Beaver Dam Lake Aquatic Plant Survey and Management Plan

Prepared for
Beaver Dam Lake Management District

January 2006

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BARR

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Executive Summary

A macrophyte survey was completed during 2005 to determine changes in the aquatic plant community since 1999 and to determine the effectiveness of treatments completed during implementation of the lake's 2000 Aquatic Plant Management (APM) Plan during 2000 through 2005. This report presents the survey results and an updated aquatic plant management plan for Beaver Dam Lake.

Survey results indicate Beaver Dam Lake contains a healthy plant community that is of higher quality and is less tolerant of disturbance than the plant community of the median Wisconsin lake. A comparison of 1999 and 2005 data indicates Beaver Dam Lake's aquatic plant community has changed substantially over time. Reduction in Eurasian watermilfoil coverage and the recolonization of areas formerly infested with Eurasian watermilfoil contributed to the change.

During 1999, EWM covered approximately 230 acres in June and 205 acres in August. During 2000 through 2005, treatment of infested areas of the lake with 2,4-D reduced EWM coverage to approximately 89 acres. Hence a 57 to 62 percent reduction in EWM coverage resulted from five consecutive years of 2,4-D treatment. In addition to reducing coverage of EWM in the lake, treatment also reduced the maximum density of EWM. West Beaver Dam Lake noted a decline in EWM maximum density from 4 (80 percent of rake head covered) in 1999 to 3 (60 percent of rake head covered) in 2005. East Beaver Dam Lake noted a decline in EWM maximum density from 3.75 (75 percent of rake head covered) in 1999 to 1 (20 percent of rake head covered) in 2005.

Although the lake's aquatic plant community is currently healthy and of good quality, the presence of EWM and curlyleaf pondweed in the lake is of concern because these species are not native to this region. The lake's CLP community is relatively stable and has changed little during the past 6 years. EWM is of greater concern because it has caused problems (i.e., displacement of native species, rapid spread, dense growths, particularly at the lake's surface) within Beaver Dam Lake in the past and will likely cause problems in the future unless managed prudently. Continued management is needed to prevent an increase in EWM coverage and, if possible, attain additional reductions in EWM coverage.

Although the lake's native community is healthy and most species are not problematic, some areas of the lake note problematic growths of water lilies, pondweed, or a combination of several species. These dense growths interfere with recreational use of the lake and result in a less than ideal habitat for the lake's fishery. Prudent management of dense growths of native species is needed to support the lake's beneficial uses and the lake's fishery.

The Beaver Dam Lake Management District has established both general and specific APM goals for the lake. The specific goals are divided into 2 categories, goals for an annual maintenance program and goals for a long-term improvement program.

The Beaver Dam Lake APM Plan outlines management scenarios to attain and sustain the lake's beneficial uses. The APM is divided into 2 sections:

- Annual Maintenance Program

- Long-Term Improvement Program

The annual maintenance program uses herbicide treatment to maintain navigation channels and clear vegetation from boat landings, swimming areas, and around the fishing pier. The annual maintenance program is a nuisance relief program and is not expected to result in long-term changes.

The long-term improvement program is expected to result in long-term changes. The program is comprised of:

- AIS Management
- Pondweed and Water Lily Harvesting
- Water Lily Management

The treatment of AIS within Beaver Dam Lake is complex and requires a complex program. Five types of treatment were identified for this program. Treatment types include (1) early spring treatment with 2,4-D using the maximum allowable dose and a split treatment to maximize contact time (2) early spring treatment using a combination of low rates of 2 herbicides, each individually effective in the treatment of EWM at higher application rates (3) spring treatment with the maximum allowable dose of 2,4-D (4) late season treatment with 2,4-D using the maximum allowable dose and a split treatment to maximize contact time and (5) treatment with lime slurry. Native vegetation is not expected to be harmed by the AIS treatment. The treatment program will, at a minimum, prevent increased coverage and density of AIS in the lake, and at a maximum, greatly reduce current levels of coverage and density.

A long-term improvement program was identified to treat problematic areas of pondweed and water lily growth. Harvesting will occur in selected portions of these problematic areas during late June through September 1. The harvesting pattern used in selected areas will be "spokes on a wheel" pattern. Removal of nutrients translocated by plants from sediments during plant growth is expected to result in a long-term reduction of sediment fertility due to harvesting effects. Regrowth of pondweed and water lilies in harvested areas is expected to be less prolific because of harvesting effects.

A herbicide treatment program has been chosen to attain long-term improvement in selected areas of problematic water lily growth. A portion of the selected areas will be treated annually with a glyphosate based herbicide during the late summer.

An annual monitoring program will determine the results of APM Plan implementation. The program is a duplication of the 2005 monitoring program. Monitoring results will be evaluated and a report issued annually.

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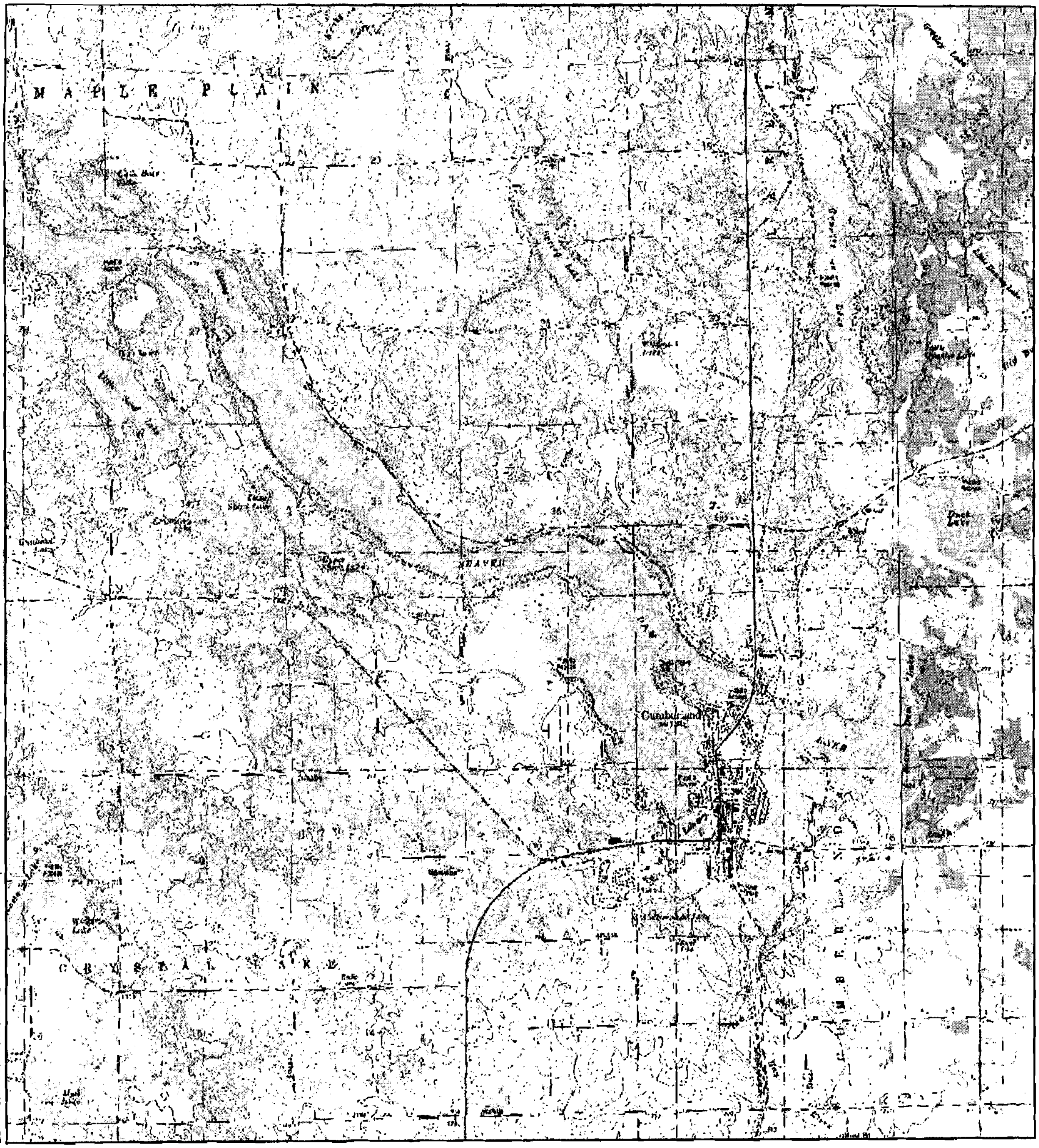
1.0 Introduction

Beaver Dam Lake in Barron County, Wisconsin is valued by lakeshore property owners, area residents, Barron County, and the Wisconsin Department of Natural Resources (WDNR) for its fisheries (northern pike, walleye, largemouth bass, smallmouth bass, and panfish) and for recreational use. The lake has a surface area of 1,169 acres, a maximum depth of 106 feet, and a mean depth of 32 feet (See Figure 1). Beaver Dam Lake is the deepest lake in Barron County and the sixth deepest lake in Wisconsin. Beaver Dam Lake is divided by Highway 63 into Beaver Dam Lake (West) and Beaver Dam Lake (East). The West lake notes a surface area of 848 acres and the East lake notes a surface area of 321 acres. The lake has five boat landings, five swimming beaches, and one fishing pier.

Eurasian watermilfoil (EWM) was introduced into the lake during the 1990's. EWM is a nuisance non-native species that typically replaces native vegetation. It has a canopy style growth pattern that causes heavy growth near the surface, making it more visible and a greater nuisance for boaters and fishermen. EWM has spread throughout the lake's littoral region and caused problematic macrophyte conditions in many areas of the lake. Because of concern for Beaver Dam Lake, the Beaver Dam Lake Management District completed a macrophyte survey in 1999 and a Macrophyte Management Plan during 2000. The 2000 Beaver Dam Lake Aquatic Plant Management Plan (APMP) identified effective macrophyte management activities and recommended a phased approach to accomplish the District goals for plant management.

- Phase 1—Primary Plan—annual herbicide treatment of swimming beaches, boat landings, the fishing pier, and boat passageways.
- Phase 2—Secondary Plan—herbicide treatment of Eurasian watermilfoil growth areas not included in Phase 1
- Phase 3—Tertiary Plan—herbicide treatment of Eurasian watermilfoil growth areas not included in the primary and secondary plans.

The District implemented the 3 phases of the lake's Macrophyte Management Plan during 2000 through 2005. From 129 to 200 acres were treated annually with herbicide. The herbicide Reward was used to annually treat swimming beaches, boat landings, the area around the fishing pier, and boat passageways. The herbicide 2,4-D was used to treat Eurasian watermilfoil growth areas.



Feet

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Meters

1,000 0 1,000 2,000

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Figure 1

SITE MAP
Beaver Dam Lake

The 2000 Beaver Dam Lake APMP recommended that a macrophyte survey be completed every five years. A macrophyte survey was completed during 2005 to determine changes in the aquatic plant community since 1999 and to determine the effectiveness of the treatments completed during management plan implementation. This report presents the survey results and an updated aquatic plant management plan for Beaver Dam Lake.

2.0 Overview of Macrophyte Growth in Lakes

The basis of the following text on macrophyte growth in lakes is Minnesota Department of Natural Resources (MDNR) *A Guide to Aquatic Plants Identification and Management* (1994).

2.1 Location of Aquatic Plant Growth Within Lakes and Impoundments

Within a lake, pond, or impoundment, aquatic plants grow in the area known as the littoral zone—the shallow transition zone between dry land and the open water area of the lake. The littoral zone extends from the shore to a depth of about 15 feet, depending on water clarity. The littoral zone is highly productive. The shallow water, abundant light, and nutrient-rich sediment provide ideal conditions for plant growth. Aquatic plants, in turn, provide food and habitat for many animals such as fish, frogs, birds, muskrats, turtles, insects, and snails. Protecting the littoral zone is important for the health of a lake's fish and other animal populations.

The width of the littoral zone often varies within a lake and among lakes. In places where the slope of the lake bottom is steep, the littoral area may be narrow, extending several feet from the shoreline. In contrast, if the lake is shallow and the bottom slopes gradually, the littoral area may extend hundreds of feet into the lake or may even cover it entirely. Impoundments frequently note extensive littoral areas in the upper portion due to sedimentation and shallow depths. In contrast, the lower portions of impoundments may have little littoral area.

Cloudy or stained water, which limits light penetration, may restrict plant growth. In lakes where water clarity is low all summer, aquatic plants will not grow throughout the littoral zone, but will be restricted to the shallow areas near shore.

Other physical factors also influence the distribution of plants within a lake or pond. For example, aquatic plants generally thrive in shallow, calm water protected from heavy wind, wave, or ice action. However, if the littoral area is exposed to the frequent pounding of waves, plants may be scarce. In a windy location, the bottom may be sand, gravel, or large boulders—none of which provides a good place for plants to take root. In areas where a stream or river enters a lake, plant growth can be variable. Nutrients carried by the stream may enrich the sediments and promote plant growth; or, suspended sediments may cloud the water and inhibit growth.

2.1.1 Categories of Aquatic Plants

Aquatic plants are grouped into four major categories:

- Algae have no true roots, stems, or leaves and range in size from tiny, one-celled organisms to large, multi-celled plant-like organisms, such as *Chara*. Plankton algae, which consist of free-floating microscopic plants, grow throughout both the littoral zone and the well-lit surface waters of an entire lake. Other forms of algae, including *Chara* and some stringy filamentous types (such as *Cladophora*), are common only in the littoral area.

- Submersed plants have stems and leaves that grow entirely underwater, although some may also have floating leaves. Flowers and seeds on short stems that extend above the water may also be present. Submerged plants grow from near shore to the deepest part of the littoral zone and display a wide range of plant shapes. Depending on the species, they may form a low-growing "meadow" near the lake bottom, grow with lots of open space between plant stems, or form dense stands or surface mats.

- Floating-leaf plants are often rooted in the lake bottom, but their leaves and flowers float on the water surface. Water lilies are a well-known example. Floating leaf plants typically grow in protected areas where there is little wave action.

- Emergent plants are rooted in the lake bottom, but their leaves and stems extend out of the water. Cattails, bulrushes, and other emergent plants typically grow in wetlands and along the shore, where the water is less than 4 feet deep.

2.1.2 Value of Aquatic Plants

Aquatic plants are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. In lakes, life depends—directly or indirectly—on water plants. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other aquatic life. Aquatic plants serve many important functions, including:

- ***Provide fish food***—More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Sunfish eat aquatic plants besides aquatic insects and crustaceans.

- ***Offer fish shelter***—Plants provide shelter for young fish. Because bass, sunfish, and yellow perch usually nest in areas where vegetation is growing, certain areas of lakes are protected and posted by the

DNR as fish spawning areas during spring and early summer. Northern pike use aquatic plants, too, by spawning in marshy and flooded areas in early spring.

- ***Improve water quality***—Certain water plants, such as rushes, can actually absorb and break down polluting chemicals.

- ***Protect shorelines and lake bottoms***—Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.

- ***Provide food and shelter for waterfowl***—Many submerged plants produce seeds and tubers (roots), which are eaten by waterfowl. Bulrushes, sago pondweed, and wild rice are especially important duck foods. Submerged plants also provide habitat to many insect species and other invertebrates that are, in turn, important foods for brooding hens and migrating waterfowl.

- ***Improve aesthetics***—The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy.

- ***Provide economic value***—As a natural component of lakes, aquatic plants support the economic value of all lake activities. Wisconsin has a huge tourism industry centered on lakes and the recreation they support. Residents and tourists spend large sums of money each year to hunt, fish, camp, and watch wildlife on and around the state's lakes.

3.0 Compilation and Assessment of Existing Information

3.1 Water Quality

Water quality studies of Beaver Dam Lake have included data collection by the Wisconsin Department of Natural Resources (WDNR), water quality studies by the Beaver Dam Lake Management District, and sample collection by a volunteer as a part of the WDNR Self-Help Lake Monitoring Program.

WDNR data collection occurred during 1975 through 1979 and during 1981 through 1987 at several stations. However, in many years only one sample was taken from a lake station and often only during the Fall, Winter, or Spring.

During 1992, the Beaver Dam Lake Management District, with assistance from Short Elliot Hendrickson Inc., completed a lake monitoring program during the lake's growing season (i.e., May through August). Samples were collected from seven sample locations. The study resulted in the following conclusions (Short Elliot Hendrickson Inc. 1995):

- Temperature profiles of Beaver Dam Lake indicated strong vertical stratification in all of the bays except Cemetery Bay. The lack of stratification in Cemetery Bay was due to its shallow depth.

- Approximately 13 percent of the volume of the hypolimnion (water column portion below the thermocline) was depleted of dissolved oxygen in Beaver Dam Lake (West), excluding Rabbit Island Bay and Library Bay.

- Approximately 86 percent of the volume of the hypolimnion was depleted of dissolved oxygen in Rabbit Island Bay of Beaver Dam Lake (West) during June, July, and August of 1992.

- The entire volume of the hypolimnion was depleted of dissolved oxygen in Norwegian Bay of Beaver Dam Lake (East) during June, July, and August of 1992.

- Beaver Dam Lake (West), excluding Rabbit Island Bay and Library Bay, noted a trophic state of oligotrophic (low nutrients, crystal clear).

- Rabbit Island Bay of Beaver Dam Lake (West) noted a trophic state of mesotrophic (moderate nutrients)

- Library Bay of Beaver Dam Lake (West) noted minor aesthetic impacts due to algae, but extensive emergent and submergent macrophyte growths.

- Norwegian Bay of Beaver Dam Lake (East) was considered to be in a highly productive trophic state with a range of recreational suitability impacts of minor to swimming impaired.

- Cemetery Bay of Beaver Dam Lake (East) was considered to be in a highly productive trophic state with recreational suitability of swimming being impaired or eliminated.

- A downward trend in total phosphorus concentrations in Beaver Dam Lake (East) was confirmed. The reason for the trend is believed to be the diversion of the City of Cumberland's wastewater treatment plant discharge to Cemetery Bay. The discharge was discontinued in 1981.

- The lake modeling of Library Bay of Beaver Dam Lake (West) indicated that urban runoff sources contribute 86 percent of its annual total phosphorus loading.

- Lake modeling of Norwegian Bay of Beaver Dam Lake (East) indicated that the Cumberland Ditch contributes approximately 17 percent of the phosphorus loading on an annual basis.

During 1994, the Beaver Dam Lake Management District, with assistance from Short Elliot Hendrickson Inc., completed a lake monitoring program during the lake's growing season (i.e., May through September). Samples were collected from seven sample locations. The study resulted in the following conclusions (Short Elliot Hendrickson Inc. 1995):

- Temperature profiles indicated vertical stratification occurred by mid-May in all seven bays except Cemetery Bay in Beaver Dam Lake (East). Stratification did not occur in Cemetery Bay because of its shallow depth.

- Oxygen depletion was observed in the hypolimnion at all stations, but was less severe than noted in 1992.

- The trophic state of Beaver Dam Lake (West), excluding Rabbit Bay and Library Bay, was oligotrophic (low nutrients, crystal clear), the same trophic state noted in 1992.

- The trophic state of Rabbit Island Bay of Beaver Dam Lake (West) appeared to improve slightly since 1992. The bay was still considered mesotrophic (moderate nutrients).

- The quality of Library Bay of Beaver Dam Lake (West) did not change significantly and was considered mesotrophic, but contained extensive emergent and submergent weed growth.

- The quality of Cemetery and Norwegian Bays of Beaver Dam Lake (East) continued to exhibit high productivity as a result of the City of Cumberland wastewater treatment works discharge. Both bays are considered eutrophic, but the physical appearance has improved from definite algae in 1992 to some algae in 1994.

- The downward trend in total phosphorus in Beaver Dam Lake (West) determined in 1992 was strengthened with the addition of the 1994 data, but may still be an artifact of improved laboratory analytical procedures and not actual water quality improvements.

- The downward trend in total phosphorus concentration in Beaver Dam Lake (East) was also strengthened with the addition of the 1994 data and is the result of the diversion of the City of Cumberland's wastewater treatment plant discharge to Cemetery Bay.

- Oxygen prediction modeling indicates the hypolimnetic oxygen depletion occurring in late summer in the bays of Beaver Dam Lake (West) may not be the result of basin morphometry, but from internal/or external nutrient loading.

- The oxygen prediction modeling confirmed that Beaver Dam Lake (East) continues to be influenced by internal nutrient loading from residuals in the bottom sediments from past wastewater treatment works discharges.

- The quality of the remaining portion of Beaver Dam Lake (East) continued to show improvement apparent since the removal of the wastewater treatment works discharge in 1981.

Self-Help Monitoring data were collected from Beaver Dam Lake during 1992 through 2005. The data indicate the lake has exhibited a relatively stable water quality. Total phosphorus, chlorophyll, and Secchi disc data collected from Beaver Dam Lake (West) indicate the lake notes a trophic state of mesotrophic (moderate nutrients, moderate algal growth, good water transparency). Limited Secchi disc data collected during 1995 through 1997 from Cemetery Bay and Norwegian Bay of Beaver Dam Lake (East) indicate the trophic state of the bays ranged from eutrophic to mesotrophic (from nutrient rich, excessive algal growth to moderate nutrients, moderate algal growth).

3.2 Fishery

Results of a 1996 WDNR survey of Beaver Dam Lake indicated the lake had a gamefish population composed primarily of largemouth bass, walleye, northern pike, and panfish, with small numbers of smallmouth bass present.

4.0 Aquatic Plant Survey Methods

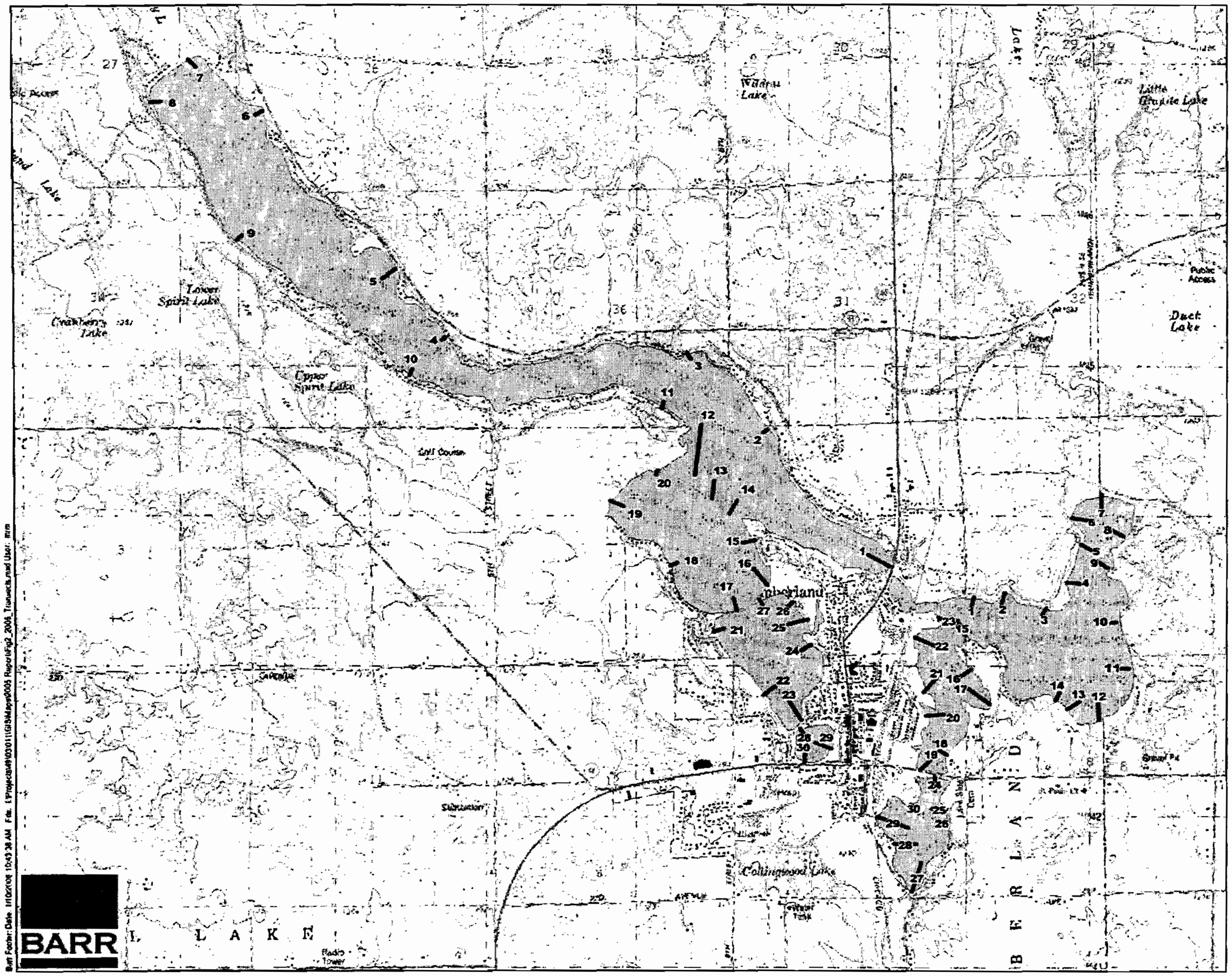
An aquatic plant survey was completed in the lake during 2005 to characterize existing conditions. The entire lake was surveyed during July and a portion of the lake was surveyed during June. The June survey was a pre-treatment survey for areas of the lake treated during June. The June survey was completed by Dr. Robert Anderson, Professor of Biology at Wisconsin Lutheran College (WLC), and 3 WLC students. The Barr Engineering Company staff person who completed the 1999 survey assisted with the first day of June sampling. The July survey was completed by 3 WLC students. A Barr Engineering staff person assisted the students during one of the sampling days. The surveys determined plant species, coverage, and density.

