipment
- Never move plants or live fish away from a waterbody
- Dispose of unwanted bait in the trash. Use leftover minnows only under certain conditions.

*Implementer: Jefferson County LWCD; Timeframe: ongoing; Funding: not needed, county staff time.*

<u>Aquatic Plants and Fish</u>

Because carp may be negatively impacting aquatic plants in Mud Lake, additional fish surveys should be performed to better assess the carp population in the lake. The DNR fish biologist for the region should be contacted to inquire about performing additional

surveys. *Implementer: DNR fish biologist; Timeframe: to be determined with new fish biologist; Funding: not needed.*

Carp control techniques could include targeted fishing. In addition, if locations of carp spawning are located, the carp could potentially be restricted from re-entering the main lake at that time and removed from the water. Another idea is to have a carp spearing event that would allow boats with motors and generators for lights to fish during a special event at night. For this type of event, a permit is needed from the Town of Lake Mills. The DNR should be contacted for any assistance, management techniques, and permit requirements. *Implementer: DNR fish biologist, Jefferson County LWCD, carp fishermen; Town of Lake Mills; Timeframe: to be determined with new fish biologist; Funding: possibly DNR grant.*

Sensitive Areas are defined in Ch. NR 107 as areas of aquatic vegetation identified by the Department of Natural Resources as offering critical or unique fish and wildlife habitat to the body of water. For Mud Lake, the area with the most diversity of plants is located at the southern tip of the lake. This area should be considered for sensitive area designation by the DNR. *Implementer: DNR; Timeframe: to be determined by DNR; Funding: not needed.*

If Sensitive Areas are designated, then the Town of Lake Mills should consider marking those areas with buoys. *Implementer: Town of Lake Mills; Timeframe: when areas are designated; Funding: Town funds for buoy placement and purchase.*

Water Quality

In order to get a better understanding of Mud Lake's water quality, more data is essential. The Department of Natural Resources has a Citizen Lake Monitoring Network Program in which a citizen volunteer is trained to take water clarity, temperature and dissolved oxygen measurements and collect water samples for phosphorus and chlorophyll analysis. Having a longer term record of these measurements could assist in future lake management decision-making.

The Jefferson County Land and Water Conservation Department could assist with the recruitment and training of a citizen monitor. Of particular interest is the dissolved oxygen levels in the lake and whether very low dissolved oxygen continues to occur in the surface waters at the end of the summer. *Implementer: Jefferson County LWCD; Timeframe: 2011-2013; Funding: DNR supported activity.*