The methodology used in the pre-treatment and late summer surveys is a blend of the line transect methodology, used to complete the 1999 survey, and the point intercept methodology, currently recommended by the Wisconsin Department of Natural Resources (WDNR). The blend was needed to concurrently determine whether changes in the lake's plant community have occurred since 1999 and follow methodology currently recommended by WDNR.

4.1 Line Transect Method

The 30 line transects monitored in East Beaver Dam Lake and 30 line transects monitored in West Beaver Dam Lake during 1999 were again monitored during 2005 to determine whether changes in the lake's plant community have occurred (See Figure 2). The methodology is based upon Jessen and Lound (1962) and is outlined in *Wisconsin's Department of Natural Resources Long-Term Trend Lake Monitoring Methods*, (Bureau of Water Resources Management, July 1987) as modified by Deppe and Lathrop (1992). Methodology details follow:

In June, a pre-treatment survey was completed on transect 6 and transects 12 through 14 in East Beaver Dam Lake (See Figure 3). A total of 11 sample locations were surveyed (3 sample locations on each of 3 transects and 2 sample locations on 1 transect) (See Figure 3). Although sampling was intended to occur on an additional 7 sample locations (3 sample locations on transect 7, 3 sample locations on transect 8, and 1 sample location on transect 6, see Figure 3) in the north arm of Norwegian Bay (East Beaver Dam Lake), dense plant growths and surface algal mats prevented boat navigation and no samples were collected.



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2005 West Transects

2005 East Transects

N

Miles

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Feet

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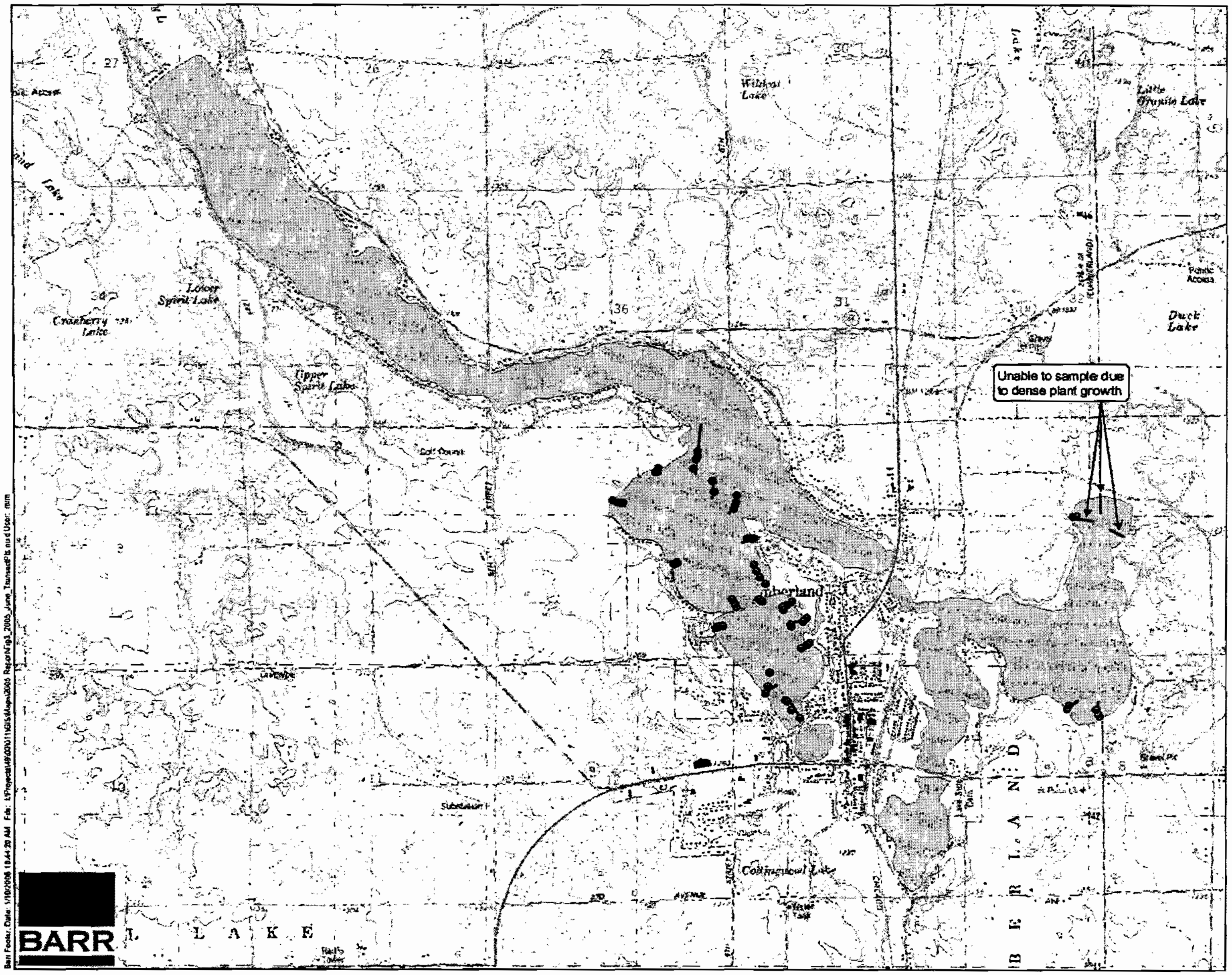
Figure 2

2005 TRANSECT LOCATIONS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



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- June 2005 Transect Sample Points
- 2005 Transects

Miles: 0.5 0 0.5

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Figure 3

2005 JUNE TRANSECT SAMPLE POINTS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

In June a pre-treatment survey was completed on transects 12 through 27 in West Beaver Dam Lake. A total of 60 sample locations were surveyed (4 sample locations on each of 13 transects, 3 sample locations on each of 2 transects, and 2 sample locations on 1 transect) (See Figure 3)

In July, thirty transects in East Beaver Dam Lake and 30 transects in West Beaver Dam Lake were surveyed (See Figure 4). A total of 84 sample locations were surveyed in East Beaver Dam Lake and 103 sample locations were surveyed in West Beaver Dam Lake.

Details of survey methods follow:

- Transects extended from shore to the maximum depth of plant growth. GPS values from the 1999 sample locations were used to locate sample locations along transects during 2005.

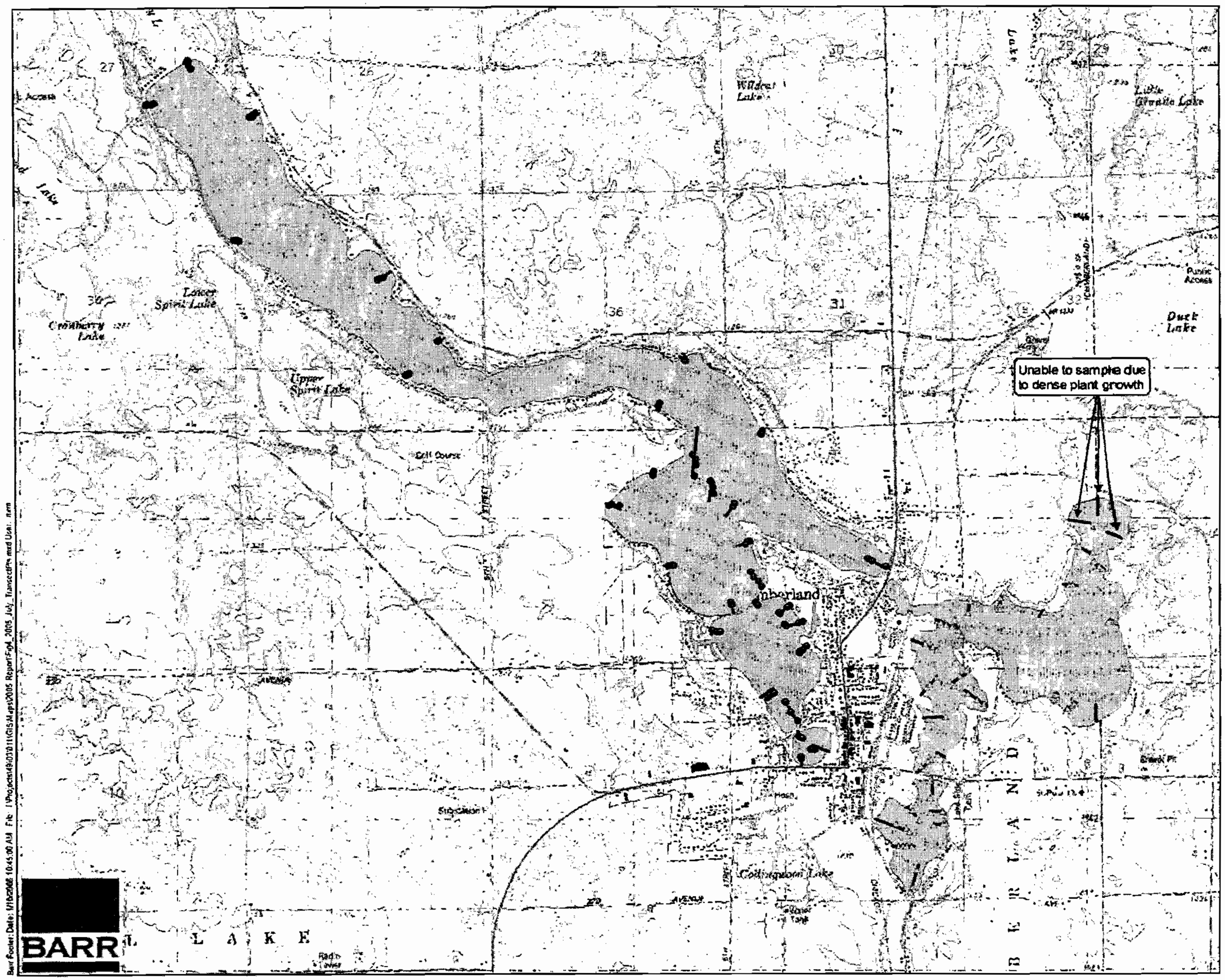
- Four rake samples were taken at each sample location to determine the species present and their abundance. The sample points at each sample location consisted of a 6-foot diameter circle divided into four quadrants. A tethered garden rake with an extended handle (16 feet) was used to collect a sample from each quadrant.

- Collection of samples, identification of species, and determination of density ratings for each species occurred at all sampling points. A determination of overall plant density also occurred at all sampling points. The rake coverage technique was used to assign density ratings (Deppe and Lathrop 1992) in accordance with the criteria shown in Table 1.

Table 1. Density Rating Criteria Based Upon Rake Coverage

Rake Coverage (% of Rake Head Covered)	Density Rating
81-100	5
61-80	4
41-60	3
21-40	2
1-20	1
0	0

- Sediment type was determined at each sampling point.



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July 2005 East Transect Sample Points

July 2005 West Transect Sample Points

2005 Transects

Miles

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Feet

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Figure 4

2005 JULY TRANSECT
SAMPLE POINTS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

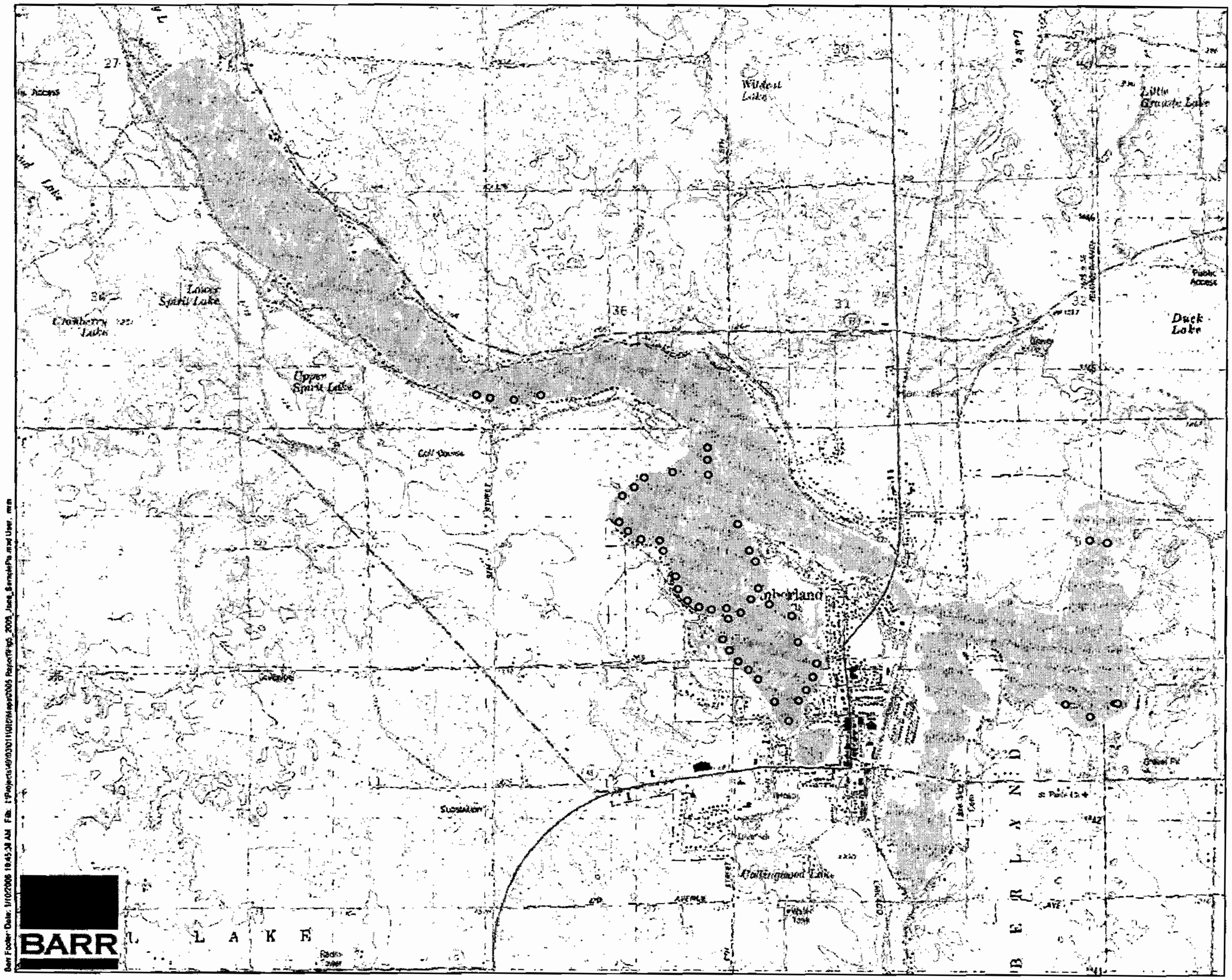
4.2 Point Intercept Method

WDNR currently recommends use of the point intercept method for aquatic plant surveys. The point intercept method uses a grid of sample points in the lake's littoral area rather than transects. The spacing between sample points is based upon the area of the lake's littoral zone. The WDNR recommends collection of samples at 300 foot intervals in the littoral zone of Beaver Dam Lake. The lake's littoral region is narrow and generally less than 300 feet in width. Hence, Beaver Dam Lake plant survey locations were generally located at 300 foot intervals along a line parallel with the shore and approximately midway between shore and the lake's maximum rooting depth. Point intercept sample locations were located between the line transects (discussed in the previous section). Hence, the following discussion uses the phrase "point intercept sample locations" to describe the sample points located between the line transects.

Point intercept sample methodology is based upon Jessen and Lound (1962) and is outlined in *Wisconsin's Department of Natural Resources Long-Term Trend Lake Monitoring Methods*, (Bureau of Water Resources Management, July 1987) as modified by Deppe and Lathrop (1992). Methodology details follow:

- In June, a pre-treatment survey included a total of 5 point intercept sample locations in East Beaver Dam Lake and 46 sample locations in West Beaver Dam Lake (See Figure 5).

- In July, 92 point intercept locations were surveyed in East Beaver Dam. An additional 5 sample locations intended for survey could not be surveyed because dense plant growth prevented boat navigation in this area of the lake. A total of 195 point intercept locations were surveyed in West Beaver Dam Lake (See Figure 6). An additional 2 sample locations within Library Bay intended for survey could not be surveyed because dense plant growth (i.e., water lilies) prevented boat navigation in this area of Library Bay.



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o June 2005 Non-Transect Sample Points

Miles

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Feet

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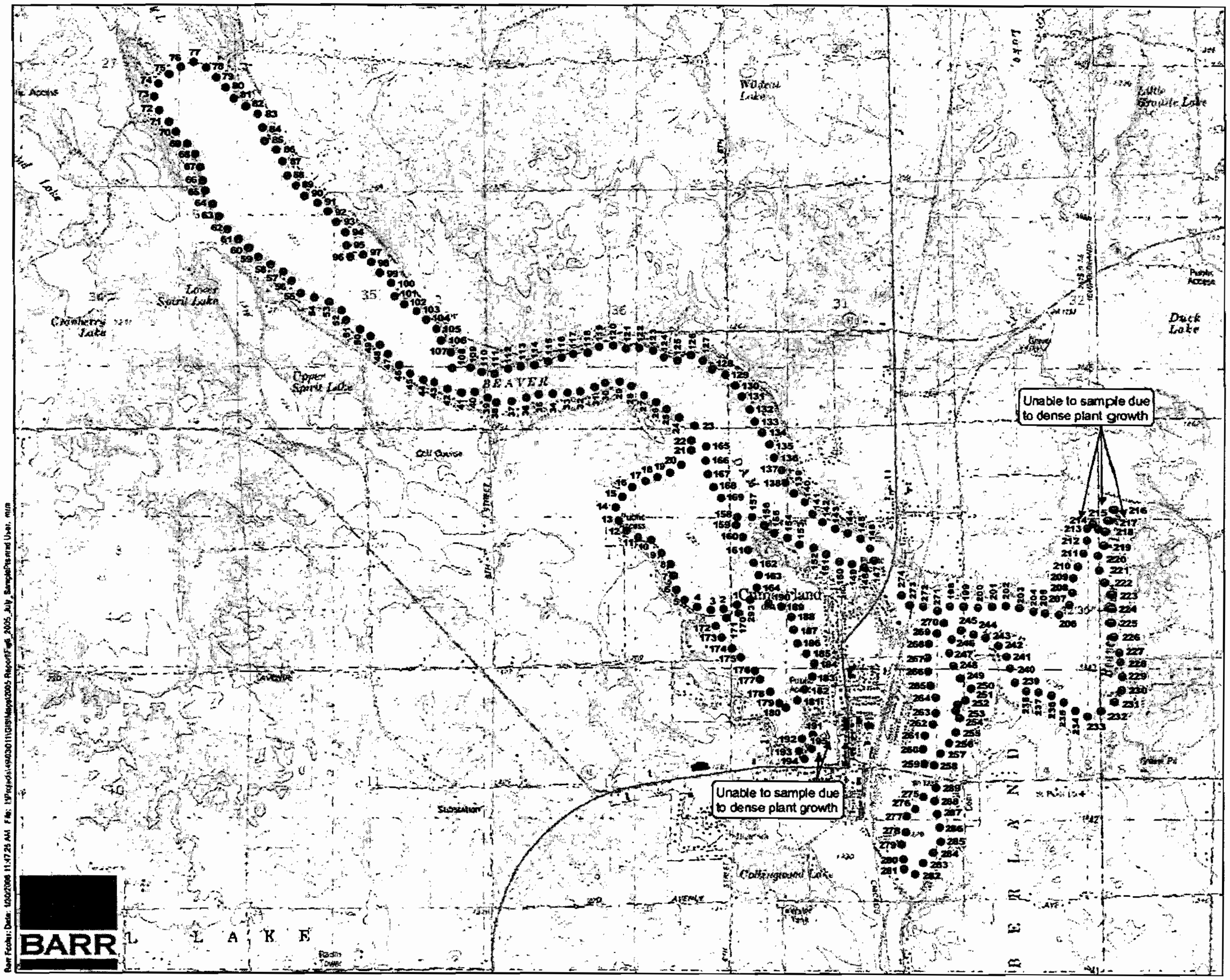
Figure 5

2005 JUNE POINT INTERCEPT
SAMPLE POINTS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



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● July 2005 Point-Intercept Sample Points

Miles

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Feet

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Figure 6

2005 JULY POINT INTERCEPT SAMPLE POINTS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

- A Global Positioning System (GPS) was used to record the location of each survey site.

- Sediment type was determined at each survey location.

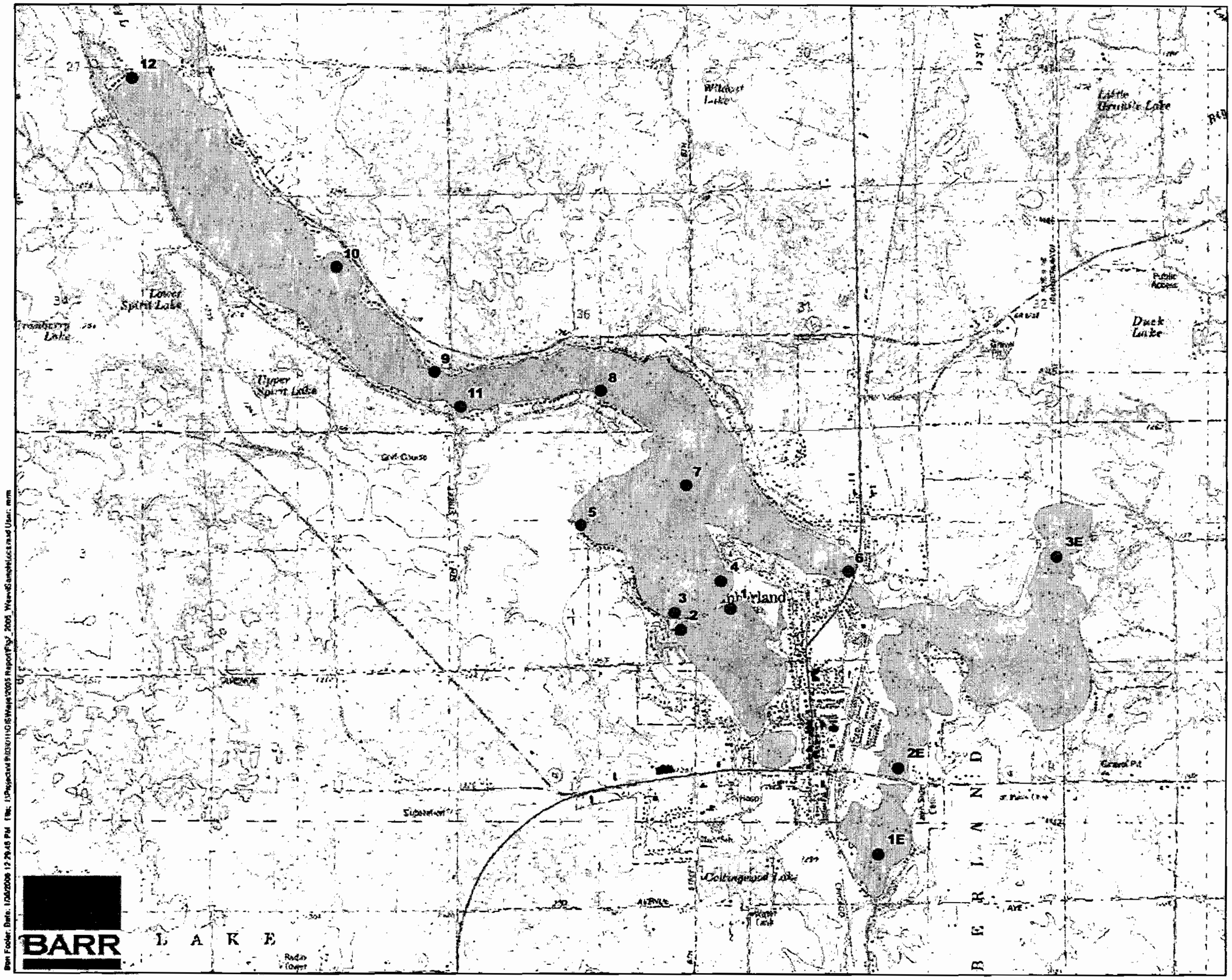
- One rake sample was taken at each survey location to determine the presence and abundance of species. A tethered garden rake with an extended handle (16 feet) was used to collect each sample. The rake was dragged along the bottom for 2.5 feet (0.75 meters) and then flipped 180 degrees to ensure that none of the plants snagged on the teeth of the rake were lost.

- Collection of samples, identification of species, and determination of density ratings for each species occurred at all sampling points. The overall plant density at each survey site was also determined. Density ratings were given in accordance with the criteria presented in Table 1.

4.3 Milfoil Weevil Monitoring

The milfoil weevil (*Euhrychiopsis lecontei*) is a small, herbivorous beetle. It is a milfoil specialist, meaning that it feeds and develops only on plants in this genus. Samples were collected from 15 locations during the July aquatic plant survey to determine whether the beetles were found in Beaver Dam Lake. Samples were collected from 12 West Beaver Dam Lake locations and 3 East Beaver Dam Lake locations (See Figure 7). A Global Positioning System (GPS) was used to record the location of each milfoil weevil sample location. A total of 86 representative stems were collected from the 15 sample locations.

A tethered garden rake with an extended handle (16 feet) was used to collect the stems. Because the beetle is only found in the plant's top 20 inches, the stems were measured to insure that the top 20 inches were collected. . Each plant stem was placed in a labeled ziplock baggie. The stem samples were then placed in a cooler on ice. At the laboratory, each stem was analyzed, using a microscope, to determine whether the meristem was damaged and whether the milfoil weevil (i.e., eggs, larvae, and/or adult) was present. The results of the stem analyses were recorded and the data summarized.



Legend

● 2005 Weevil Sample Locations

Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 7

2005 WEEVIL SAMPLE LOCATIONS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

5.0 Results and Discussion

5.1 Aquatic Plant Survey Results

5.1.1 Aquatic Plant Types

Results of the Beaver Dam Lake aquatic plant surveys during 1999 and 2005 indicate the lake contained a diverse assemblage of aquatic plant species representing three aquatic plant types—submersed plants, floating-leaf plants, and emergent plants. Of the three types, submersed plants dominated the aquatic plant community in both years. Table 2 summarizes 2005 survey results and compares these results with 1999 survey results.

Table 2. Macrophyte Type Distribution

	Total Area Covered in Acres		
Aquatic Plant Type	**June 1999**	**August 1999**	**July 2005**
Submersed Aquatic Plants	403	403	450
Floating Aquatic Plants	47	94	57
Emergent Plants	58	83	6

The June and July 2005 spatial distribution of the 3 macrophyte types in Beaver Dam Lake are presented in Figures 8 and 9. A comparison of the spatial distribution of submergent, floating, and emergent vegetation during 1999 and 2005 are presented in Figures 10, 11, and 12.

5.1.2 Number of Species

The large number of species noted in Beaver Dam Lake is indicative of a stable and healthy aquatic plant community. In July of 2005, a total of 27 species were found in West Beaver Dam Lake and 20 species were found in East Beaver Dam Lake. The number of species observed during 2005 was within the range found during 1999. In 1999, 27 species were found in West Beaver Dam Lake in June and 23 in August. East Beaver Dam Lake noted 19 species in June and 22 during August. The presence of a large number of species in the lake (1) Provides a diverse habitat for fish and invertebrates (i.e., food for fish) and encourages a more diverse fish and invertebrate community and (2) Protects fisheries' habitat from destruction as a species specific disease would affect only one species of the community.

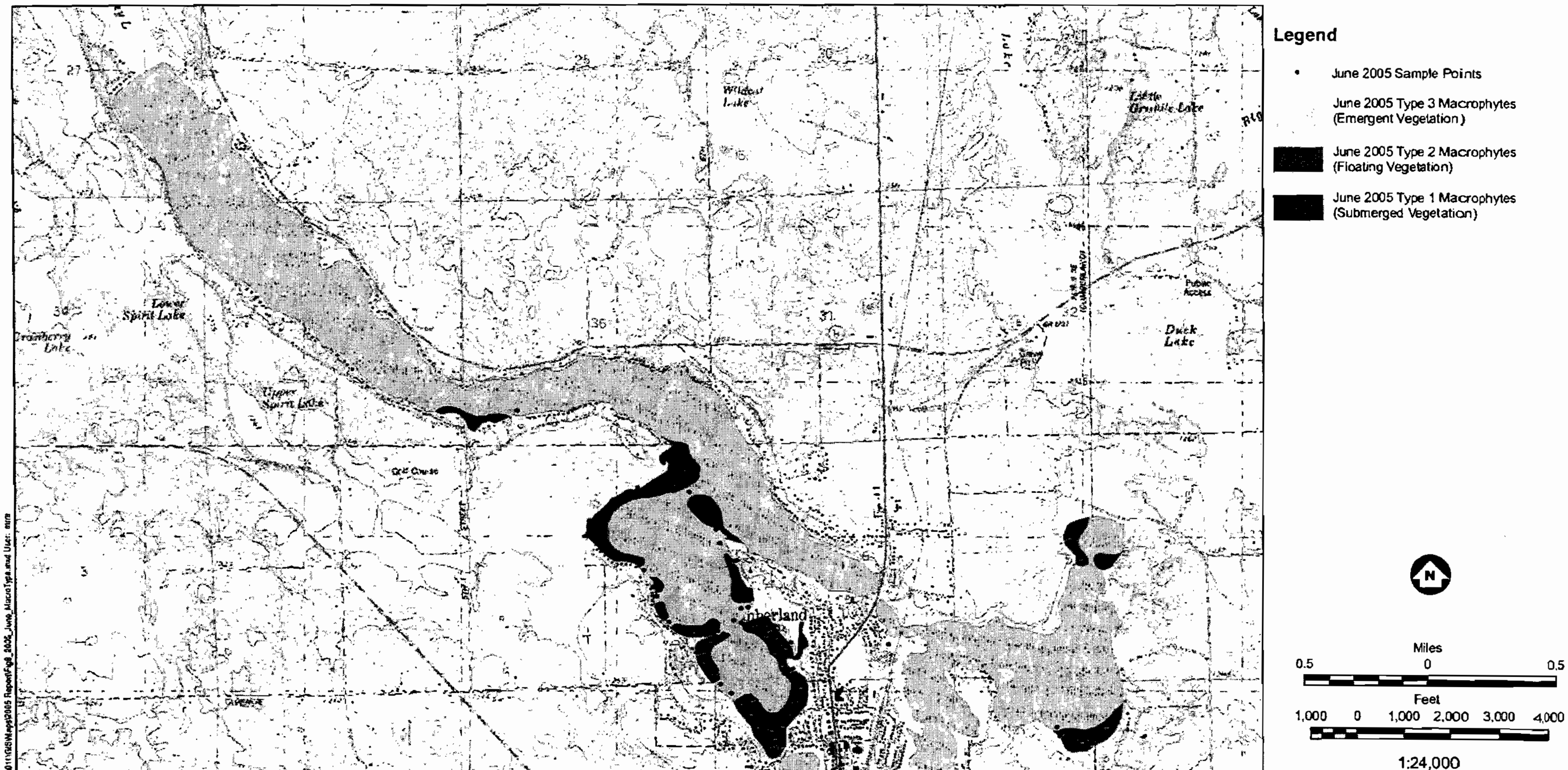


Figure 8

2005 JUNE MACROPHYTE TYPES
2005 Aquatic Plant Management Plan
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Barron County, WI
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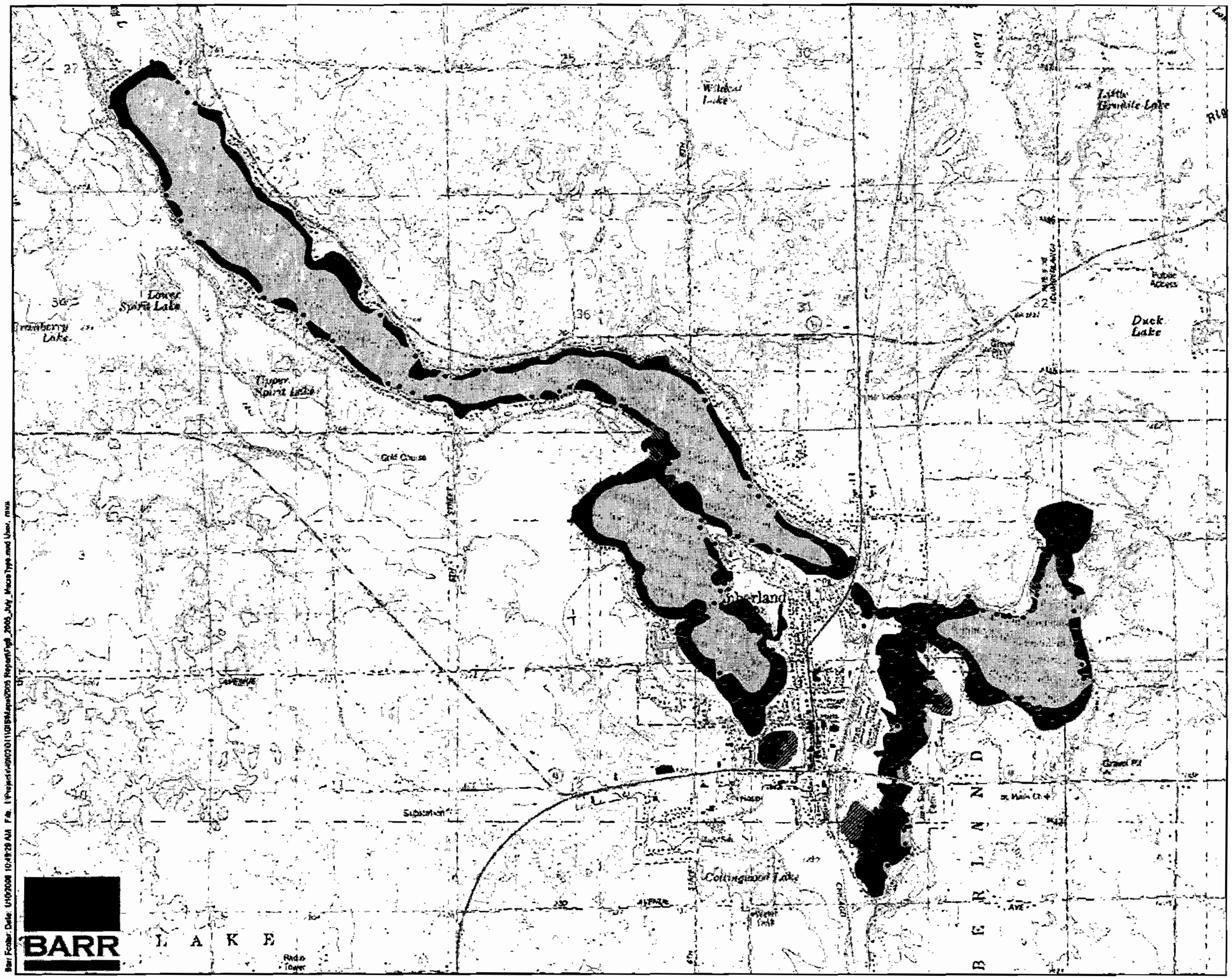

Legend

- July 2005 Sample Points
- July 2005 Type 3 Macrophytes (Emergent Vegetation)
- July 2005 Type 2 Macrophytes (Floating Vegetation)
- July 2005 Type 1 Macrophytes (Submerged Vegetation)

Miles: 0.5 0 0.5

Feet: 1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 9

2005 JULY MACROPHYTE TYPES
2005 Aquatic Plant Management Plan
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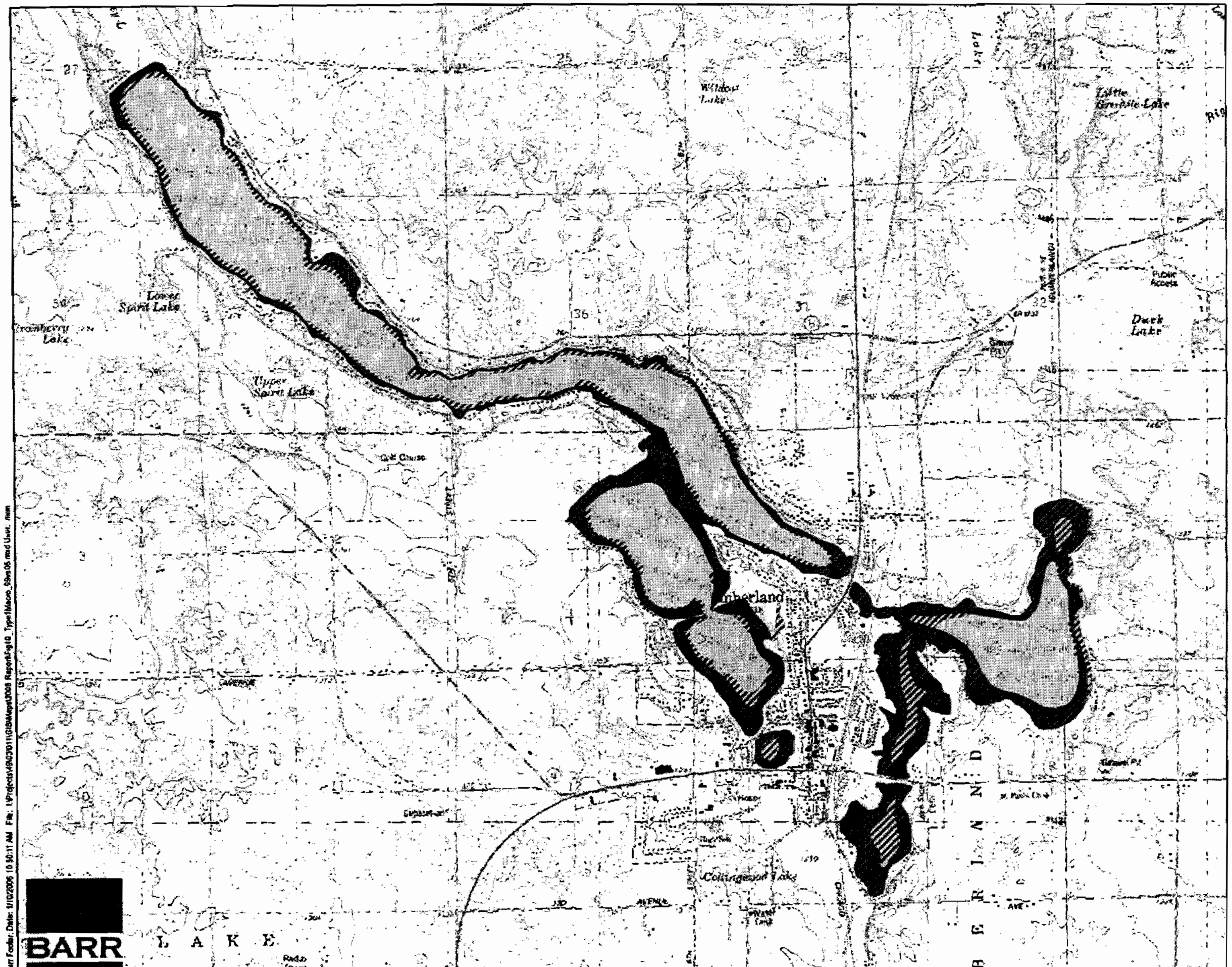

Legend

Type 1 (Submerged) Macrophyte Distribution

2005 July Type 1 Macrophytes

1999 August Type 1 Macrophytes

Miles

0.5 0 0.5

Feet

1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 10

1999 VS. 2005 TYPE 1 (SUBMERGED) MACROPHYTE DISTRIBUTION
2005 Aquatic Plant Management Plan
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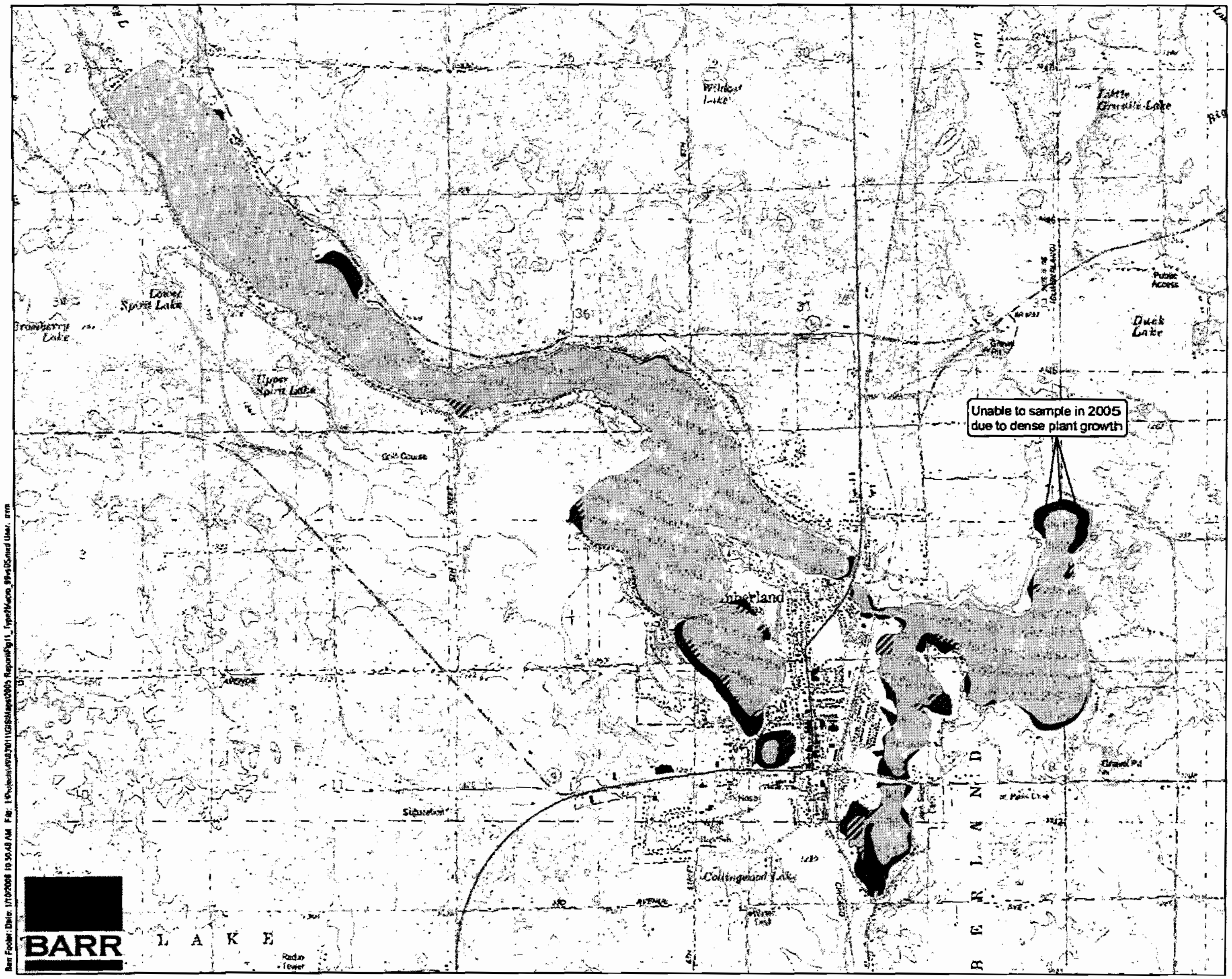

Legend

Type 2 (Floating) Macrophyte Distribution

2005 July Type 2 Macrophytes

1999 August Type 2 Macrophytes

Miles: 0.5 0 0.5

Feet: 1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 11

1999 VS. 2005 TYPE 2 (FLOATING) MACROPHYTE DISTRIBUTION
2005 Aquatic Plant Management Plan
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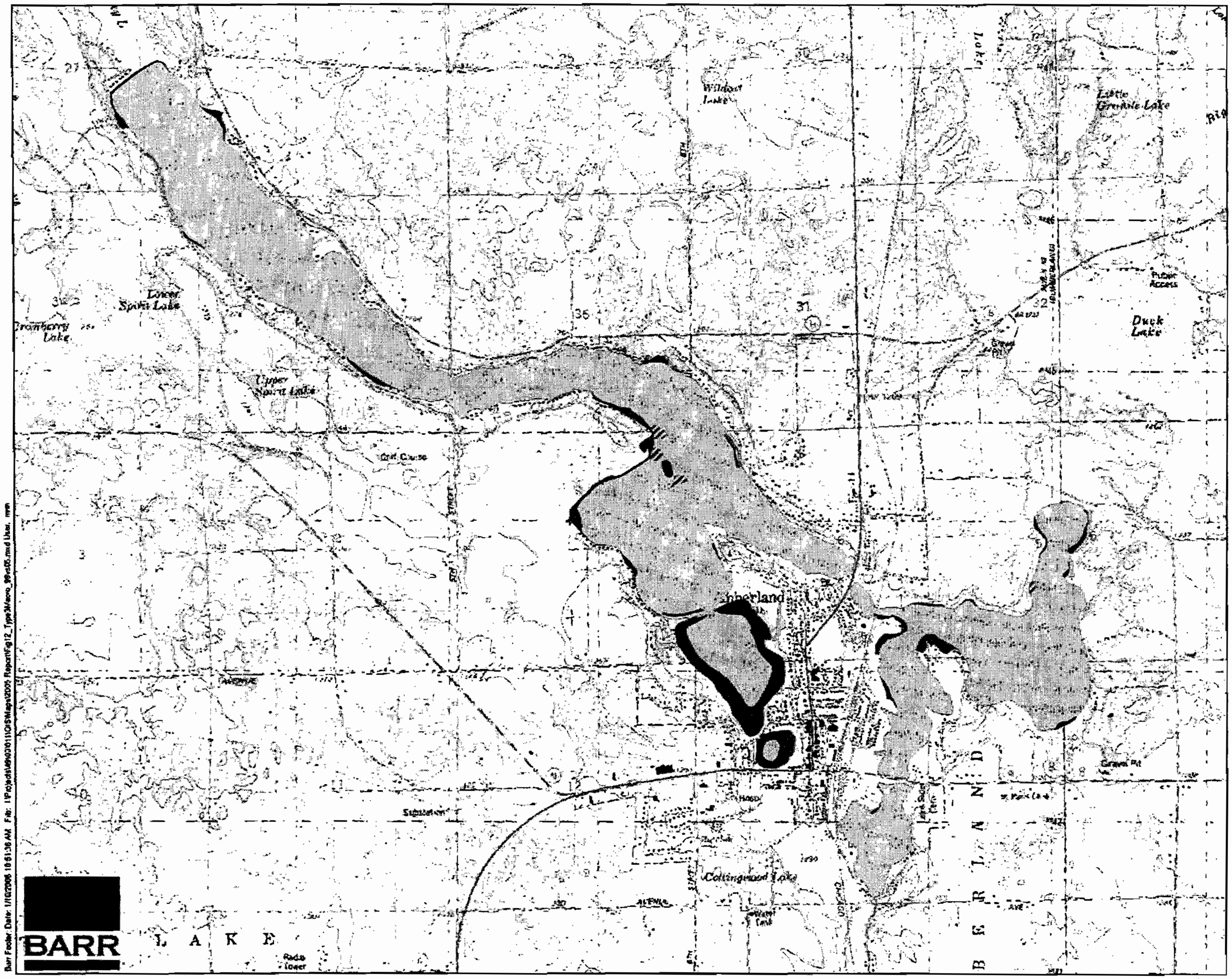

Legend
Type 3 (Emergent) Macrophyte Distribution
2005 July Type 3 Macrophytes
1999 August Type 3 Macrophytes

Miles
0.5 0 0.5
Feet
1,000 0 1,000 2,000 3,000 4,000
1:24,000

Figure 12

1999 VS. 2005 TYPE 3 (EMERGENT) MACROPHYTE DISTRIBUTION
2005 Aquatic Plant Management Plan
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5.1.3 Frequently Occurring Species

Although a diverse aquatic plant community was observed, a few species were abundant. One measure of abundance is the frequency of occurrence of a species measured as the percentage of sample locations containing a species. As shown in Figure 13, the 6 most frequently occurring species in West Beaver Dam Lake during July of 2005 were:

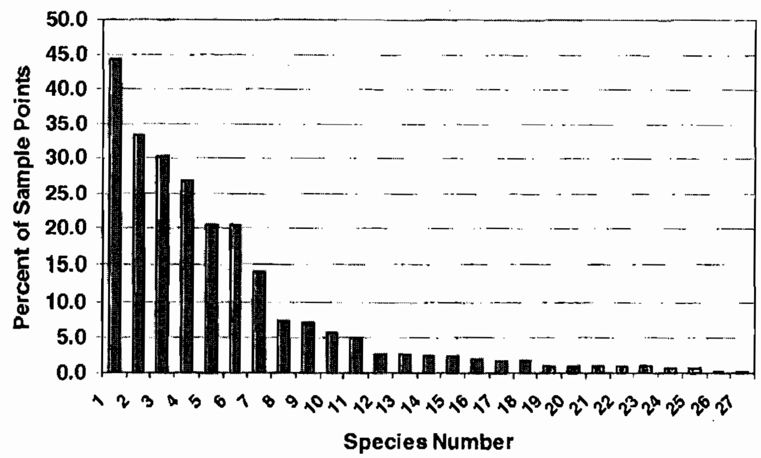
- *Chara spp.* (muskgrass) was found in 44 percent of sample locations
- *Potamogeton illinoensis* (Illinois pondweed) was found in 33 percent of sample locatrions
- *Potamogeton sp. (possibly epihydrus* or *robbinsi)i* (pondweed, possibly ribbonleaf or Robbin's) was found in 30 percent of sample locations.
- *Elodea canadensis* (Canada waterweed) was found in 27 percent of sample locations.
- *Ceratophyllum demersum* (coontail) was found in 20 percent of sample locations
- *Myriophyllum spicatum* (Eurasian watermilfoil) was found in 20 percent of sample locations.