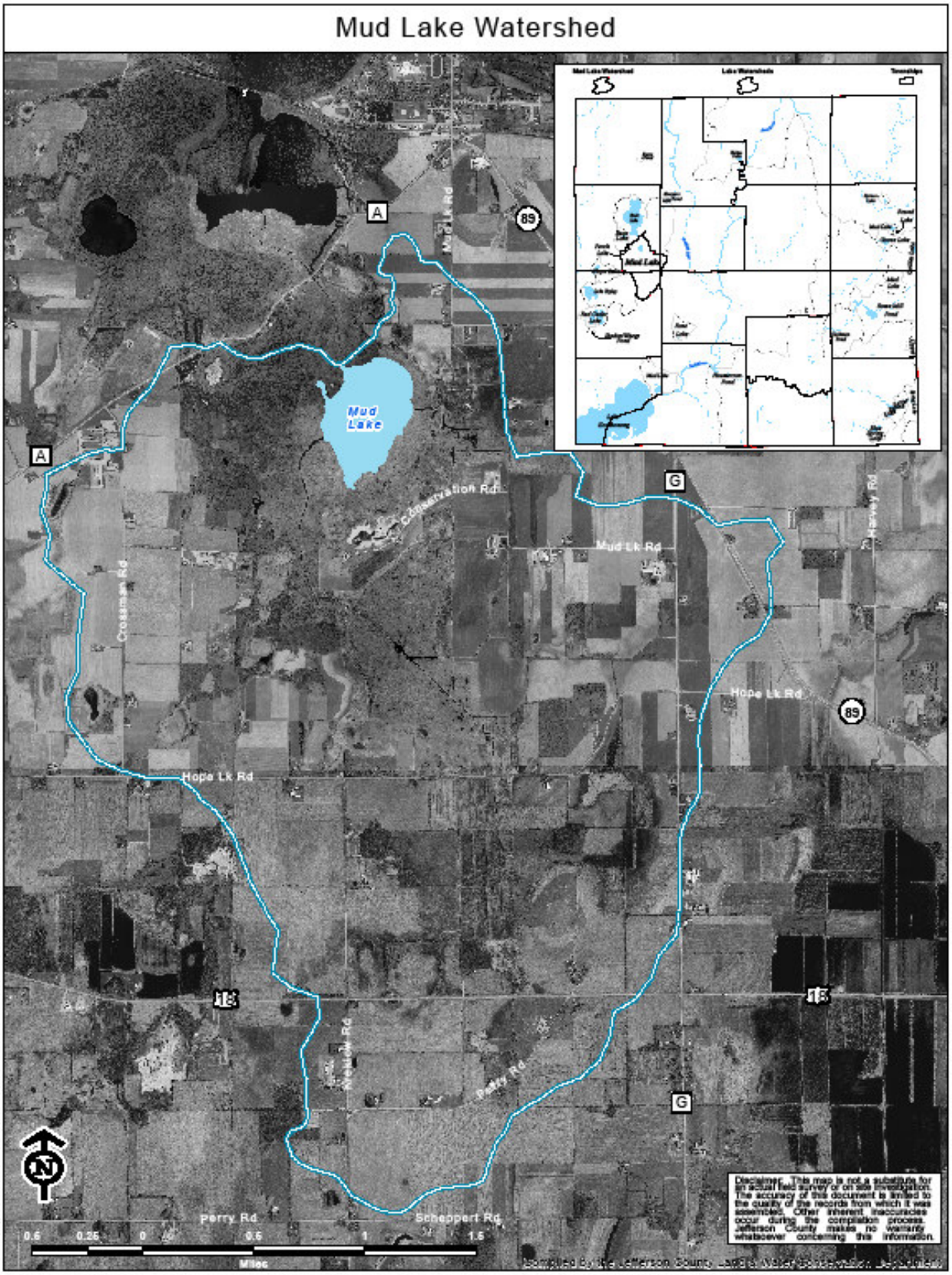
Recreation

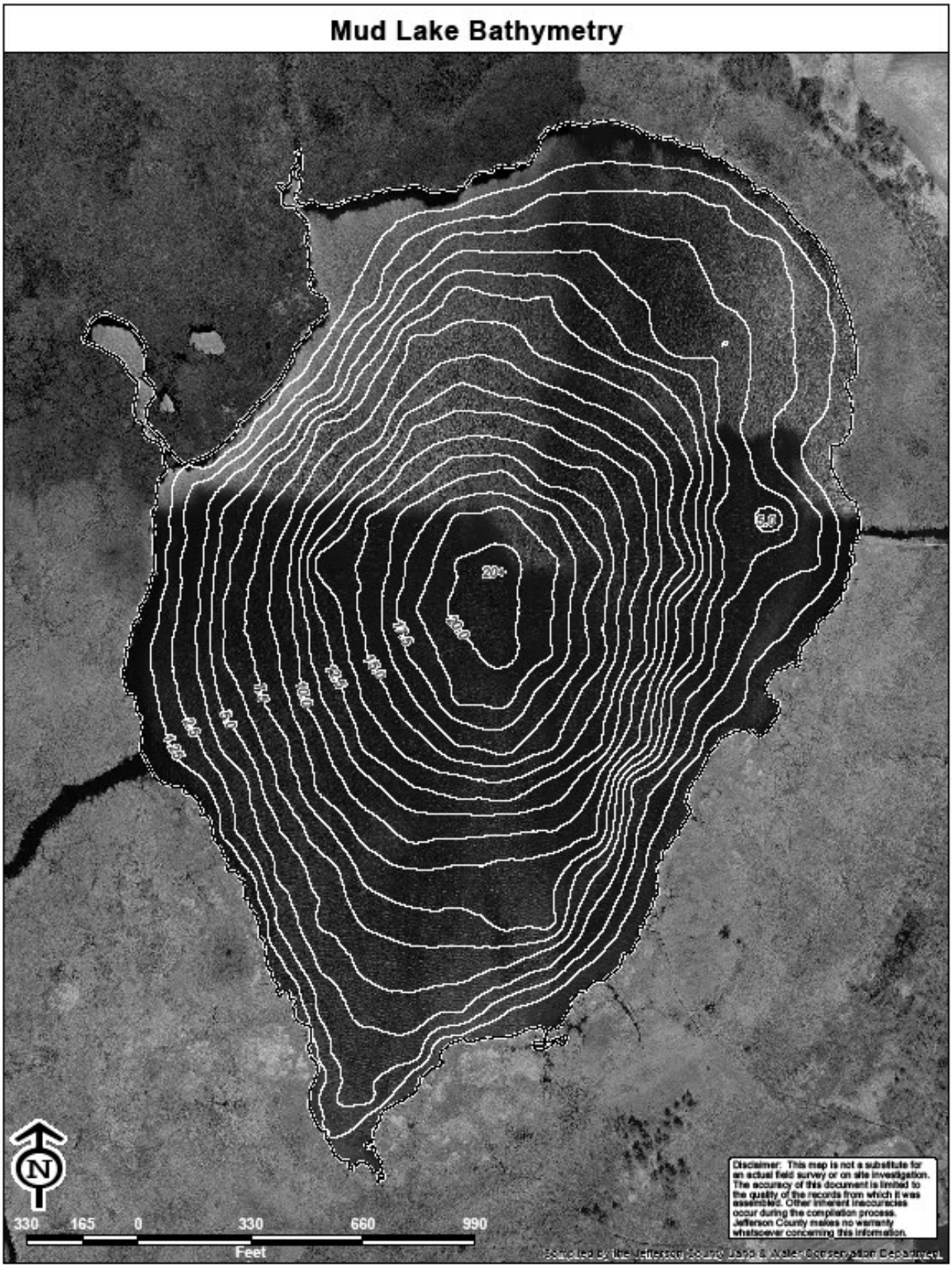
Because of problems with navigating the last few feet of the channel before entering the lake, efforts to deepen the channel directly adjacent to the lake should be explored. Dredging is certainly an expensive option. But perhaps there are some less expensive options that could be considered. *Implementer: DNR; Timeframe: by 2015; Funding: possible DNR grant.*