During July of 2005, three of the six species occurring most frequently in West Beaver Dam Lake were also the three most frequently occurring species in East Beaver Dam Lake (See Figure 14):

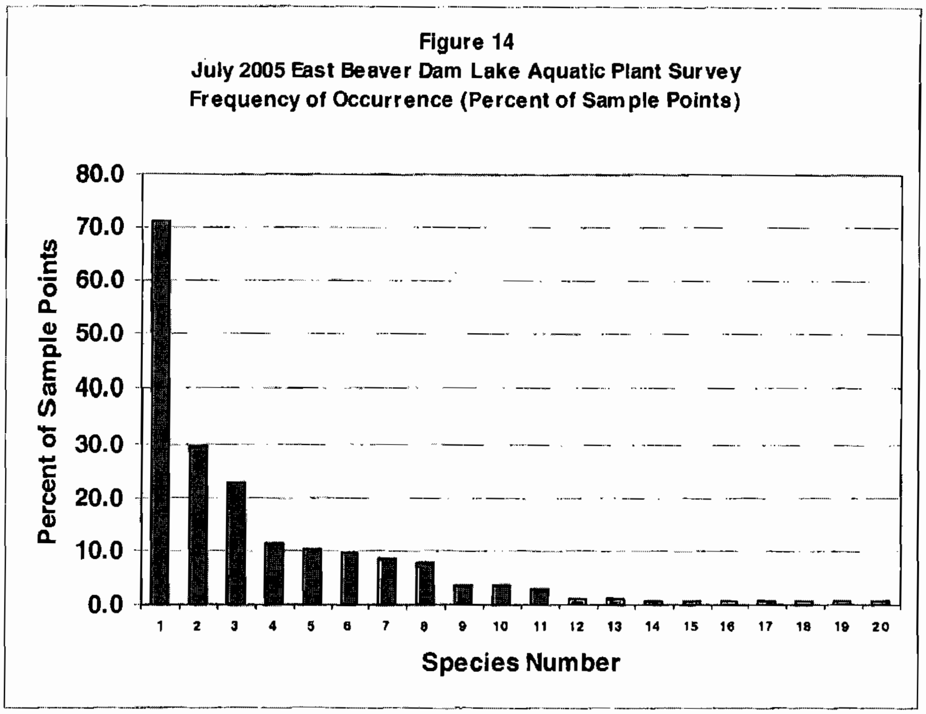
- *Potamogeton sp. (possibly epihydrus* or *robbinsii)* (pondweed, possibly ribbonleaf or Robbin's) was found in 71 percent of sample locations.
- *Ceratophyllum demersum* (coontail) was found in 30 percent of sample locations
- *Elodea canadensis* (Canada waterweed) was found in 23 percent of sample locations.

A comparison of plant species' frequency of occurrence during 1999 and 2005 is shown in Figures 15 and 16. The frequency of occurrence of *Myriophyllum spicatum* (Eurasian watermilfoil, EWM) declined substantially in both West and East Beaver Dam Lake during 1999 through 2005. In West Beaver Dam Lake, EWM noted a frequency of occurrence of 68 to 82 percent in 1999. A decline to 20 percent was observed in 2005. In East Beaver Dam Lake, EWM noted a frequency of occurrence of 33 to 39 percent in 1999. A decline to 10 percent was observed in 2005.

Figure 13
July 2005 West Beaver Dam Lake Aquatic Plant Survey
Frequency of Occurrence (Percent of Sample Points)



Species Number	Scientific Name	Common Name	Frequency (% of Sample Points)
1	*Chara spp.*	muskgrass	44.3
2	*Potamogeton illinoensis*	Illinois pondweed	33.3
3	*Potamogeton sp. (possibly epihydrus or robbinsii)*	pondweed (possibly ribbonleaf or Robbin's)	30.3
4	*Elodea Canadensis*	Canada waterweed	26.7
5	*Ceratophyllum demersum*	coontail	20.3
6	*Myriophyllum spicatum*	Eurasian watermilfoil	20.3
7	*Potamogeton zosteriformis*	flatstem pondweed	14.0
8	*Ceratophyllum sp.*	coontail	7.3
9	*Vallisneria americana*	Wild celery	7.0
10	*Potamogeton crispus*	curlyleaf pondweed	5.7
11	*Najas flexilis*	bushy naiad	5.0
12	*Brasenia schreberi*	watershield	2.7
13	*Nuphar advena*	yellow water lily	2.7
14	*Nymphaea tuberose*	white waterlily	2.3
15	*Potamogeton natans*	floatingleaf pondweed	2.3
16	*Utricularia spp.*	bladderwort	2.0
17	*Potamogeton sp. (possibly diversifolius)*	pondweed (possibly waterthread)	1.7
18	*Scirpus subterminalis*	swaying bulrush	1.7
19	*Myriophyllum sp.*	watermilfoil	1.0
20	*Potamogeton amplifolius*	largeleaf pondweed	1.0
21	*Potamogeton pectinatus*	sago pondweed	1.0
22	*Sagittaria graminea*	grassy arrowhead	1.0
23	*Scirpus sp.*	bulrush	1.0
24	*Nuphar variegate*	spatterdock	0.7
25	*Typha. spp.*	cattail	0.7
26	*Lemna minor*	lesser duckweed	0.3
27	*Myriophyllum sibiricum*	northern watermilfoil	0.3



Species Number	Scientific Name	Common Name	Frequency (% of Sample Points)
1	*Potamogeton sp. (possibly epihydrus or Robbinsii)*	pondweed (possibly ribbonleaf or Robbins)	70.9
2	*Ceratophyllum demersum*	coontail	29.7
3	*Elodea Canadensis*	Canada waterweed	23.0
4	*Potamogeton zosteriformis*	flatstem pondweed	11.5
5	*Myriophyllum spicatum*	eurasian watermilfoil	10.3
6	*Chara spp.*	muskgrass	9.7
7	*Potamogeton illinoensis*	Illinois pondweed	8.5
8	*Nymphaea tuberose*	white waterlily	7.9
9	*Potamogeton crispus*	curlyleaf pondweed	3.6
10	*Vallisneria americana*	Wild celery	3.6
11	*Najas flexilis*	bushy naiad	3.0
12	*Ceratophyllum sp.*	coontail	1.2
13	*Nuphar variegate*	spatterdock	1.2
14	*Eleocharis spp.*	spikerush	0.6
15	*Potamogeton amplifolius*	largeleaf pondweed	0.6
16	*Potamogeton sp. (possibly diversifolius)*	pondweed (possibly waterthread)	0.6
17	*Potamogeton natans*	floatingleaf pondweed	0.6
18	*Sagittaria graminea*	grassy arrowhead	0.6
19	*Scirpus sp.*	bulrush	0.6
20	*Utricularia spp.*	Bladderwort	0.6

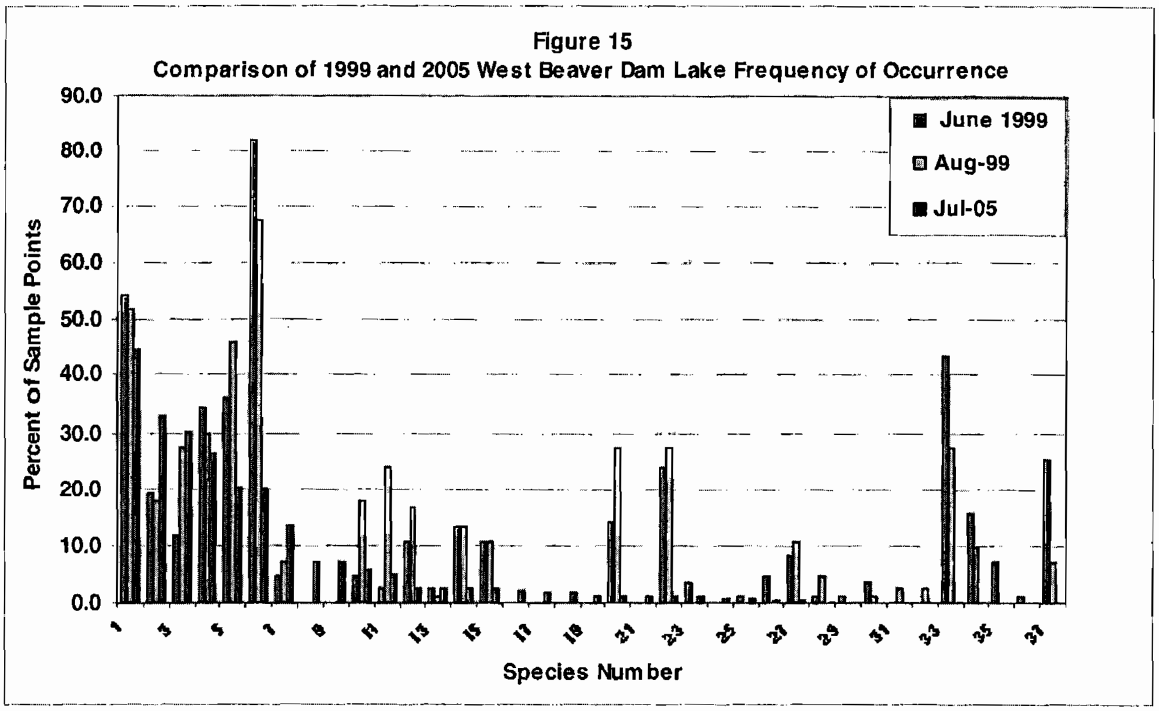


Figure 15
Comparison of 1999 and 2005 West Beaver Dam Lake Frequency of Occurrence
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percent of Sample Points
June 1999
Aug-99
Jul-05
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
Species Number

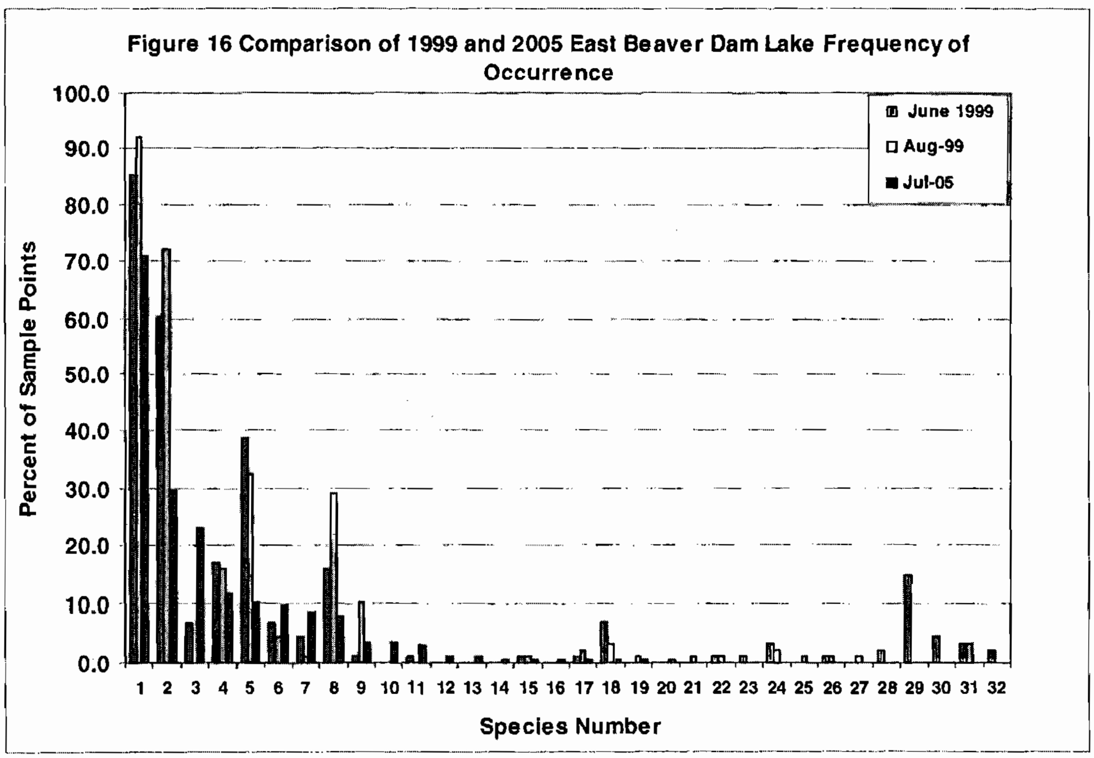


Figure 16 Comparison of 1999 and 2005 East Beaver Dam Lake Frequency of Occurrence
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percent of Sample Points
June 1999
Aug-99
Jul-05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Species Number

Figure 15 (Continued)
Comparison of 1999 and 2005 West Beaver Dam Lake Frequency of Occurrence

Species Number	Scientific Name	Common Name	1999 Frequency (% of Sample Points) June	1999 Frequency (% of Sample Points) August	2005 Frequency (% of Sample Points) July
1	Chara spp.	muskgrass	54.2	51.8	44.3
2	Potamogeton illinoensis	Illinois pondweed	19.3	18.1	33.3
3	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	12.0	27.7	30.3
4	Elodea canadensis	Canada waterweed	34.9	30.1	26.7
5	Ceratophyllum demersum	Coontail	36.1	45.8	20.3
6	Myriophyllum spicatum	Eurasian watermilfoil	81.9	67.5	20.3
7	Potamogeton zosteriformis	Flatstem pondweed	4.8	7.2	14.0
8	Ceratophyllum sp.	Coontail	0.0	0.0	7.3
9	Vallisneria americana	wild celery	0.0	0.0	7.0
10	Potamogeton crispus	curlyleaf pondweed	4.8	18.1	5.7
11	Najas flexilis	bushy naiad	2.4	24.1	5.0
12	Brasenia schreberi	watershield	10.8	16.9	2.7
13	Nuphar advena	yellow water lily	2.4	1.2	2.7
14	Nymphaea tuberosa	white waterlily	13.3	13.3	2.3
15	Potamogeton natans	floatingleaf pondweed	10.8	10.8	2.3
16	Utricularia spp.	bladderwort	0.0	0.0	2.0
17	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	0.0	0.0	1.7
18	Scirpus subterminalis	Swaying bulrush	0.0	0.0	1.7
19	Myriophyllum sp.	watermilfoil	0.0	0.0	1.0
20	Potamogeton amplifolius	largeleaf pondweed	14.5	27.7	1.0
21	Potamogeton pectinatus	sago pondweed	0.0	0.0	1.0
22	Sagittaria graminea	grassy arrowhead	24.1	27.7	1.0
23	Scirpus sp.	Bulrush	3.6	0.0	1.0
24	Nuphar variegata	spatterdock	0.0	0.0	0.7
25	Typha. spp.	cattail	1.2	0.0	0.7
26	Lemna minor	lesser duckweed	4.8	0.0	0.3
27	Myriophyllum sibiricum	Northern watermilfoil	8.4	10.8	0.3
28	Eleocharis spp.	spike rush	1.2	4.8	0.0
29	Lythrum salicaria	purple loosestrife	1.2	0.0	0.0
30	Polygonum amphibium	waterweed	3.6	1.2	0.0
31	Pontederia cordata	pickerelweed	0.0	2.4	0.0
32	Potamogeton gramineus	grass-leaved pondweed	0.0	2.4	0.0
33	Potamogeton pusillus	small pondweed	43.4	27.7	0.0
34	Potamogeton richardsonii	claspingleaf pondweed	15.7	9.6	0.0
35	Sagittaria sp	arrowhead	7.2	0.0	0.0
36	Wolffia columbiana	water meal	1.2	0.0	0.0
37	Zosterella dubia	mud plantain	25.3	7.2	0.0

Figure 16 (Continued)
Comparison of 1999 and 2005 East Beaver Dam Lake Frequency of Occurrence

Species Number	Scientific Name	Common Name	1999 Frequency (% of Sample Points) June	1999 Frequency (% of Sample Points) August	2005 Frequency (% of Sample Points) July
1	Potamogeton sp. (possibly epihydrus or Robbinsii)	pondweed (possibly ribbonleaf or Robbins)	85.2	92.1	70.9
2	Ceratophyllum demersum	coontail	60.2	71.9	29.7
3	Elodea canadensis	Canada waterweed	6.8	0.0	23.0
4	Potamogeton zosteriformis	flatstem pondweed	17.0	15.7	11.5
5	Myriophyllum spicatum	Eurasian watermilfoil	38.6	32.6	10.3
6	Chara spp.	muskgrass	6.8	4.5	9.7
7	Potamogeton illinoensis	Illinois pondweed	4.5	1.1	8.5
8	Nymphaea tuberosa	white waterlily	15.9	29.2	7.9
9	Potamogeton crispus	curlyleaf pondweed	1.1	10.1	3.6
10	Vallisneria americana	wild celery	0.0	0.0	3.6
11	Najas flexilis	bushy naiad	1.1	0.0	3.0
12	Ceratophyllum sp.	coontail	0.0	0.0	1.2
13	Nuphar variegata	spatterdock	0.0	0.0	1.2
14	Eleocharis spp.	spikerush	0.0	0.0	0.6
15	Potamogeton amplifolius	largeleaf pondweed	1.1	1.1	0.6
16	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	0.0	0.0	0.6
17	Potamogeton natans	floatingleaf pondweed	1.1	2.2	0.6
18	Sagittaria graminea	grassy arrowhead	6.8	3.4	0.6
19	Scirpus sp.	bulrush	0.0	1.1	0.6
20	Utricularia spp.	bladderwort	0.0	0.0	0.6
21	Brasenia schreberi	watershield	0.0	1.1	0.0
22	Eleocharis acicularis	needle spikerush, hairgrass	1.1	1.1	0.0
23	Lemna minor	lesser duckweed	1.1	0.0	0.0
24	Myriophyllum sibericum	northern watermilfoil	3.4	2.2	0.0
25	Nuphar variegata	yellow waterlily	0.0	1.1	0.0
26	Pontederia cordata	pickerelweed	1.1	1.1	0.0
27	Potamogeton gramineus	grass-leaved pondweed	0.0	1.1	0.0
28	Potamogeton pusillus	small pondweed	2.3	0.0	0.0
29	Potamogeton richardsonii	claspingleaf pondweed	14.8	0.0	0.0
30	Ranunculus sp.	marsh marigold	4.5	0.0	0.0
31	Typha spp.	cattail	3.4	3.4	0.0
32	Zosterella dubia	mud plantain	2.3	0.0	0.0

5.1.4 Density of Individual Species

2005 aquatic plant density in Beaver Dam Lake ranged from 0 to 5 (See Methods Section—0 denotes no macrophytes and densities of 1 through 5 denote increasing plant density to a maximum density denoted by 5). Densities denoted by each individual species in Beaver Dam Lake were averaged to determine the species' average density.

Areas within Beaver Dam Lake with heavy plant densities (i.e., greater than 2.5) do not support the lake's beneficial uses and provide a less than ideal habitat for the lake's fisheries. Species noting an average density in West Beaver Dam Lake greater than 2.5 were *Nymphaea tuberosa* (white water lily) and *Nuphar variegata* (spatterdock) (See Table 3). One species, *Sagittaria graminea* (slender arrowhead), noted an average density in East Beaver Dam Lake greater than 2.5 (i.e., heavy density). However, this emergent species was only noted in one sample location.

Densities of many plant species within the lake varied from light to heavy and noted a moderate average density. Nonetheless, areas within the lake with heavy plant densities do not support the lake's beneficial uses. Species in West Beaver Dam Lake that noted heavy plant densities (i.e., greater than 2.5) include *Brasenia schreberi* (watershield), *Ceratophyllum demersum* (coontail), *Chara* (muskgrass), *Elodea canadensis* (Canada waterweed), *Myriophyllum spicatum* (Eurasian watermilfoil), *Nuphar advena* (yellow water lily), *Nymphaea tuberosa* (white water lily), *Potamogeton natans* (floatingleaf pondweed), and *Potamogeton sp.* (pondweed, possibly ribbonleaf or Robbin's) (See Table 3 and Figure 17) Species in East Beaver Dam Lake that noted heavy plant densities include *Elodea canadensis* (Canada waterweed), *Nymphaea tuberosa* (white waterlily), *Potamogeton sp.* (pondweed, possibly ribbonleaf or Robbin's), and *Sagittaria graminea* (slender arrowhead) (See Table 4 and Figure 18).

Although many species noted minor changes in density during 1999 through 2005, some species noted increases from moderate to heavy densities and one from heavy to moderate (See Figures 19 and 20). Species noting a density increase from moderate density (i.e., less than 2.5) in 1999 to heavy density (i.e, more than 2.5) in 2005 include *Nuphar advena* (yellow water lily) and *Nymphaea tuberosa* (white waterlily) in West Beaver Dam Lake and *Sagittaria graminea* (slender arrowhead) in East Beaver Dam Lake. One species, *Najas flexilis* (bushy naiad) noted a density reduction in East Beaver Dam Lake from a heavy density in 1999 to a light density in 2005 (See Figure 20).

Although Eurasian watermilfoil decreased substantially in coverage during the 1999 through 2005 period, a relatively small decrease in average density occurred during this period. The change in average density between June 1999 and July 2005 was about a 10 percent reduction and the change between August 1999 and July 2005 was about a 1 percent reduction.

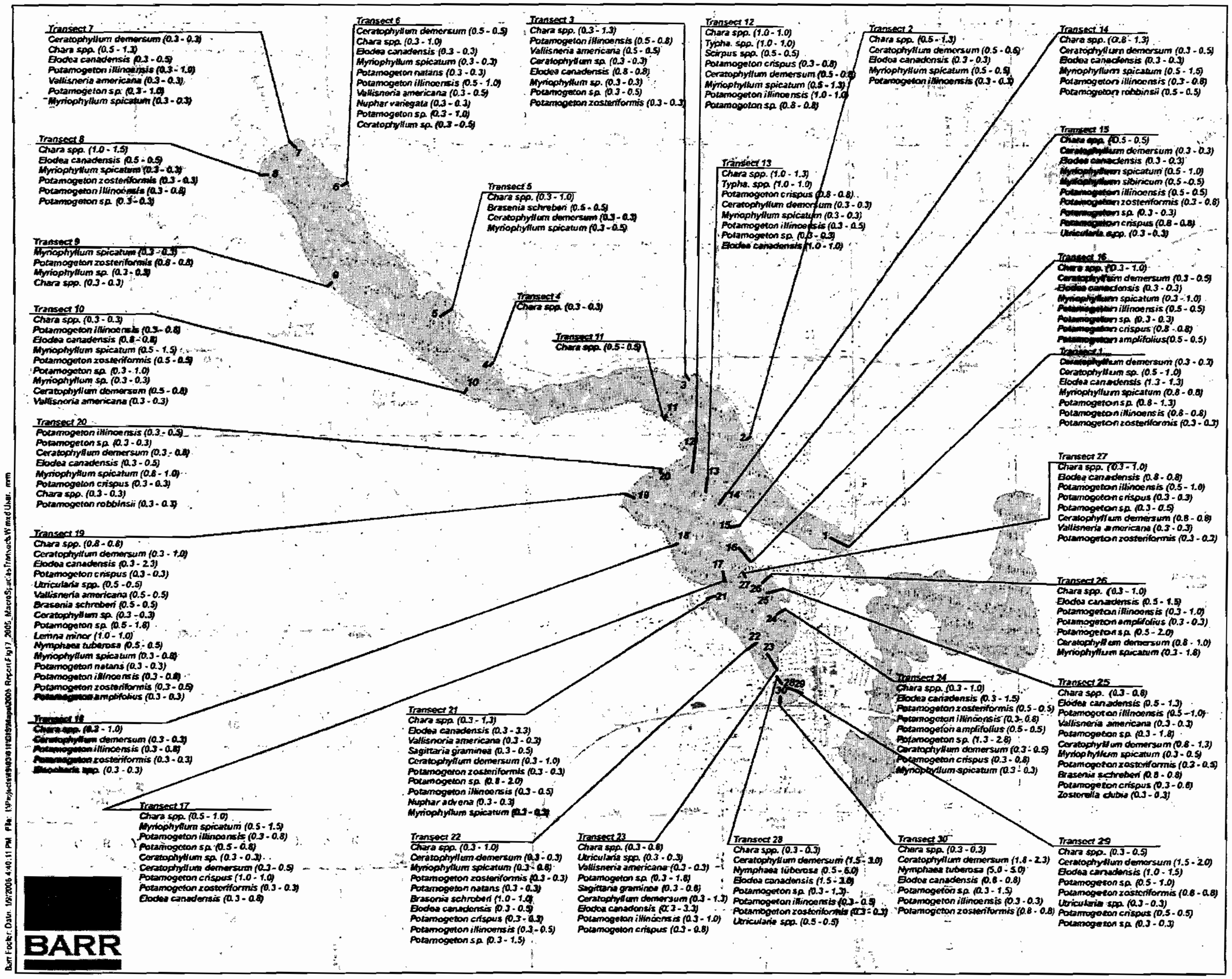
Table 3

2005 West Beaver Dam Lake Low, Average, and High Density of Individual Species

	Species (Scientific Name)	Species (Common name)	Low Density	Average Density	High Density
1	*Brasenia schreberi*	Watershield	0.50	1.09	3.00
2	*Ceratophyllum demersum*	Coontail	0.25	1.05	4.00
3	*Ceratophyllum sp.*	spineless hornwort	0.25	0.74	1.00
4	*Chara spp.*	Muskgrass	0.25	0.97	4.00
5	*Elodea Canadensis*	Canada waterweed	0.25	0.94	5.00
6	*Lemna minor*	lesser duckweed	1.00	1.00	1.00
7	*Myriophyllum sp.*	Watermilfoil	0.25	0.25	0.25
8	*Myriophyllum sibiricum*	northern watermilfoil	0.50	0.50	0.50
9	*Myriophyllum spicatum*	Eurasian watermilfoil	0.25	0.93	3.00
10	*Najas flexilis*	bushy naiad	1.00	1.00	1.00
11	*Nuphar advena*	yellow water lily	2.00	3.00	4.00
12	*Nuphar variegate*	spatterdock	0.25	0.63	1.00
13	*Nymphaea tuberose*	white waterlily	0.50	3.71	5.00
14	*Potamogeton amplifolius*	largeleaf pondweed	0.25	0.33	0.50
15	*Potamogeton crispus*	curlyleaf pondweed	0.25	0.47	1.00
16	*Potamogeton sp. (possibly diversifolius)*	pondweed (possibly waterthread)	0.25	0.70	1.00
17	*Potamogeton sp. (possibly epihydrus or robbinsii)*	pondweed (possibly ribbonleaf or Robbin's)	0.25	0.99	4.00
18	*Potamogeton illinoensis*	Illinois pondweed	0.25	0.79	1.00
19	*Potamogeton natans*	Floatingleaf pondweed	0.25	1.11	3.00
20	*Potamogeton pectinatus*	sago pondweed	1.00	1.00	1.00
21	*Potamogeton zosteriformis*	flatstem pondweed	0.25	0.60	1.00
22	*Sagittaria graminea*	grassy arrowhead	0.25	0.50	0.75
23	*Scirpus sp.*	Bulrush	0.50	0.83	1.00
24	*Scirpus subterminalis*	swaying bulrush	1.00	1.20	2.00
25	*Typha. Spp.*	cattail	1.00	1.00	1.00
26	*Utricularia spp.*	bladderwort	0.25	0.58	1.00
27	*Vallisneria americana*	wild celery	0.25	0.64	1.00

Table 4
2005 East Beaver Dam Lake Low, Average, and High Density of Individual Species

	Species (Scientific Name)	Species (Common name)	Low Density	Average Density	High Density
1	*Ceratophyllum demersum*	coontail	0.25	0.71	2.00
2	*Ceratophyllum sp.*	coontail	0.25	0.25	0.25
3	*Chara spp.*	muskgrass	0.25	0.59	1.00
4	*Eleocharis spp.*	spikerush	0.25	0.25	0.25
5	*Elodea canadensis*	Canada waterweed	0.25	0.76	5.00
6	*Myriophyllum spicatum*	eurasian watermilfoil	0.25	0.63	1.00
7	*Najas flexilis*	bushy naiad	0.25	0.80	1.50
8	*Nuphar variegata*	spatterdock	1.00	1.50	2.00
9	*Nymphaea tuberosa*	white waterlily	0.25	2.42	5.00
10	*Potamogeton amplifolius*	largeleaf pondweed	0.25	0.25	0.25
11	*Potamogeton crispus*	curlyleaf pondweed	0.25	0.54	1.00
12	*Potamogeton sp. (possibly diversifolius)*	pondweed (possibly waterthread)	0.25	0.25	0.25
13	*Potamogeton sp. (possibly epihydrus or robbinsii)*	pondweed (possibly ribbonleaf or Robbin's)	0.25	1.77	5.00
14	*Potamogeton illinoensis*	Illinois pondweed	0.25	0.71	2.00
15	*Potamogeton natans*	floatingleaf pondweed	0.25	0.25	0.25
16	*Potamogeton zosteriformis*	flatstem pondweed	0.25	0.54	1.00
17	*Sagittaria graminea*	slender arrowhead	3.00	3.00	3.00
18	*Scirpus sp.*	bulrush	1.00	1.00	1.00
19	*Utricularia spp.*	bladderwort	0.5	0.50	0.50
20	*Vallisneria americana*	wild celery	0.25	0.71	1.00



2005 West Transect Macrophytes and Average Density Range (average of 4 rake tosses)
Note: 1 average density unit equals 20% rake coverage.

N

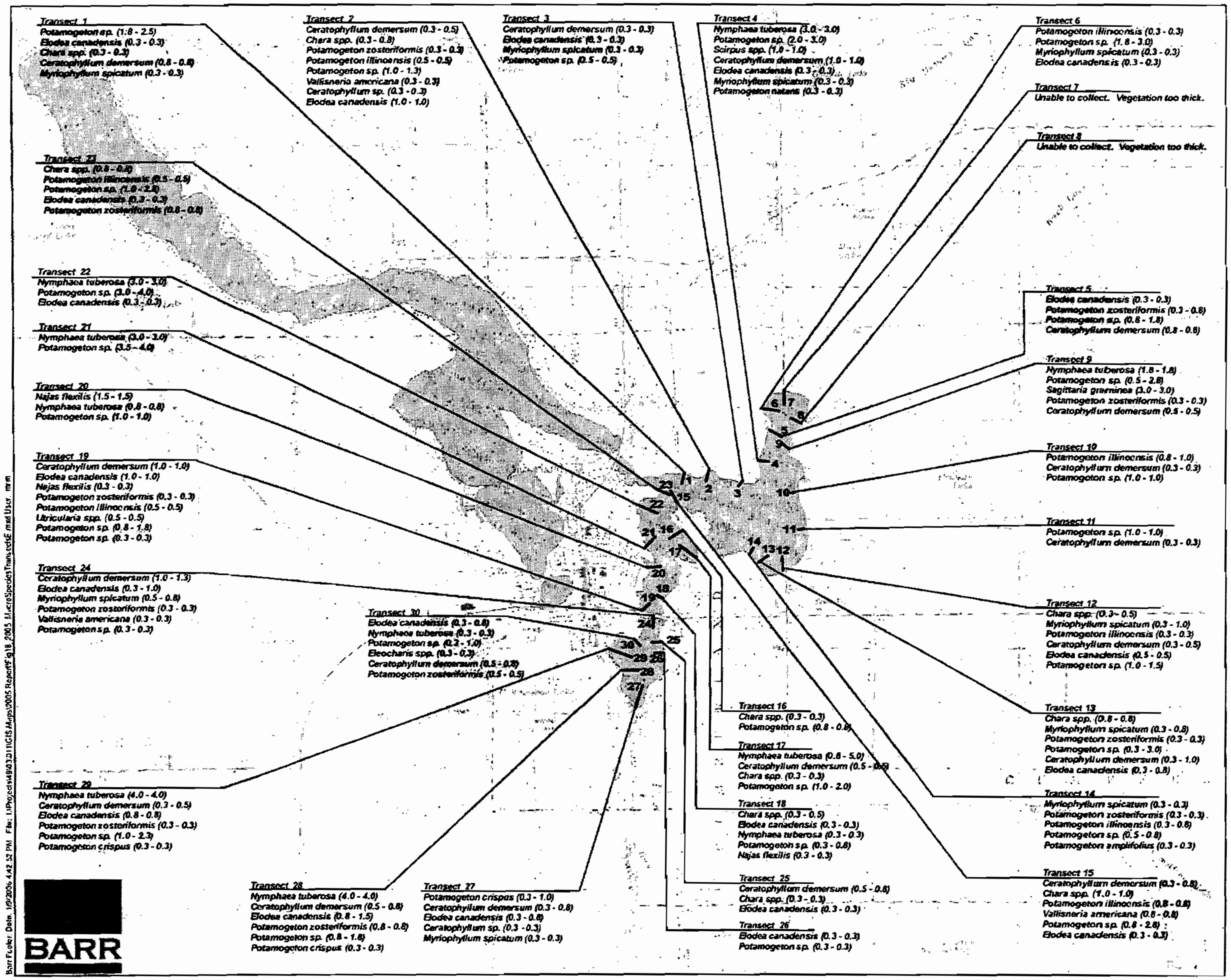
0.5 0.25 0 0.5 Miles

2,000 1,000 0 2,000 4,000 Feet

1:30,000

Figure 17

2005 MACROPHYTES
WEST TRANSECTS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



2005 East Transect Macrophyte and Average Density Range (average of 4 rake tosses)
Note: 1 average density unit equals 20% rake coverage.

0.5 0.25 0 0.5 Miles

2,000 1,000 0 2,000 4,000 Feet

1:30,000

Figure 18

2005 MACROPHYTES
EAST TRANSECTS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

Figure 19
West Beaver Dam Lake Macrophyte Survey
Comparison of 1999 and 2005 Average Density (Per Sample Point)

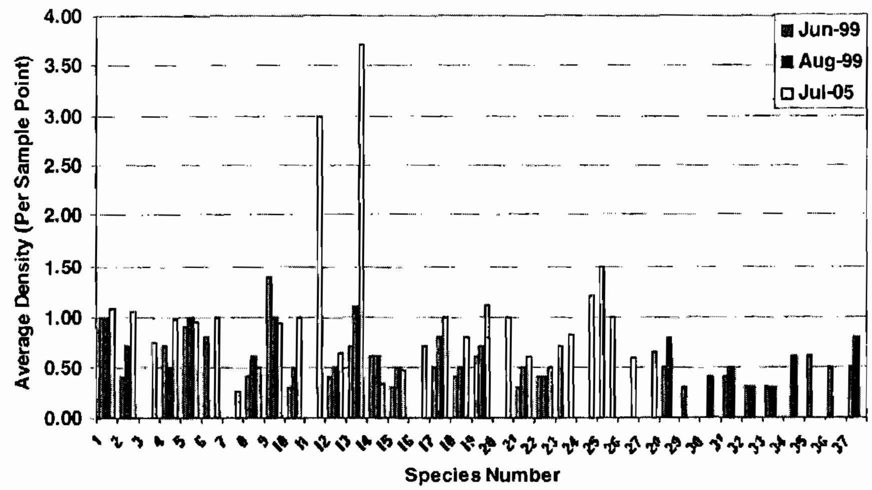


Figure 20
East Beaver Dam Lake Macrophyte Survey
Comparison of 1999 and 2005 Average Density (Per Sample Point)

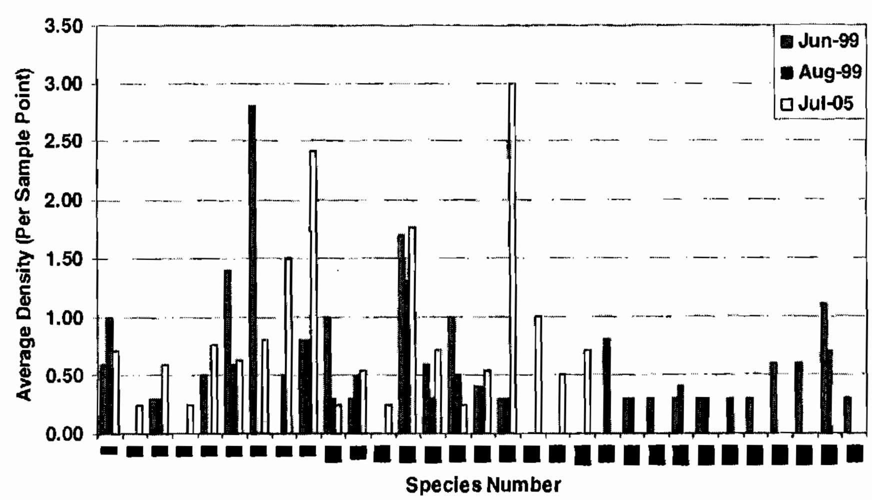


Figure 19 (Continued)

Comparison of 1999 and 2005 West Beaver Dam Lake Average Density

Species Number	Scientific Name	Common Name	1999 Average Density Per Sample Point June	1999 Average Density Per Sample Point August	2005 Average Density Per Sample Point
1	*Brasenia schreberi*	watershield	1.00	1.00	1.09
2	*Ceratophyllum demersum*	coontail	0.40	0.70	1.05
3	*Ceratophyllum sp.*	coontail	0.00	0.00	0.74
4	*Chara spp.*	muskgrass	0.70	0.50	0.97
5	*Elodea canadensis*	Canada waterweed	0.90	1.00	0.94
6	*Lemna minor*	lesser duckweed	0.80	0.00	1.00
7	*Myriophyllum sp.*	watermilfoil	0.00	0.00	0.25
8	*Myriophyllum sibiricum*	northern watermilfoil	0.40	0.60	0.50
9	*Myriophyllum spicatum*	Eurasian watermilfoil	1.40	1.00	0.93
10	*Najas flexilis*	Bushy naiad	0.30	0.50	1.00
11	*Nuphar advena*	Yellow water lily	0.00	0.00	3.00
12	*Nuphar variegata*	spatterdock	0.40	0.50	0.63
13	*Nymphaea tuberosa*	White waterlily	0.70	1.10	3.71
14	*Potamogeton amplifolius*	largeleaf pondweed	0.60	0.60	0.33
15	*Potamogeton crispus*	curlyleaf pondweed	0.30	0.50	0.47
16	*Potamogeton sp. (possibly diversifolius)*	pondweed (possibly waterthread)	0.00	0.00	0.70
17	*Potamogeton sp. (possibly epihydrus or robbinsii)*	pondweed (possibly ribbonleaf or Robbin's)	0.50	0.80	0.99
18	*Potamogeton illinoensis*	Illinois pondweed	0.40	0.50	0.79
19	*Potamogeton natans*	floatingleaf pondweed	0.60	0.70	1.11
20	*Potamogeton pectinatus*	sago pondweed			1.00
21	*Potamogeton zosteriformis*	flatstem pondweed	0.30	0.50	0.60
22	*Sagittaria graminea*	grassy arrowhead	0.40	0.40	0.50
23	*Scirpus sp.*	bulrush	0.70	0.00	0.83
24	*Scirpus subterminalis*	swaying bulrush			1.20
25	*Typha. spp.*	cattail	1.50	0.00	1.00
26	*Utricularia spp.*	bladderwort	0.00	0.00	0.58
27	*Vallisneria americana*	wild celery	0.00	0.00	0.64
28	*Eleocharis spp*	Spike rush	0.50	0.80	0.00
29	*Lythrum salicaria*	purple loosestrife	0.30	0.00	0.00
30	*Potamogeton gramineus*	Grass-leaved pondweed	0.00	0.40	0.00
31	*Potamogeton pusillus*	small pondweed	0.40	0.50	0.00
32	*Potamogeton richardsonii*	claspingleaf pondweed	0.30	0.30	0.00
33	*Polygonum amphibium*	Water smartweed	0.30	0.30	0.00
34	*Pontedoria cordata*	pickerelweed	0.00	0.60	0.00
35	*Sagittaria sp.*	arrowhead	0.60	0.00	0.00
36	*Wolffia columbiana*	Water meal	0.50	0.00	0.00
37	*Zosterella dubia*	mud plantain	0.50	0.80	0.00

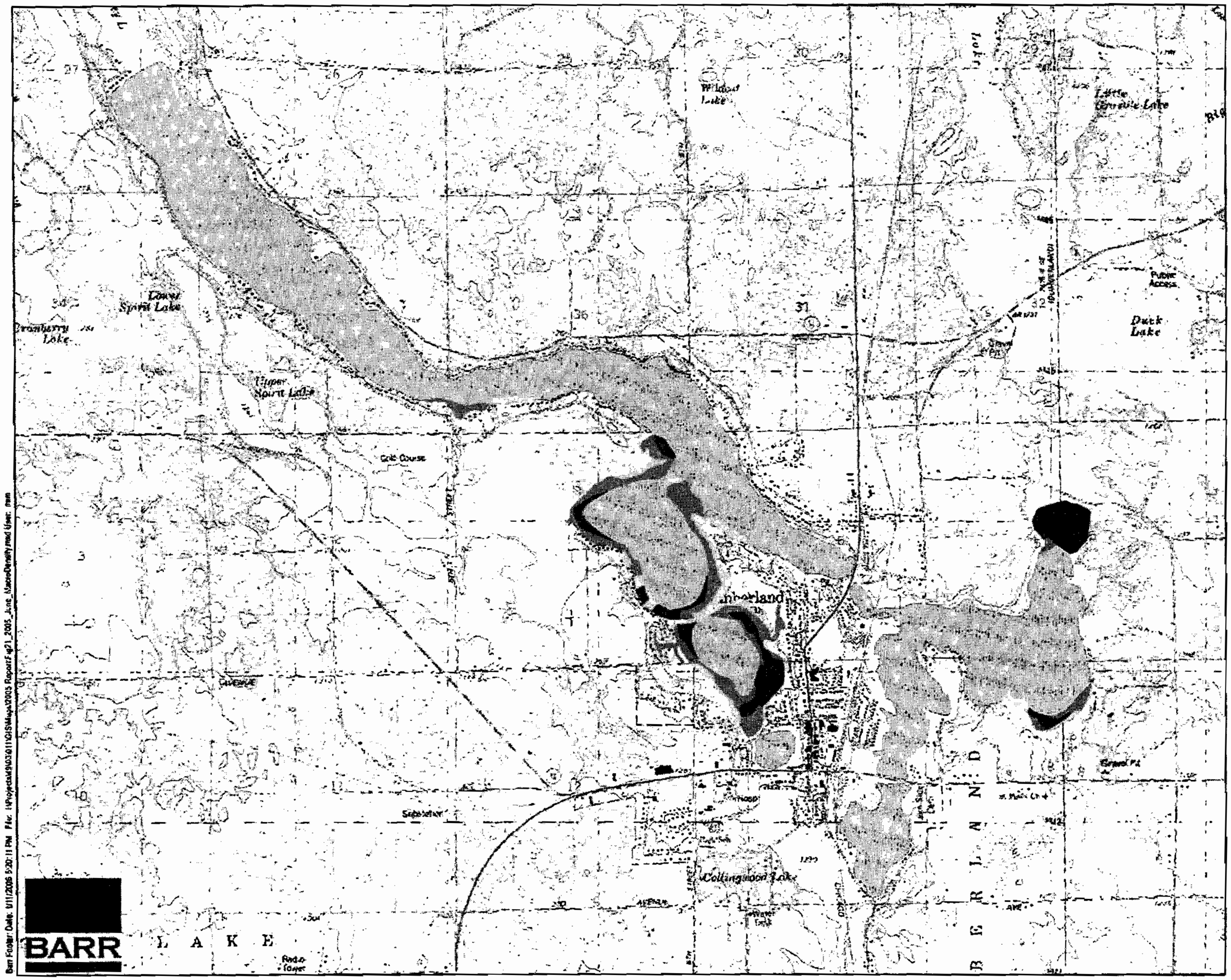
Figure 20 (Continued)
Comparison of 1999 and 2005 East Beaver Dam Lake Average Density

Species Number	Scientific Name	Common Name	1999 Average Density Per Sample Point June	1999 Average Density Per Sample Point August	2005 Average Density Per Sample Point
1	*Ceratophyllum demersum*	coontail	0.60	1.00	0.71
2	*Ceratophyllum sp.*	coontail	0.00	0.00	0.25
3	*Chara spp.*	muskgrass	0.30	0.30	0.59
4	*Eleocharis spp.*	spikerush	0.00	0.00	0.25
5	*Elodea canadensis*	Canada waterweed	0.50	0.00	0.76
6	*Myriophyllum spicatum*	Eurasian watermilfoil	1.40	0.60	0.63
7	*Najas flexilis*	Bushy naiad	2.80	0.00	0.80
8	*Nuphar variegata*	spatterdock	0.00	0.50	1.50
9	*Nymphaea tuberosa*	White waterlily	0.80	0.80	2.42
10	*Potamogeton amplifolius*	largeleaf pondweed	1.00	0.30	0.25
11	*Potamogeton crispus*	curlyleaf pondweed	0.30	0.50	0.54
12	*Potamogeton sp. (possibly diversifolius)*	pondweed (possibly waterthread)	0.00	0.00	0.25
13	*Potamogeton sp. (possibly epihydrus or robbinsii*	pondweed (possibly ribbonleaf or Robbin's)	1.70	1.30	1.77
14	*Potamogeton illinoensis*	Illinois pondweed	0.60	0.30	0.71
15	*Potamogeton natans*	floatingleaf pondweed	1.00	0.50	0.25
16	*Potamogeton zosteriformis*	flatstem pondweed	0.40	0.40	0.54
17	*Sagittaria graminea*	slender arrowhead	0.30	0.30	3.00
18	*Scirpus sp.*	bulrush	0.00	0.00	1.00
19	*Utricularia spp.*	bladderwort	0.00	0.00	0.50
20	*Vallisneria americana*	wild celery	0.00	0.00	0.71
21	*Brasenia schreberi*	watershield	0.00	0.80	0.00
22	*Eleocharis acicularis*	needle spikerush, hairgrass	0.30	0.30	0.00
23	*Lemna minor*	lesser duckweed	0.30	0.00	0.00
24	*Myriophyllum sibiricum*	northern watermilfoil	0.30	0.40	0.00
25	*Pontedoria cordata*	pickerelweed	0.30	0.30	0.00
26	*Potamogeton gramineus*	grass-leaved pondweed	0.00	0.30	0.00
27	*Potamogeton pusillus*	small pondweed	0.30	0.00	0.00
28	*Potamogeton richardsonii*	claspingleaf pondweed	0.60	0.00	0.00
29	*Ranunculus sp.*	marsh marigold	0.60	0.00	0.00
30	*Typha spp.*	cattail	1.10	0.70	0.00
31	*Zosterella dubia*	mud plantain	0.30	0.00	0.00

5.1.5 Total Aquatic Plant Density (Cumulative Total of All Species)

In 2005, total plant density in Beaver Dam Lake during June and July ranged from light to heavy (See Figures 21 through 23). Plant density in West Beaver Dam Lake was generally moderate, but heavy densities were noted at a number of locations. Plant density in East Beaver Dam Lake ranged from light to heavy. Several large areas with heavy densities were observed within East Beaver Dam Lake. Species contributing to the dense plant growths in East Beaver Dam Lake include pondweed, Canada waterweed, and water lilies.