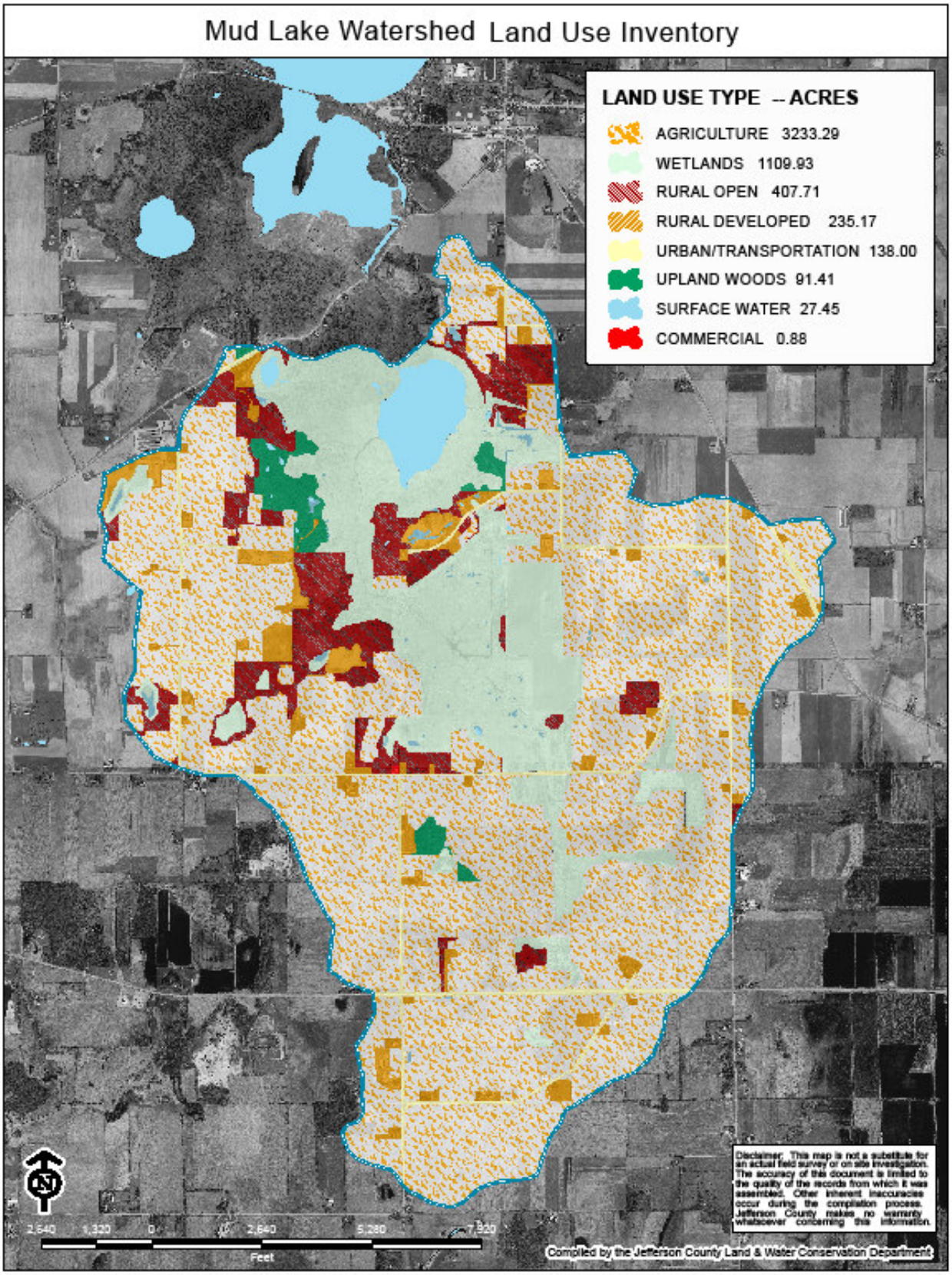
The Mud Lake should be kept as a no-motor lake because of it's size. However, the Town should consider allowing fishermen access to the lake with motors for a special event for carp-spearing at night. *Implementer: Town of Lake Mills; Timeframe: ongoing; Funding: not needed.*

# Appendix A

# Lake Characteristics Maps


Mud Lake Watershed
Mud Lake
Mud Lk Rd
Conservation Rd
Crossman Rd
Harvey Rd
Hope Lk Rd
Meadow Rd
Perry Rd
Scheppert Rd
A
G
89
18
N
Miles
Disclaimer: This map is not a substitute for an actual field survey or on site investigation. The accuracy of this document is limited to the quality of the records from which it was assembled. Other inherent inaccuracies occur during the compilation process. Jefferson County makes no warranty whatsoever concerning this information.


Mud Lake Bathymetry
N
330 165 0 330 660 990
Feet
Disclaimer: This map is not a substitute for an actual field survey or on site investigation. The accuracy of this document is limited to the quality of the records from which it was assembled. Other inherent inaccuracies occur during the compilation process. Jefferson County makes no warranty whatsoever concerning this information.
Compiled by the Jefferson County Land & Water Conservation Department


Mud Lake Watershed Land Use Inventory
LAND USE TYPE -- ACRES
AGRICULTURE 3233.29
WETLANDS 1109.93
RURAL OPEN 407.71
RURAL DEVELOPED 235.17
URBAN/TRANSPORTATION 138.00
UPLAND WOODS 91.41
SURFACE WATER 27.45
COMMERCIAL 0.88
N
2,640 1,320 0 2,640 5,280 7,920
Feet
Disclaimer: This map is not a substitute for an actual field survey or on site investigation. The accuracy of this document is limited to the quality of the records from which it was assembled. Other inherent inaccuracies occur during the compilation process. Jefferson County makes no warranty whatsoever concerning this information.
Compiled by the Jefferson County Land & Water Conservation Department