A comparison of 1999 and 2005 total plant density indicates several areas within West Beaver Dam Lake (i.e., Williams and Rabbit Island Bays and Library Lake) noted reductions in plant density during this period. Several areas with heavy (i.e., 70 to 100 percent coverage of rake head) density in 1999 noted moderate densities (i.e., ranging from 10 to 54 percent coverage of rake head) in 2005. Fewer changes in density were observed in East Beaver Dam Lake during this period (See Figures 24 and 25).



Legend
June 2005
Macrophyte Density (% of Rake Head)

- 0 to 9
- 10 to 29
- 30 to 54
- 55 to 69
- 70 to 100

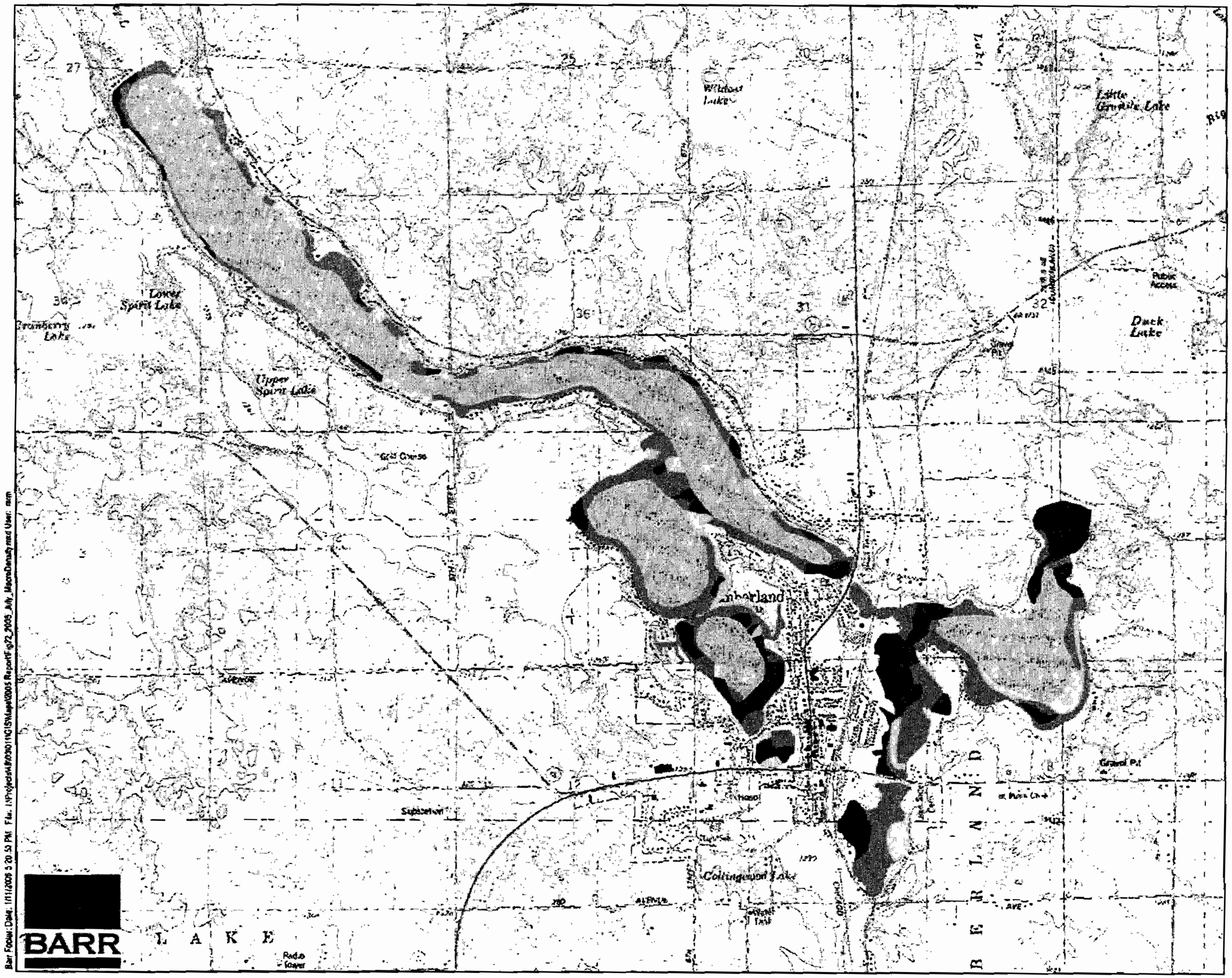
Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 21

JUNE 2005 MACROPHYTE DENSITY
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



Legend
July 2005
Macrophyte Density (% of Rake Head)

- 0 to 9
- 10 to 29
- 30 to 54
- 55 to 69
- 70 to 100

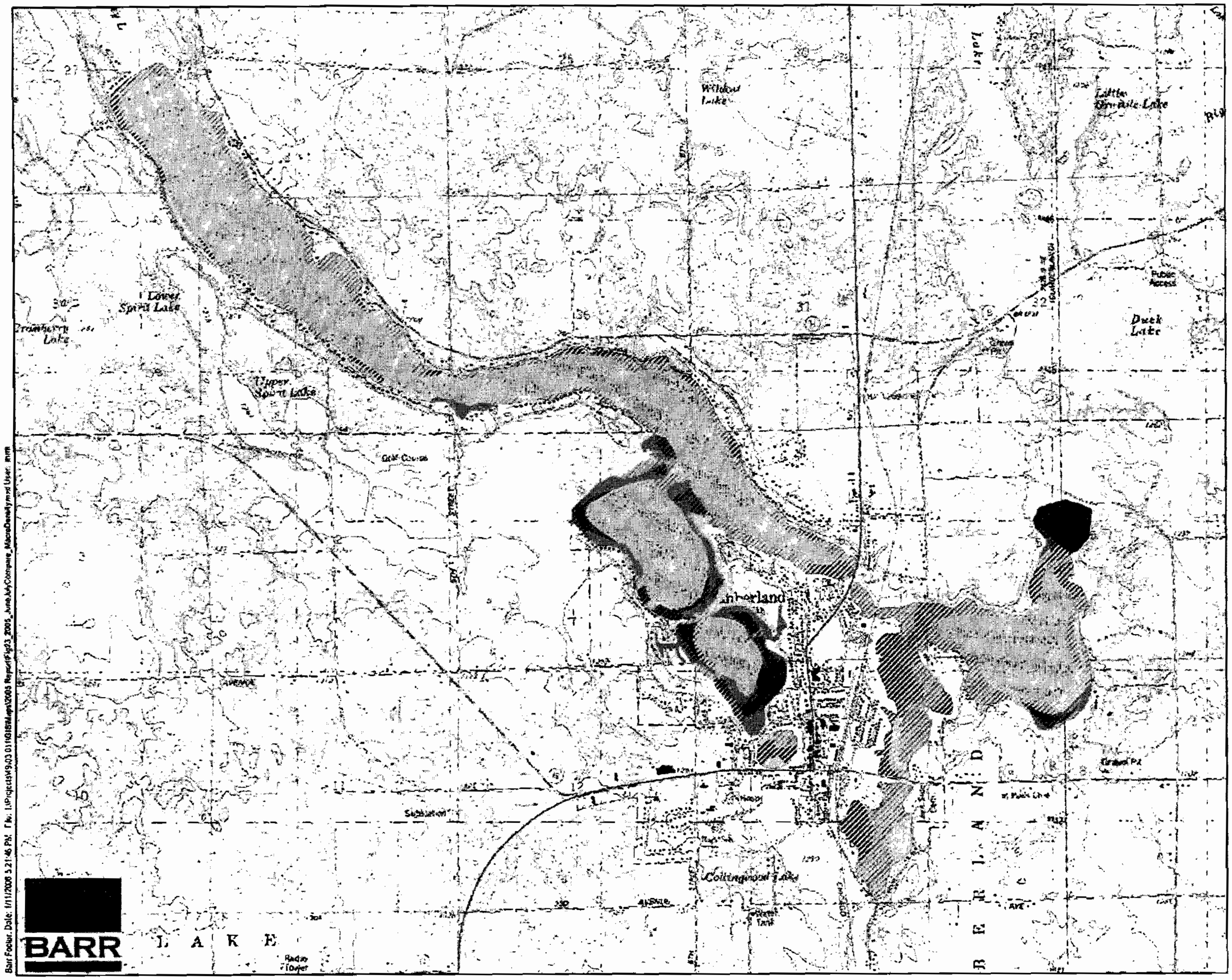
Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 22

JULY 2005 MACROPHYTE DENSITY
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



Legend

June 2005
Macrophyte Density (% of Rake Head)

- 0 to 9
- 10 to 29
- 30 to 54
- 55 to 69
- 70 to 100

July 2005
Macrophyte Density (% of Rake Head)

- 0 to 9
- 10 to 29
- 30 to 54
- 55 to 69
- 70 to 100

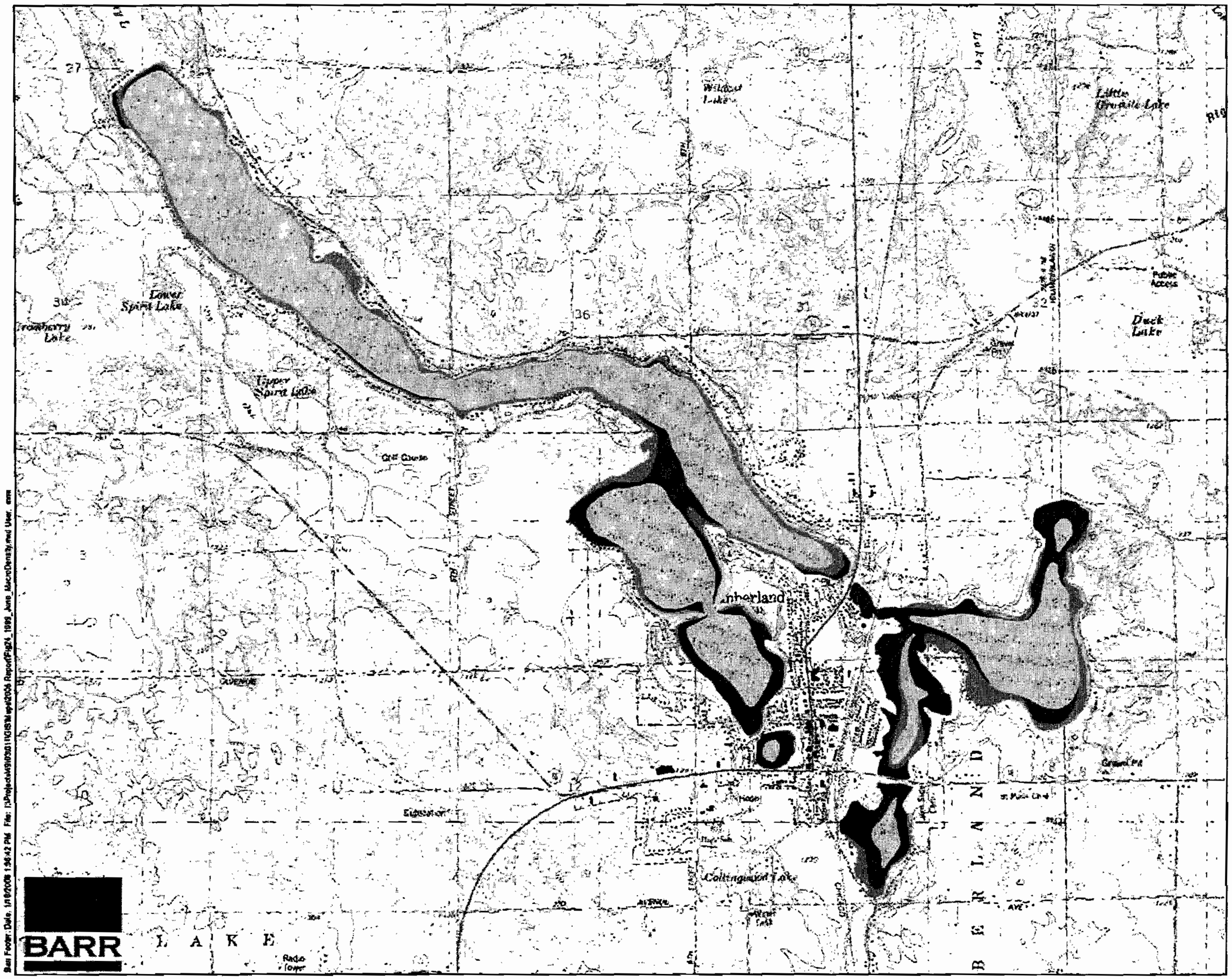
Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 23

JUNE & JULY 2005 MACROPHYTE DENSITY COMPARISON
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



Legend

1999 June Macrophyte Density (Percent of Rake Head)

- 0 to 9
- 10 to 29
- 30 to 54
- 55 to 69
- 70 to 100

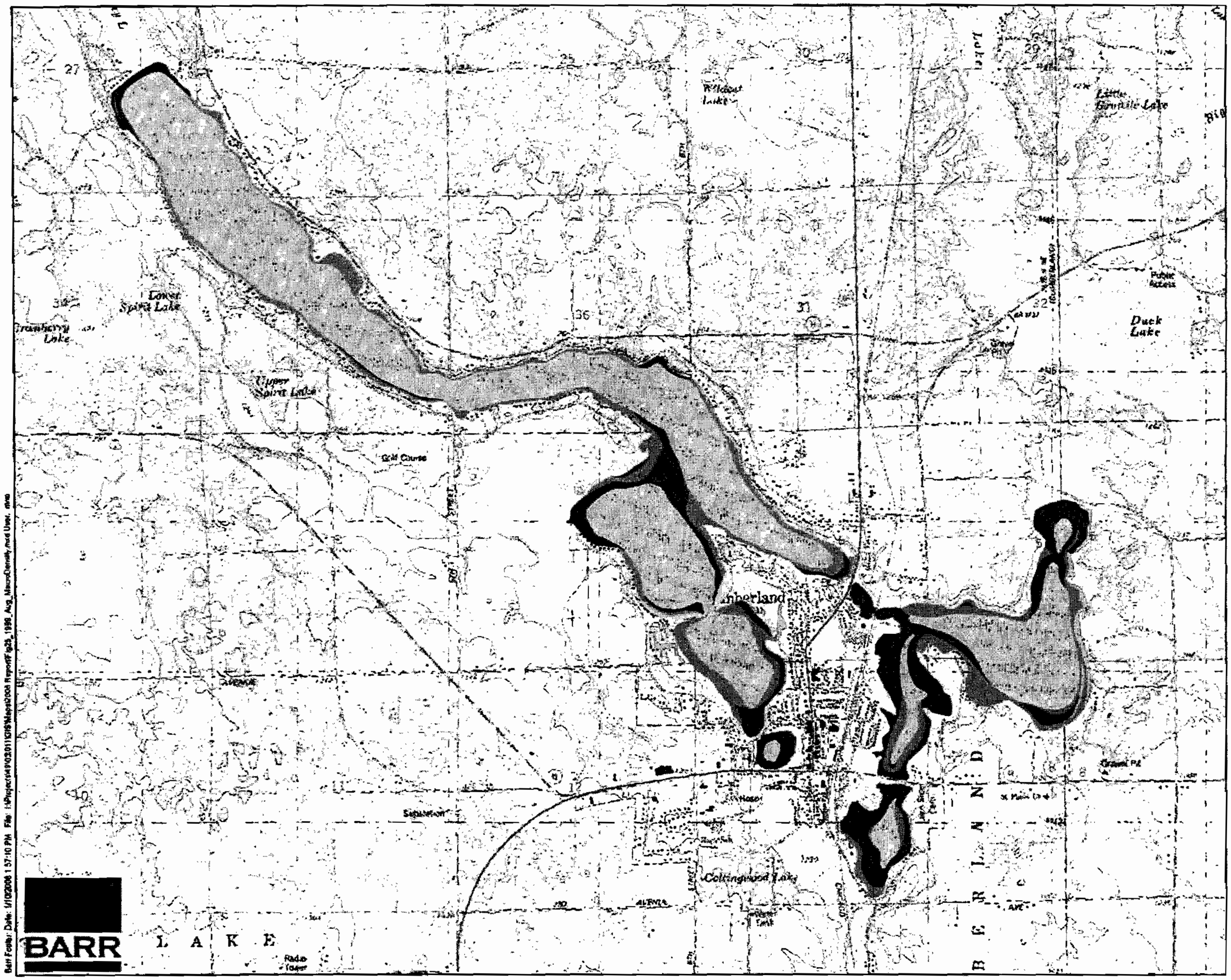
Miles: 0.5, 0, 0.5

Feet: 1,000, 0, 1,000, 2,000, 3,000, 4,000

1:24,000

Figure 24

1999 JUNE MACROPHYTE DENSITY
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



Legend

1999 August Macrophyte Density (Percent of Rake Head)

- 0 to 9
- 10 to 29
- 30 to 54
- 55 to 69
- 70 to 100

Miles: 0.5 — 0 — 0.5

Feet: 1,000 — 0 — 1,000 — 2,000 — 3,000 — 4,000

1:24,000

Figure 25

1999 AUGUST MACROPHYTE DENSITY
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

5.1.6 Aquatic Plant Diversity

Beaver Dam Lake's 2005 plant community consisted of a diverse assemblage of many species. To determine the diversity of this assemblage, an aquatic plant diversity calculation was completed for Beaver Dam Lake using a modification of Simpson's Index (1949):

$1-\sum (rf/100)^2$

Where:

rf = the relative frequency of each species.

Frequencies were calculated as the number of sampling points where a species occurred divided by the total number of sampling points at depths less than or equal to the maximum depth of plant growth. Frequencies were relativized to 100 percent to describe community structure (i.e., rf). Frequencies and relative frequencies are presented in Appendix A.

The data indicate a highly diverse plant community was found in Beaver Dam Lake. On a scale of 0 to 1, with 0 indicating no plant diversity and 1 indicating the highest plant diversity, West Beaver Dam Lake noted a diversity of 0.91 and East Beaver Dam Lake noted a diversity of 0.82 during 2005. The diversity measured in West and East Beaver Dam Lake in 1999 was 0.92 and 0.81, respectively. During the 1999 through 2005 period, diversity in West Beaver Dam Lake declined by 1 percent and diversity in East Beaver Dam Lake increased by 1 percent. The diversities measured in West Beaver Dam Lake during 1999 and 2005 are near the high end of the range of diversities measured in 56 Wisconsin Lakes (See Table 5).

During 1999 and 2005, lower diversities were measured in East Beaver Dam Lake than West Beaver Dam Lake. The denser and less diverse plant community found in East Beaver Dam Lake is attributed to its fertile sediments and poorer water quality. Secchi disc transparency data collected during the July 2005 aquatic plant survey indicate transparency ranged from 1.75 to 4.50 meters in West Beaver Dam Lake and from 1.00 to 2.75 meters in East Beaver Dam Lake (See Appendices H and I). The average transparency in East Beaver Dam Lake (1.89 meters) was approximately 1 meter less than the average transparency of West Beaver Dam Lake (2.90 meters). In general, plant diversity increases as water quality increases and decreases as water quality decreases.

Table 5. Diversities of Some Wisconsin Plant Communities (from Nichols 1997 and Barr 2001-2005)—Samples Collected by WDNR Unless Otherwise Indicated

Lake Name	Diversity	Lake Name	Diversity
Amnicon Lake	0.95	Como Lake	0.88
Balsam Lake 2005	0.93*	White Ash Lake, North	0.88**
Church Pine Lake	0.93*	Dowling Lake	0.87
Decorah Lake	0.93	Chute Pond	0.86
Half Moon Lake	0.93	Enterprise Lake	0.86
Spider Chain of Lakes—North Lake	0.93*	Okauchee Lake	0.86
Balsam Lake 1999	0.92*	Pearl Lake	0.86
1999 Beaver Dam Lake (West)	**0.92****	Bear Lake	0.85
Muskellunge Lake	0.92	Big Butternut Lake	0.84
Round (Wind) Lake	0.92*	**2005 Beaver Dam Lake (East)**	**0.82*****
Spider Chain of Lakes—Fawn Lake	0.92*	**1999 Beaver Dam Lake (East)**	**0.81****
Spider Chain of Lakes--Spider Lake (north)	0.92*	Long Lake T32N	0.81
Apple River Flowage	0.91	Twin Lake, South	0.81
Ashippun Lake	0.91	Helen Lake	0.80
2005 Beaver Dam Lake (West)	**0.91*****	McCann Lake	0.80
Big Blake Lake (Blake)	0.91*	Cary Pond	0.79
Cedar Lake	0.91	Island Lake	0.78
Little Elkhart Lake	0.91	Leota Lake	0.78
Pine Lake	0.91	Little Arbor Vitae Lake	0.78
Post Lake	0.91	Mid Lake (Nawaii)	0.78
Morris Lake (Mt. Morris)	0.91	Half Moon Lake T47N	0.77
Sand Lake	0.91*	Clear Lake	0.74
White Ash Lake*	0.91**	Chain Lake	0.74
Pike Lake	0.90	Twin Lake North	0.73
Mud Hen Lake	0.90	Rib Lake	0.71
Spider Chain of Lakes--Spider Lake (south)	0.90*	Oconomowoc Lake, Upper	0.70
Big Round Lake	0.89	Silver Lake (Anderson)	0.69
Pigeon Lake	0.89	Tichigan Lake	0.69
Big Hills Lake (Hills)	0.88	George Lake	0.58
Spider Chain of Lakes—Clear Lake	0.88*		

*Sampled by Barr Engineering Company **Sampled by volunteers trained by Barr Engineering Company
***Sampled by Wisconsin Lutheran College Students

5.1.7 Percent Open Area

The cumulative effect of the lake's diverse aquatic plant community was assessed from the proportion of open area in the littoral zone (i.e., Percent Open Area). The percent open area was estimated from the number of sampling points containing no vegetation divided by the total number of sampling points at a depth less than or equal to the maximum depth of plant growth. Maximum depth of plant growth is the deepest water depth at which plant growth was found. In 2005, the maximum depth of plant growth was 16 feet in West Beaver Dam Lake and 11 feet in East Beaver Dam Lake. In July 2005, a 19 percent open area was observed in West and East Beaver Dam Lake. The majority of open areas were either in shallow water or deeper waters (i.e., near the maximum rooting depth). In West Beaver Dam Lake, approximately 59 percent of the open areas were at depths of 5 feet or less and 20 percent were in depths of 10 feet or greater. In East Beaver Dam Lake, approximately 35 percent of open areas were at depths of 5 feet or less and 26 percent were at depths of 10 feet or greater. Approximately 28 percent of open areas within Beaver Dam Lake were found at depths greater than 5 feet and less than 10 feet. Substrates in open areas were generally comprised of rock and boulder, sand, or sand and gravel.

The 2005 open area was larger than the 1999 area in both the West and East portions of the lake. A comparison of sample locations sampled during 1999 and 2005 indicates West Beaver Dam Lake noted a 5 percent open area during June and August of 1999 and a 15 percent open area during July of 2005. East Beaver Dam Lake noted no open area during June of 1999, a 2 percent open area during August of 1999, and a 15 percent open area during July of 2005.

5.1.8 Total Acreage Covered by Macrophytes

In July 2005, the total aquatic plant coverage of Beaver Dam Lake was 513 acres, which is 44 percent of the lake's surface area.

5.1.9 Wisconsin Floristic Quality Assessment

The Beaver Dam Lake plant community was assessed using the Wisconsin Floristic Quality Assessment (WFQA). The WFQA is an adaptation for use in Wisconsin of the original floristic quality assessment method developed for the Chicago region (Swink and Wilhelm 1994). The basis of the floristic quality assessment is the concept of species conservatism, the degree to which a species can tolerate disturbance and its fidelity to undegraded conditions. Conservatism is not always equated with rarity. The method uses the aggregate conservatism of all species found on a site as a measure of the site's intactness, an indication of its ecological integrity (Bernthal 2003).

The method requires the *a priori* assignment of "coefficients of conservatism" to every aquatic plant species in a regional flora, relying on the collective knowledge of a group of experts. The coefficients for Wisconsin aquatic plants were assigned by a group of aquatic ecologists led by Stanley Nichols (Bernthal 2003)

The method requires an accurate and complete inventory of aquatic plants within a lake. The appropriate coefficient is applied to each species, and an average coefficient of conservatism (Mean C) is calculated for the entire lake. The Floristic Quality Index (FQI) adds a weighted measure of species richness by multiplying the Mean C by the square root of the total number of native species. FQI = Mean C * $\sqrt{N}$

Where:

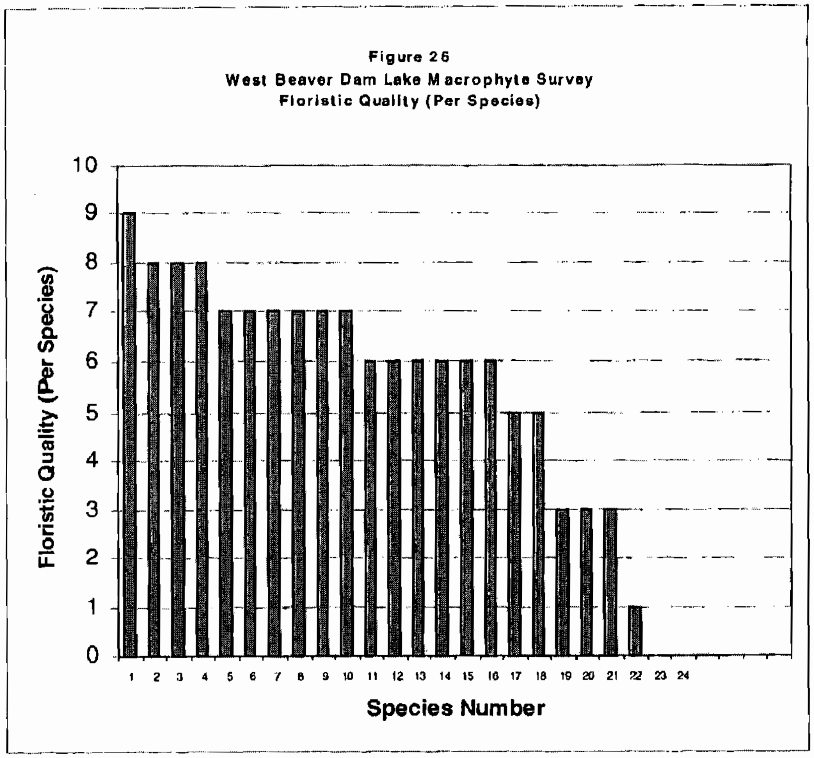
Mean C = $\sum(c_1+c_2+c_3+\ldots c_n)/N$

Non-native species are assigned a C value of 0. Higher Mean C and FQI numbers indicate higher floristic integrity and a lower level of disturbance impacts to the site (Bernthal 2003)

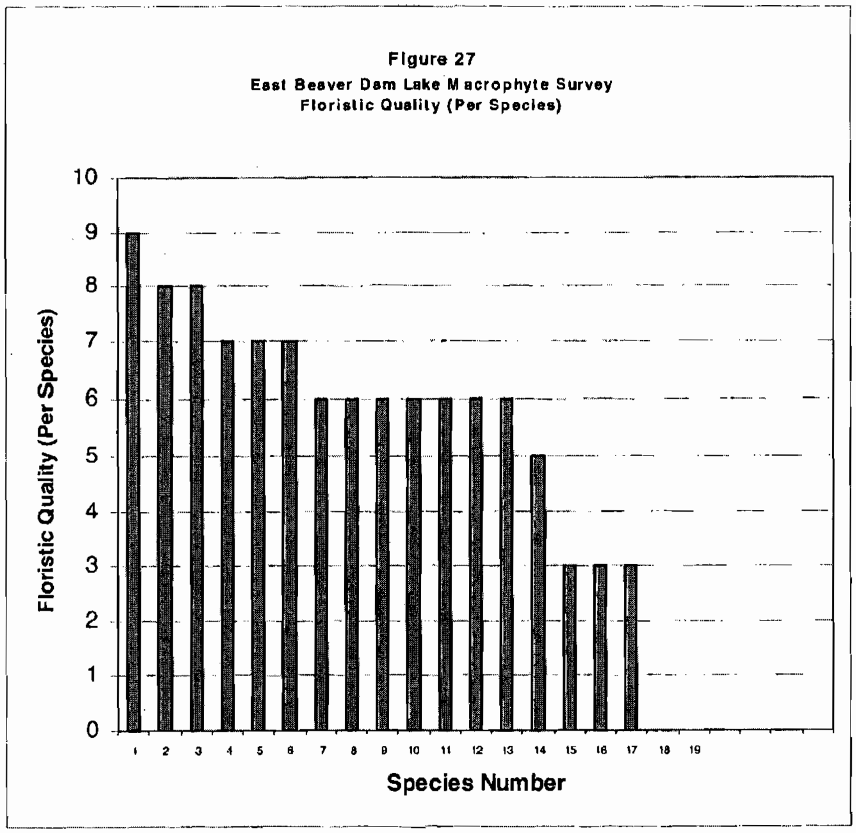
The method is based on the concept of species conservatism. Each native aquatic plant species occurring in a regional flora is assigned a coefficient of conservatism (C) representing an estimated probability that a species is likely to occur in a lake relatively unaltered from what is believed to be a pre-settlement condition. The most conservative species require a narrow range of ecological conditions, are intolerant of disturbance, and are unlikely to be found outside undegraded remnant natural settings, while the least conservative species can be found in a wide variety of settings, and thrive on disturbance. Coefficients range from 0 (highly tolerant of disturbance, little fidelity to any natural community) to 10 (highly intolerant of disturbance, restricted to pre-settlement remnants). Conceptually, this 10-point scale can be subdivided into several ranges.

- 0-3—taxa found in a wide variety of plant communities and very tolerant of disturbance
- 4-6—taxa typically associated with a specific plant community, but tolerate moderate disturbance
- 7-8—taxa found in a narrow range of plant communities, but can tolerate minor disturbance
- 9-10—taxa restricted to a narrow range of synecological conditions, with low tolerance of disturbance(Bernthal 2003)

In 2005, the mean C of West Beaver Dam Lake was 5 and the FQI was 26.7 (See Figure 26). The mean C of East Beaver Dam Lake was 5 and the FQI was 23.4. The Mean C of 5 indicates the lake's plant community is tolerant of moderate disturbance. The median FQI for Wisconsin is 22.2 (WDNR 2005). Beaver Dam Lake's FQI is higher than the median Wisconsin Lake, indicating the lake's plant community is of higher quality and less tolerant to disturbance than the plant community of the median Wisconsin lake. West Beaver Dam Lake noted a higher FQI than East Beaver Dam Lake. The plant community in West Beaver Dam Lake is of higher quality than the plant community of East Beaver Dam Lake.



Species Number	Scientific Name	Common Name	Floristic Quality
1	Sagittaria graminea	grassy arrowhead	9
2	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	8
3	Nuphar advena	yellow water lily	8
4	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	8
5	Chara spp.	Muskgrass	7
6	Brasenia schreberi	Watershield	7
7	Utricularia spp.	Bladderwort	7
8	Myriophyllum sp.	Watermilfoil	7
9	Potamogeton amplifolius	largeleaf pondweed	7
10	Myriophyllum sibiricum	northern watermilfoil	7
11	Potamogeton illinoensis	Illinois pondweed	6
12	Potamogeton zosteriformis	flatstem pondweed	6
13	Vallisneria americana	wild celery	6
14	Najas flexilis	bushy naiad	6
15	Nymphaea tuberosa	white waterlily	6
16	Nuphar variegata	Spatterdock	6
17	Potamogeton natans	floatingleaf pondweed	5
18	Lemna minor	lesser duckweed	5
19	Elodea canadensis	Canada waterweed	3
20	Ceratophyllum demersum	Coontail	3
21	Ceratophyllum sp.	Coontail	3
22	Typha spp.	cattail	1
23	Myriophyllum spicatum	Eurasian watermilfoil	0
24	Potamogeton crispus	curlyleaf pondweed	0



Species Number	Scientific Name	Common Name	Floristic Quality
1	Sagittaria graminea	slender arrowhead	9
2	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	8
3	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (posibly ribbonleaf or Robbin's)	8
4	Chara spp.	Muskgrass	7
5	Potamogeton amplifolius	largeleaf pondweed	7
6	Utricularia spp.	Bladderwort	7
7	Najas flexilis	bushy naiad	6
8	Nuphar variegata	Spatterdock	6
9	Nymphaea tuberosa	white waterlily	6
10	Potamogeton illinoensis	Illinois pondweed	6
11	Potamogeton zosteriformis	flatstem pondweed	6
12	Vallisneria americana	wild celery	6
13	Eleocharis spp.	Spikerush	6
14	Potamogeton natans	floatingleaf pondweed	5
15	Ceratophyllum demersum	Coontail	3
16	Ceratophyllum sp.	Coontail	3
17	Elodea canadensis	Canada waterweed	3
18	Myriophyllum spicatum	eurasian watermilfoil	0
19	Potamogeton crispus	curlyleaf pondweed	0

5.2 Functions and Values of Aquatic Plants

The Beaver Dam Lake aquatic plant community (See Appendices B, C, D, and E) performs a number of valuable functions. These include:

- Habitat for fish, insects, and small aquatic invertebrates
- Food for waterfowl, fish, and wildlife
- Oxygen producers
- Provide spawning areas for fish in early spring
- Helps stabilize marshy borders of the lake; helps protect shorelines from wave erosion
- Provides nesting sites for waterfowl and marsh birds

Functions of individual species found in Beaver Dam Lake are presented in Table 6.

Table 6 Functions of Aquatic Plant Species Found in Beaver Dam Lake*

Scientific Name (Common Name)	Plant Type	Plant Functions
Brasenia schreberi	Watershield	The seeds, leaves, stems, and buds of watershield are consumed by a wide variety of waterfowl. The floating leaves also offer shade and shelter for fish and invertebrates.
Ceratophyllum demersum and *Ceratophyllum sp.* (coontail)	Submersed	Many waterfowl species eat the shoots; it provides cover for young bluegills, perch, largemouth bass, and northern pike; supports insects that fish and ducklings eat.
Chara spp. (muskgrass)	Submersed	Muskgrass is a favorite waterfowl food. Algae and invertebrates found on muskgrass provide additional grazing. It is also considered valuable fish habitat. Beds of muskgrass offer cover and are excellent producers of food, especially for largemouth bass and smallmouth bass.
Eleocharis spp (spike rush)	Emergent	Spike rush provides food for a variety of waterfowl as well as muskrats. Submersed beds offer habitat and shelter for invertebrates and small fish.
Elodea canadensis (Canada waterweed)	Submersed	Provides habitat for many small aquatic animals, which fish and wildlife eat.
Lemna minor (lesser duckweed)	Floating	Lesser duckweed is a nutritious food source that can provide up to 90% of the dietary needs for a variety of ducks and geese. It is also consumed by muskrat, beaver, and fish. Rafts of duckweed offer shade and cover for fish and invertebrates. Extensive mats of duckweed can also inhibit mosquito breeding.
Myriophyllum sibericum (formerly exalbescens) (northern milfoil)	Submersed	Provides cover for fish and invertebrates; supports insects and other small animals eaten by fish; waterfowl occasionally eat the fruit and foliage.
Myriophyllum spicatum (Eurasian watermilfoil)	Submersed	Waterfowl graze on fruit and foliage to a limited extent. Milfoil beds provide invertebrate habitat, but studies have shown mixed stands of pondweeds and wild celery have higher diversity and numbers of invertebrates (Engel 1990)
Najas flexilis (nushy naiad)	Submersed	Bushy naiad is one of the most important plants for waterfowl. Stems, leaves, and seeds are all consumed by a wide variety of ducks including black duck, bufflehead, canvasback, gadwall, mallard, pintail, redhead, ringnecked duck, scaup, shoveler, blue-winged teal, green-winged teal, wigeon, and wood duck. It is also important to a variety of marsh birds as well as muskrats.l
Nuphar advena (yellow water lily)	Floatiang	Yellow water lily provides seeds for waterfowl including mallard, northern pintail, ring-necked duck and scaup. Leaves, stems and flowers are grazed by deer. Muskrat, beaver and porcupine eat the rhizomes. The leaves offer shade and shelter for fish as well as habitat for invertebrates.
Nuphar variegata (spadderdock)	Floating	Spadderdock anchors the shallow water community and provides food for many residents. It provides seeds for waterfowl including mallard, pintail, ringneck and scaup. The leaves, stems and flowers are grazed by deer. Muskrat, beaver and even porcupine have been reported to eat the rhizomes. The leaves offer shade and shelter for fish as well as habitat for invertebrates.

Scientific Name (Common Name)	Plant Type	Plant Functions
Nymphaea tuberosaa (white water lily)	Floating	White water lily provides seeds for waterfowl. Rhizomes are eaten by deer, muskrat, beaver, moose and porcupine. The leaves offer shade and shelter for fish.
Potamogeton amplifolius (large-leaf pondweed)	Submersed	The broad leaves of *Potamogeton amplifolius* offer shade, shelter and foraging opportunities for fish. Abundant production of large nutlets makes this a valuable waterfowl food.
Potamogeton crispus (curlyleaf pondweed)	Submersed	Provides some cover for fish; several waterfowl species feed on the seeds; diving ducks often eat the winter buds.
Potamogeton Illinoensis (Illinois pondweed)	Submersed	The fruit produced by Illinois pondweed can be a locally important food source for a variety of ducks and geese. The plant may also be grazed by muskrat, deer, beaver, and moose. This pondweed offers excellent shade and cover for fish and good surface area for invertebrates.
Potamogeton natans (floating-leaf pondweed)	Submersed	The fruit of floating-leaf pondweed is held on the stalk until late in the growing season. This provides valuable grazing opportunities for ducks and geese including scaup and blue-winged teal. Portions of this pondweed may also be consumed by muskrat, beaver, deer, and moose. Floating-leaf pondweed is considered good fish habitat because it provides shade and foraging opportunities.
Potamogeton sp. (possibly diversifolius) (pondweed, possibly waterthread)	Submersed	The fruit can be a locally important food source for a variety of ducks and geese. The plant may also be grazed by muskrat, deer, beaver, and moose. Leaves may be colonized by invertebrates and offer foraging opportunities for fish.
Potamogeton sp. (possibly epihydrus or robbinsii (pondweed, possibly ribbonleaf or Robbin's Pondweed)	Submersed	Pondweed provides habitat for invertebrates that are grazed by waterfowl. It also offers good cover and foraging opportunities for fish, particularly northern pike.
Potamogeton zosteriformis (flat-stem pondweed),	Submersed	Flat-stem pondweed can be a locally important food source for a variety of geese and ducks including redhead and green-winged teal. The plant may also be grazed by muskrat, deer, beaver, and moose. Flat-stem pondweed provides a food source and cover for fish and invertebrates.
Sagittaria graminea (grassy arrowhead)	Emergent	Grassy arrowhead has high wildlife value. Waterfowl graze on the rhizomes and the seeds are consumed by a wide variety of ducks, geese, marsh birds and shore birds. Muskrats beavers and porcupines eat both leaves and rhizomes. Arrowhead beds offer shade and shelter for young fish.
Scirpus subterminalis (swaying bulrush)	Submersed	Grass-like meadows of water bulrush provide invertebrate habitat and shelter for fish.
Scirpus sp. (bulrush)	Emergent	Bulrush offers habitat for invertebrates and shelter for young fish, especially northern pike. The nutlets are consumed by a wide variety of waterfowl, marsh birds, (including bitterns, herons, rails) and upland birds. Stems and rhizomes are eaten by geese and muskrats. Bulrushes also provide nesting material and cover for waterfowl, marsh birds, and muskrats.

Scientific Name (Common Name)	Plant Type	Plant Functions
Typha spp. (cattail)	Emergent	Cattails provide nesting habitat for many marsh birds ranging from small (red-winged blackbird, marsh wren) to large (least bittern, coot). Shoots and rhizomes are consumed by muskrats and geese. Submersed stalks provide spawning habitat for sunfish and shelter for young fish.
Utricularia spp (bladderwort)	Submersed	The trailing stems of bladderwort provide food and cover for fish. Because they are free-floating, they can grow in areas with very loosely consolidated sediment. This provides needed fish habitat in areas that are not readily colonized by rooted plants.
Vallisneria americana (wild celery)	Submersed	Wild celery is a premiere source of food for waterfowl. All portions of the plant are consumed including foliage, rhizomes, tubers, and fruit. Wild celery beds become a prime destination for thouBeaver Dams of canvasback ducks every fall. Wild celery is also important to marsh birds and shore birds including rail, plover, Beaver Dam piper, and snipe. Muskrats are also known to graze on it. Beds of wild celery are considered good fish habitat providing shade, shelter, and feeding opportunities.

*Plant functions are from: Borman, S. et al. 1997. Through the Looking Glass...A Field Guide to Aquatic Plants and Minnesota Department of Natural Resources. 1997. A Guide to Aquatic Plants--Identification and Management.

5.3 Comparison of 1999 and 2005 Data

A comparison of aquatic plant survey data from 1999 and 2005 indicates Beaver Dam Lake's aquatic plant community has changed substantially over time. The comparison tool used to assess changes in the lake's plant community was percent similarity. The percent similarity (C) is a means of comparing data from the two surveys by estimating the degree to which the communities share common components. Percent similarity C is computed as follows:

$$C_{ij} = 1 - 1/2\sum_{k=1}^{s} |p_{ik}-p_{ij}|)$$

Where C_{ij} = percent similarity between survey 1 (1999) and 2 (2005).

$\sum_{k=1}^{s}$ = summing over all species, from species k=1 to the last species (k=s)

$|p_{ik}-p_{jk}|$ = absolute value of the relative frequency of species k at sampling period I (or the first sampling in 1999) minus the relative frequency of species k at sampling period j (or the second sampling in 2005).

The maximum similarity, in which there is the same frequency of each species at both sampling times, is 1. The minimum similarity, where there is no overlap of any species, is 0. West Beaver Dam Lake noted a similarity of 0.52 for the comparison between the June 1999 and July 2005 communities (See Table 7). A similarity of 0.57 was noted for the comparison between the August 1999 and July 2005 communities (See Table 8). East Beaver Dam Lake noted a similarity of 0.72 for the comparison between the June 1999 and July 2005 communities (See Table 9). A similarity of 0.71 was noted for the comparison between the August 1999 and July 2005 communities (See Table 10). The data indicate the lake's plant community has changed during the past 6 years. West Beaver Dam Lake noted a larger change in its plant community than East Beaver Dam Lake. The change in the lake's plant community resulted from small changes in the relative frequency of a large number of species and did not result from a large change in any one species. The absolute value of the changes in relative frequency of individual species was small, ranging from 0 to 0.1 in West Beaver Dam Lake and from 0 to 0.12 in East Beaver Dam Lake. Because the lake's plant community is diverse, the cumulative total of individual species' differences resulted in a substantial community difference when the percent similarity for the lake was computed. Reduction in Eurasian watermilfoil coverage and the recolonization of areas formerly infested with Eurasian watermilfoil contributed to the change.

5.4 Aquatic Invasive Species

In 2005, aquatic plants in Beaver Dam Lake primarily consisted of native species (i.e., species historically present in this region). However, two aquatic invasive species (i.e., not native) occurred in the lake, *Myriophyllum spicatum* (Eurasian watermilfoil, EWM) and *Potamogeton crispus* (curlyleaf pondweed, CLP). Aquatic invasive species are undesirable because their natural control mechanisms are not introduced with the species. Consequently, AIS frequently exhibit unchecked growth patterns.

5.4.1 Eurasian Watermilfoil (EWM)

EWM, a submersed aquatic plant, is native to northern Europe and Asia. It arrived in North America sometime between the late 1800s (Reed 1977) and the early 1940s (Couch and Nelson 1985); the later date has verified vouchers. EWM is a particularly problematic AIS in North America, due to its ability to reproduce from fragments and spread quickly, its high growth rate in a range of temperatures and environmental conditions, and its tendency to reach the surface and form extensive mats of plant at the surface, which can allow it to shade and out compete native vegetation (Madsen et al. 1991; Valley and Newman 1998). Grace and Wetzel (1978), Aiken et al. (1979), and Smith and Barko (1990) provide good overviews of Eurasian watermilfoil biology and ecology.