# APPENDIX B

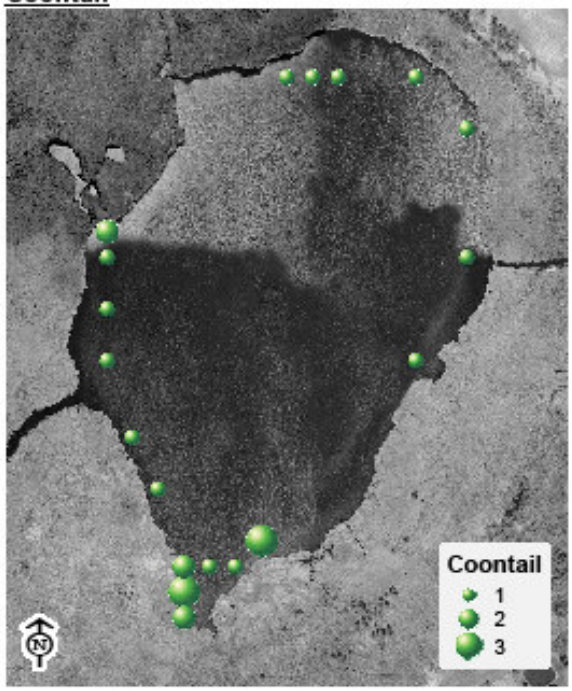
## Aquatic Plant Distribution and Density Maps

Rake Sampling Plant Density
1 = Few Plants on Rake
2 = Rake 1/2 Full
3 = Rake Overflowing

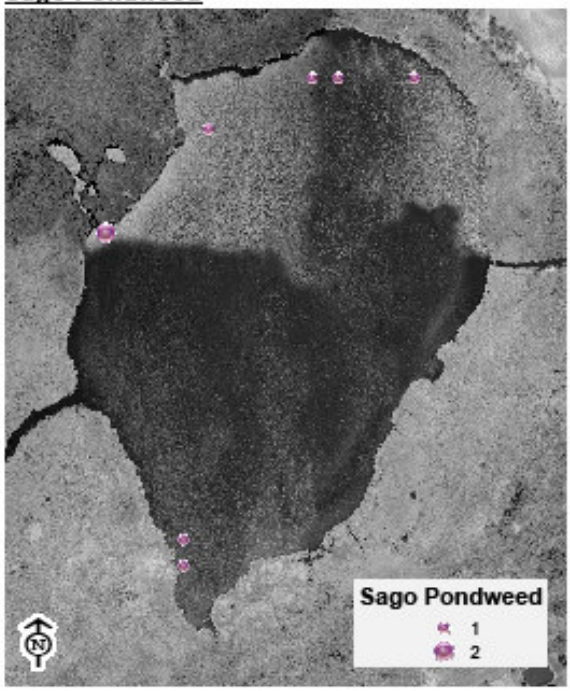
# Mud Lake
# Individual Aquatic Plant Densities

Illustration of Rake Fullness Rating

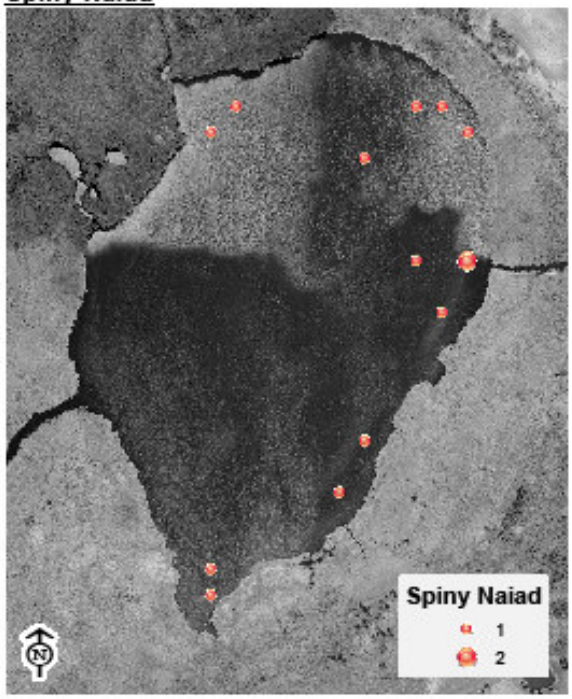

**Coontail**



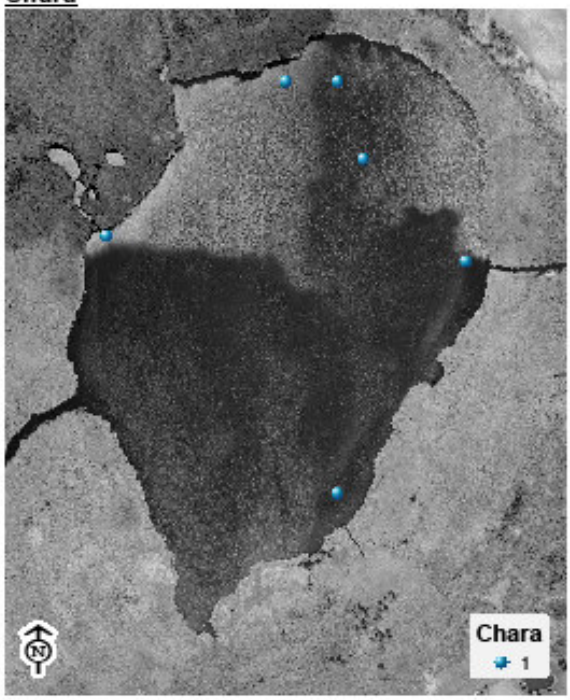

**Sago Pondweed**




**Spiny Naiad**




**Chara**



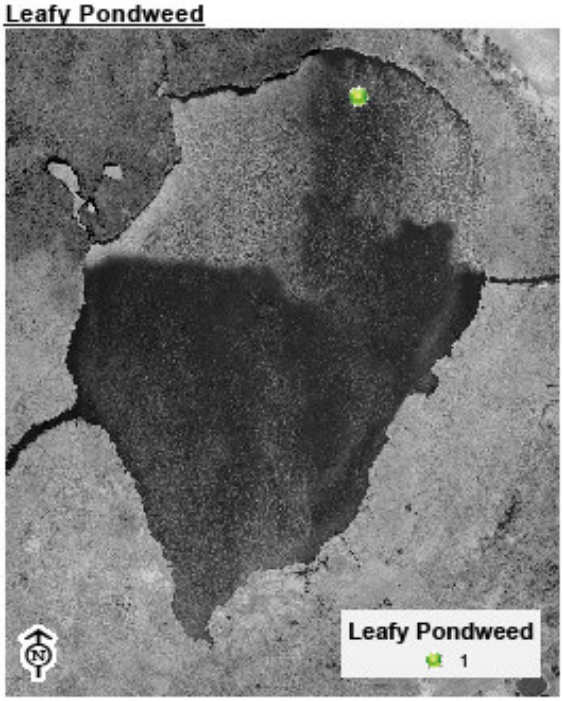
Rake Sampling Plant Density
1 = Few Plants on Rake
2 = Rake 1/2 Full
3 = Rake Overflowing

# Mud Lake Individual Aquatic Plant Densities

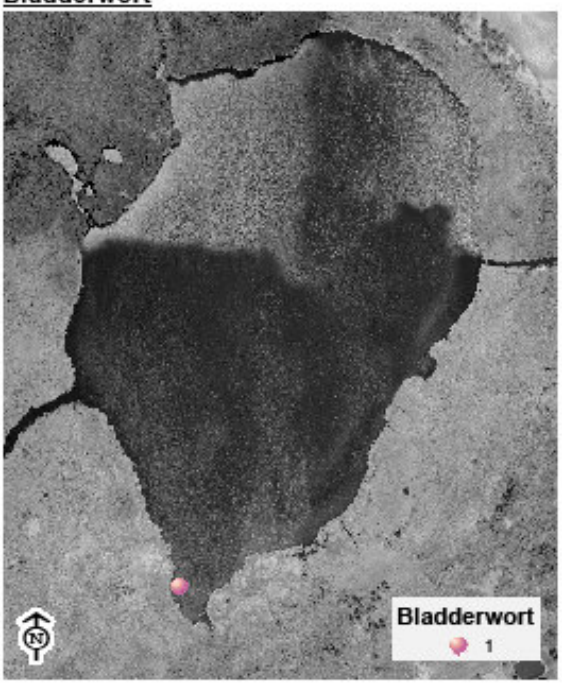
Illustration of Rake Fullness Rating

1 2 3

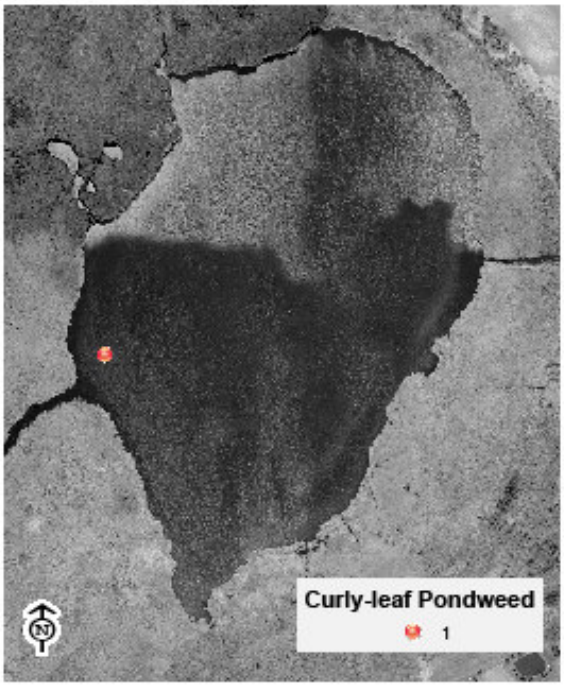
**Leafy Pondweed**




**Bladderwort**

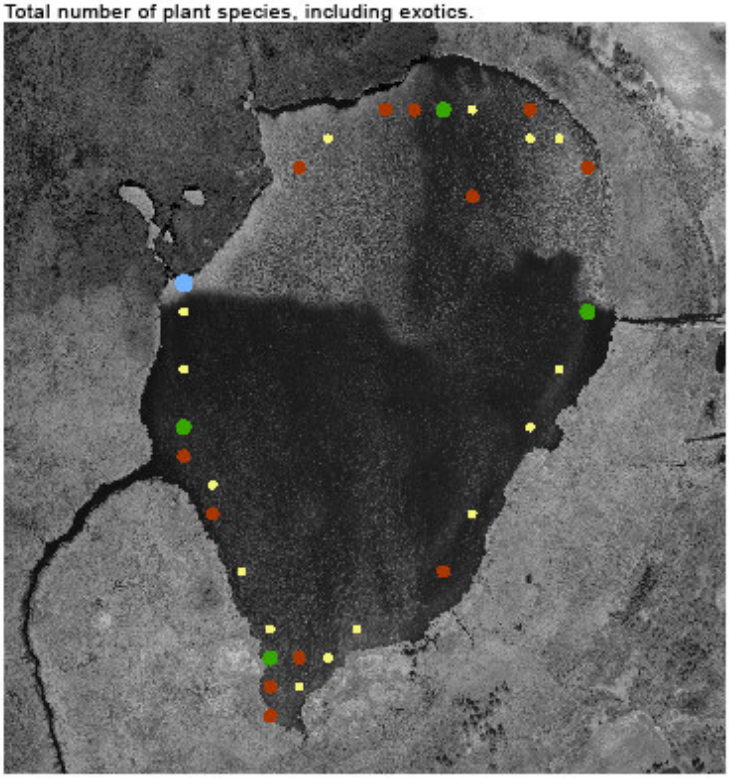



**Curly-leaf Pondweed**



# Total Number of Plant Species


Total number of plant species, including exotics.



Total number of plant species,excluding exotics.