Table 7. West Beaver Dam Lake Percent Similarity: June 1999 and July 2005

Species Number	Scientific Name	Common Name	June 1999 Relative Frequency	July 2005 Relative Frequency	$\lvert p_{ik}-p_{ij}\rvert$
1	Chara spp.	muskgrass	0.12	0.19	0.07
2	Potamogeton illinoensis	Illinois pondweed	0.04	0.14	0.10
3	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	0.03	0.13	0.10
4	Elodea canadensis	Canada waterweed	0.08	0.11	0.03
5	Ceratophyllum demersum	coontail	0.08	0.09	0.00
6	Myriophyllum spicatum	Eurasian watermilfoil	0.19	0.09	0.10
7	Potamogeton zosteriformis	flatstem pondweed	0.01	0.06	0.05
8	Ceratophyllum sp.	coontail	0.00	0.03	0.03
9	Vallisneria americana	wild celery	0.00	0.03	0.03
10	Potamogeton crispus	curlyleaf pondweed	0.01	0.02	0.01
11	Najas flexilis	bushy naiad	0.01	0.02	0.02
12	Brasenia schreberi	watershield	0.02	0.01	0.01
13	Nuphar advena	yellow water lily	0.00	0.01	0.01
14	Nymphaea tuberosa	white waterlily	0.03	0.01	0.02
15	Potamogeton natans	floatingleaf pondweed	0.02	0.01	0.01
16	Utricularia spp.	bladderwort	0.00	0.01	0.01
17	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	0.00	0.01	0.01
18	Scirpus subterminalis	swaying bulrush	0.00	0.01	0.01
19	Myriophyllum sp.	watermilfoil	0.00	0.00	0.00
20	Potamogeton amplifolius	largeleaf pondweed	0.03	0.00	0.03
21	Potamogeton pectinatus	sago pondweed	0.00	0.00	0.00
22	Sagittaria graminea	grassy arrowhead	0.05	0.00	0.05
23	Scirpus sp.	bulrush	0.01	0.00	0.00
24	Nuphar variegata	spatterdock	0.01	0.00	0.00
25	Typha. spp.	cattail	0.00	0.00	0.00
26	Lemna minor	lesser duckweed	0.01	0.00	0.01
27	Myriophyllum sibiricum	northern watermilfoil	0.02	0.00	0.02
28	Eleocharis spp.	spike rush	0.00	0.00	0.00
29	Lythrum salicaria	purple loosestrife	0.00	0.00	0.00
30	Polygonum amphibium	waterweed	0.01	0.00	0.01
31	Pontederia cordata	pickerelweed	0.00	0.00	0.00
32	Potamogeton gramineus	grass-leaved pondweed	0.00	0.00	0.00
33	Potamogeton pusillus	small pondweed	0.10	0.00	0.10
34	Potamogeton richardsonii	claspingleaf pondweed	0.04	0.00	0.04
35	Sagittaria sp	arrowhead	0.02	0.00	0.02
36	Wolffia columbiana	water meal	0.00	0.00	0.00
37	Zosterella dubia	mud plantain	0.06	0.00	0.06
				sum $p_{ik}-p_{ij}$	**0.96**
				$C_{ij} = 1-(0.5)^*(\text{sum } \lvert p_{ih}-p_{ij}\rvert)$	**0.52**

Table 8. West Beaver Dam Lake Percent Similarity: August 1999 and July 2005

Species Number	Scientific Name	Common Name	August 1999 Relative Frequency	July 2005 Relative Frequency	$\|p_{ik}-p_{ij}\|$
1	Chara spp.	muskgrass	0.11	0.19	0.07
2	Potamogeton illinoensis	Illinois pondweed	0.04	0.14	0.10
3	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	0.06	0.13	0.07
4	Elodea canadensis	Canada waterweed	0.07	0.11	0.05
5	Ceratophyllum demersum	coontail	0.10	0.09	0.01
6	Myriophyllum spicatum	Eurasian watermilfoil	0.15	0.09	0.07
7	Potamogeton zosteriformis	flatstem pondweed	0.02	0.06	0.04
8	Ceratophyllum sp.	coontail		0.03	0.03
9	Vallisneria americana	wild celery		0.03	0.03
10	Potamogeton crispus	curlyleaf pondweed	0.04	0.02	0.02
11	Najas flexilis	bushy naiad	0.05	0.02	0.03
12	Brasenia schreberi	watershield	0.04	0.01	0.03
13	Nuphar advena	yellow water lily		0.01	0.01
14	Nymphaea tuberosa	white waterlily	0.03	0.01	0.02
15	Potamogeton natans	floatingleaf pondweed	0.02	0.01	0.01
16	Utricularia spp.	bladderwort		0.01	0.01
17	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)		0.01	0.01
18	Scirpus subterminalis	swaying bulrush		0.01	0.01
19	Myriophyllum sp.	watermilfoil		0.00	0.00
20	Potamogeton amplifolius	largeleaf pondweed	0.06	0.00	0.06
21	Potamogeton pectinatus	sago pondweed		0.00	0.00
22	Sagittaria graminea	grassy arrowhead	0.06	0.00	0.06
23	Scirpus sp.	bulrush	0.00	0.00	0.00
24	Nuphar variegata	spatterdock	0.00	0.00	0.00
25	Typha. spp.	cattail	0.00	0.00	0.00
26	Lemna minor	lesser duckweed	0.00	0.00	0.00
27	Myriophyllum sibiricum	northern watermilfoil	0.02	0.00	0.02
28	Eleocharis spp.	spike rush	0.01	0.00	0.01
29	Lythrum salicaria	purple loosestrife	0.00	0.00	0.00
30	Polygonum amphibium	waterweed	0.00	0.00	0.00
31	Pontederia cordata	pickerelweed	0.01	0.00	0.01
32	Potamogeton gramineus	grass-leaved pondweed	0.01	0.00	0.01
33	Potamogeton pusillus	small pondweed	0.06	0.00	0.06
34	Potamogeton richardsonii	claspingleaf pondweed	0.02	0.00	0.02
35	Sagittaria sp	arrowhead	0.00	0.00	0.00
36	Wolffia columbiana	water meal	0.00	0.00	0.00
37	Zosterella dubia	mud plantain	0.02	0.00	0.02
				sum $p_{ik}-p_{ij}$	0.85
				$C_{ij} = 1-(0.5)^{*}(\text{sum } \|p_{ih}-p_{ij}\|)$	0.57

Table 9. East Beaver Dam Lake Percent Similarity: June 1999 and July 2005

Species Number	Scientific Name	Common Name	June 1999 Relative Frequency	July 2005 Relative Frequency	$\lvert p_{ik}-p_{ij}\rvert$
1	Chara spp.	muskgrass	0.02	0.05	0.03
2	Elocharis acicularis	needle spikerush, hairgrass	0.00	0.00	0.00
3	Potamogeton illinoensis	Illinois pondweed	0.02	0.05	0.03
4	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	0.30	0.38	0.07
5	Elodea canadensis	Canada waterweed	0.02	0.12	0.10
6	Ceratophyllum demersum	coontail	0.22	0.16	0.06
7	Myriophyllum spicatum	Eurasian watermilfoil	0.14	0.06	0.08
8	Potamogeton zosteriformis	flatstem pondweed	0.06	0.06	0.00
9	Potamogeton crispus	curlyleaf pondweed	0.00	0.02	0.02
10	Najas flexilis	bushy naiad	0.00	0.02	0.02
11	Brasenia schreberi	watershield	0.00	0.00	0.00
12	Nymphaea tuberosa	white waterlily	0.06	0.04	0.02
13	Potamogeton natans	floatingleaf pondweed	0.00	0.00	0.00
14	Utricularia spp.	bladderwort	0.00	0.00	0.00
15	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	0.00	0.00	0.00
16	Potamogeton amplifolius	largeleaf pondweed	0.00	0.00	0.00
17	Sagittaria graminea	grassy arrowhead	0.02	0.00	0.02
18	Scirpus sp.	bulrush	0.00	0.00	0.00
19	Nuphar variegata	spatterdock	0.00	0.01	0.01
20	Typha. spp.	cattail	0.01	0.00	0.01
21	Lemna minor	lesser duckweed	0.00	0.00	0.00
22	Myriophyllum sibiricum	northern watermilfoil	0.01	0.00	0.01
23	Ceratophyllum sp.	coontail	0.00	0.01	0.01
24	Eleocharis spp.	spike rush	0.00	0.00	0.00
25	Pontederia cordata	pickerelweed	0.00	0.00	0.00
26	Potamogeton gramineus	grass-leaved pondweed	0.00	0.00	0.00
27	Potamogeton pusillus	small pondweed	0.01	0.00	0.01
28	Potamogeton richardsonii	claspingleaf pondweed	0.05	0.00	0.05
29	Ranunculus spp	marsh marigold	0.02	0.00	0.02
30	Zosterella dubia	mud plantain	0.01	0.00	0.01
				sum $p_{ik}-p_{ij}$	0.56
				$C_{ij} = 1-(0.5)^{*}(\text{sum } \lvert p_{ih}-p_{ij}\rvert)$	0.72

Table 10. East Beaver Dam Lake Percent Similarity: August 1999 and July 2005

Species Number	Scientific Name	Common Name	August 1999 Relative Frequency	July 2005 Relative Frequency	$\lvert p_{ik}-p_{ij}\rvert$
1	Chara spp.	Muskgrass	0.02	0.05	0.04
2	Elocharis acicularis	needle spikerush, hairgrass	0.00	0.00	
3	Potamogeton illinoensis	Illinois pondweed	0.00	0.05	0.04
4	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	0.33	0.38	0.05
5	Elodea canadensis	Canada waterweed	0.00	0.12	0.12
6	Ceratophyllum demersum	Coontail	0.26	0.16	0.10
7	Myriophyllum spicatum	Eurasian watermilfoil	0.12	0.06	0.06
8	Potamogeton zosteriformis	flatstem pondweed	0.06	0.06	0.01
9	Potamogeton crispus	curlyleaf pondweed	0.04	0.02	0.02
10	Najas flexilis	bushy naiad	0.00	0.02	0.02
11	Brasenia schreberi	Watershield	0.00	0.00	0.00
12	Nymphaea tuberosa	white waterlily	0.11	0.04	0.06
13	Potamogeton natans	floatingleaf pondweed	0.01	0.00	0.01
14	Utricularia spp.	Bladderwort	0.00	0.00	0.00
15	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	0.00	0.00	0.00
16	Potamogeton amplifolius	largeleaf pondweed	0.00	0.00	0.00
17	Sagittaria graminea	grassy arrowhead	0.01	0.00	0.01
18	Scirpus sp.	Bulrush	0.00	0.00	0.00
19	Nuphar variegata	Spatterdock	0.00	0.01	0.00
20	Typha. spp.	cattail	0.01	0.00	0.01
21	Lemna minor	lesser duckweed	0.00	0.00	0.00
22	Myriophyllum sibiricum	northern watermilfoil	0.01	0.00	0.01
23	Ceratophyllum sp.	Coontail	0.00	0.01	0.01
24	Eleocharis spp.	spike rush		0.00	0.00
25	Pontederia cordata	Pickerelweed	0.00	0.00	0.00
26	Potamogeton gramineus	grass-leaved pondweed	0.00	0.00	0.00
27	Potamogeton pusillus	small pondweed	0.00	0.00	0.00
28	Potamogeton richardsonii	claspingleaf pondweed	0.00	0.00	0.00
29	Ranunculus spp	marsh marigold	0.00	0.00	0.00
30	Zosterella dubia	mud plantain	0.01	0.00	0.01
				sum $p_{ik}-p_{ij}$	0.57
				C_{ij} = 1-(0.5)*(sum $\lvert p_{ih}-p_{ij}\rvert$)	0.71

Eurasian watermilfoil has been reported in 48 states (Madsen 2005) and it is estimated that millions of dollars are spent annually on Eurasian watermilfoil control (Sales 1997). Eurasian watermilfoil has been in Wisconsin since the 1960s. In 1999 it was found in 319 Wisconsin waterbody sites, more than any state in the United States (Engel 1999).

EWM was introduced into Beaver Dam Lake during the 1990s. The plant spread rapidly throughout West and East Beaver Dam Lake. During 1999, EWM covered approximately 230 acres during June and 205 acres during August (See Figure 28). During 2000 through 2005, treatment of infested areas of the lake with 2,4-D reduced EWM coverage to approximately 89 acres (See Figure 28). Hence, a 57 to 62 percent reduction in EWM coverage resulted from six consecutive years of 2,4-D treatment. In addition to reducing coverage of EWM in the lake, treatment also reduced the maximum density of EWM. West Beaver Dam Lake noted a decline in EWM maximum density from 4 (80 percent of rake head covered) in 1999 to 3 (60 percent of rake head covered) in 2005. East Beaver Dam Lake noted a decline in EWM maximum density from 3.75 (75 percent of rake head covered) in 1999 to 1 (20 percent of rake head covered) in 2005. Treatment details follow.

During 2000 through 2005, EWM was treated on 2 occasions each summer. The first treatment occurred during June and the second treatment occurred in July or August. Each year from 50 to 102 acres of EWM were treated with 2,4-D during the first treatment and from 18 to 75 acres were treated with 2,4-D during the second treatment. Prior to each treatment, a visual inspection of the lake occurred to determine the areas in need of treatment. Treatment dose was determined on a site specific basis and ranged from 100 pounds per acre to 150 pounds per acre. The 2000 through 2005 treatment record is found in Appendix F.

5.4.1.1 2005 Comparison of June and July Surveys of EWM Treatment Area

In 2005, a pre-treatment and post-treatment survey were completed to determine the results of a 2,4-D treatment of 53 acres. Figure 29 provides a comparison between June and July EWM coverage in the 53 acre treatment area. The comparison indicates the treatment resulted in some success in that some areas containing EWM in June did not contain EWM in July. Also shown on Figure 29 is EWM coverage throughout Beaver Dam Lake, based upon the July 2005 survey of the entire lake.

Percent similarity (C) was used to compare the 2005 pre-treatment and post-treatment survey data from the 53 acre treatment area. The maximum similarity, in which there is the same frequency of each species at both sampling times, is 1. The minimum similarity, where there is no overlap of any species, is 0. Percent similarity results indicate treatment of EWM in June contributed towards a change in the lake's plant community, but was not the sole cause of changes occurring during the June through July period. A comparison of June and July plant communities within the West Beaver Dam Lake treatment area resulted in a similarity of 0.79 (See Table 11). A comparison of June and July plant communities within the East Beaver Dam Lake treatment area resulted in a similarity of 0.66 (See Table 12). The data indicate changes occurred in the plant communities of the West and East lakes and that the East lake exhibited a greater change than the West lake.

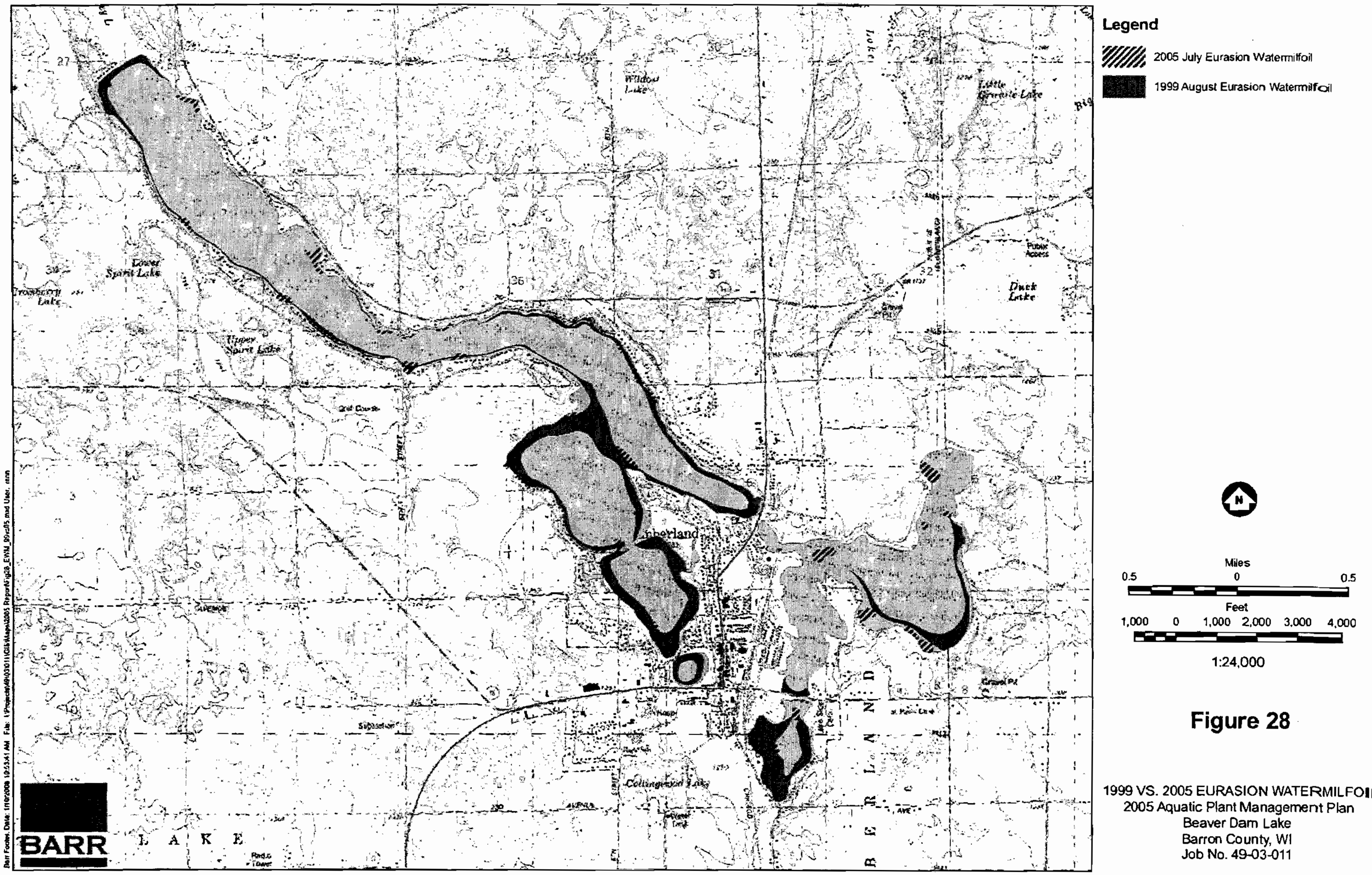
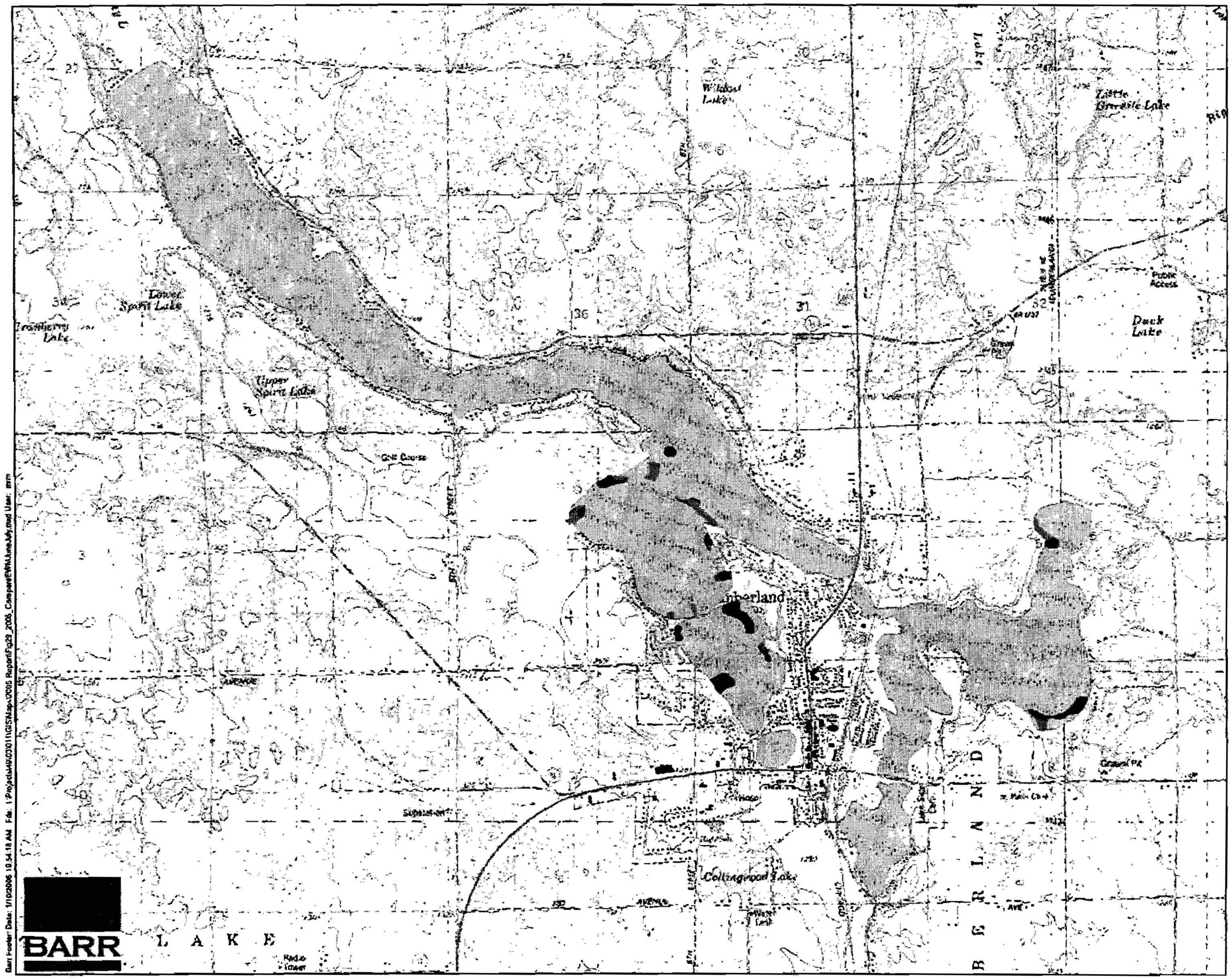


Figure 28

1999 VS. 2005 EURASION WATERMILFOIL
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



Legend

- 2005 July Eurasion Watermilfoil
- 2005 June Eurasion Watermilfoil

Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 29

2005 EURASION WATERMILFOIL
COMPARE JUNE AND JULY, 2005
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

Table 11. West Beaver Dam Lake Percent Similarity: June and July, 2005

Species Number	Scientific Name	Common Name	2005 Relative Frequency June	2005 Relative Frequency July	$\lvert p_{ik}-p_{jk} \rvert$
1	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	0.224	0.165	0.058
2	Chara spp.	muskgrass	0.196	0.196	0.001
3	Elodea Canadensis	Canadian Waterweed	0.160	0.165	0.005
4	Potamogeton illinoensis	Illinois pondweed	0.132	0.165	0.033
5	Myriophyllum spicatum	eurasian watermilfoil	0.123	0.100	0.023
6	Ceratophyllum demersum	coontail	0.119	0.130	0.012
7	Potamogeton crispus	curlyleaf pondweed	0.027	0.070	0.042
9	Utricularia spp.	Bladderwort	0.018	0.009	0.010
10	Potamogeton amplifolius	largeleaf pondweed	0.014	0.013	0.001
11	Potamogeton foliosus	leafy pondweed	0.009	0.000	0.009
12	Brasenia schreberi	watershield	0.005	0.022	0.017
13	Eleocharis spp.	spikerush	0.005	0.000	0.005
14	Myriophyllum sibiricum	northern watermilfoil	0.005	0.004	0.000
15	Nuphar advena	yellow pond lily	0.005	0.000	0.005
16	Potamogeton robbinsii	Robbins' pondweed	0.005	0.000	0.005
17	Potamogeton zosteriformis	flatstem pondweed	0.005	0.074	0.069
18	Sagittaria graminea	slender arrowhead	0.005	0.013	0.008
19	Zosterella dubia	mud plantain	0.005	0.000	0.005
20	Najas flexilis	bushy naiad	0.000	0.039	0.039
21	Vallisneria Americana	wild celery	0.000	0.022	0.022
22	Potamogeton natans	floatingleaf pondweed	0.000	0.018	0.018
23	Potamogeton sp. (possibly diversifolius)	pondweed (possibly waterthread)	0.000	0.018	0.018
23	Typha spp.	cattail	0.000	0.009	0.009
24	Nymphaea tuberose	white waterlily	0.000	0.004	0.004
				$\text{sum}\lvert p_{ik}-p_{jj} \rvert$	0.417
				C_{ij}	0.79

Table 12. East Beaver Dam Lake Percent Similarity: June and July, 2005

Species Number	Scientific Name	Common Name	2005 Relative Frequency June	2005 Relative Frequency July	$\lvert p_{ik}-p_{jk}\rvert$
1	Potamogeton sp. (possibly epihydrus or robbinsii)	pondweed (possibly ribbonleaf or Robbin's)	0.444	0.300	0.144
2	Myriophyllum spicatum	eurasian watermilfoil	0.333	0.150	0.183
3	Ceratophyllum demersum	coontail	0.111	0.100	0.011
4	Potamogeton illinoensis	Illinois pondweed	0.111	0.150	0.039
5	Chara spp.	muskgrass	0.000	0.050	0.050
6	Elodea Canadensis	Canadian Waterweed	0.000	0.100	0.100
7	Potamogeton amplifolius	largeleaf pondweed	0.000	0.050	0.050
8	Potamogeton zosteriformis	flatstem pondweed	0.000	0.100	0.100
				sum$\lvert p_{ik}-p_{jk}\rvert$	0.678
				C_{ij}	0.66

One component of the change in the lake's plant community was a decline in the relative frequency of EWM. Consequently, native species recolonized areas in which EWM disappeared following 2,4-D treatment. Other plant community changes occurring during the June through July period include reductions in the relative frequency of some native species (e.g., pondweed) and increases in the relative frequency of other native species (e.g., Canada waterweed).

5.4.1.2 2005 Milfoil Weevil Survey Results

The milfoil weevil is a small, herbivorous aquatic beetle, belonging to the family Curculionidae. It is a milfoil (Myriophyllum spp.) specialist, meaning that it feeds and develops only on plants in this genus. The weevil completes all life stages fully submersed and the larvae are stem miners. These characteristics make it very unique, as specialist herbivores are very rare among insects (Solarz and Newman 1996). These characteristics are precisely why the milfoil weevil has shown the most promise as a potential biocontrol agent for EWM and why it has been the subject of much research (Newman 1999).

During 1997, the Wisconsin Department of Natural Resources (WDNR) completed a milfoil weevil project in Beaver Dam Lake. During late June and early July 1997, weevil eggs and larvae were stocked in three plots in Beaver Dam Lake West (Library Lake). Stocking was done by tying small bundles of Eurasian water milfoil containing the eggs and larvae onto existing milfoil plants in the plots. Approximately 5 weeks post-stocking, weevil density was measured again among the plots. Weevil densities were also measured a full year post-stocking in June and August 1998. A survey completed just prior to stocking in June of 1997 indicated milfoil weevils in Beaver Dam Lake occurred at an average density of 1.3 weevils per plant. Stocking occurred to increase weevil density to 2 weevils per plant. August 1997 survey results indicated weevil density had declined to 0.1 weevils per plant. Densities observed in 1998 were 0.4 weevils per plant in June and 0.5 weevils per plant in August. Despite the reductions in density noted during the project, surveys of Eurasian watermilfoil during the study indicated considerable weevil damage occurred in the top few inches of the plants. The damage did not allow the plants to flower. However, weevil damage was usually confined to the upper portions of the plant and did not cause the milfoil to "crash" in the water column and sink out of site. In fact, the lower portions of the plants often appeared healthy. Study results indicated a significant increase in percent of Eurasian watermilfoil plants noting broken tips occurred following milfoil weevil stocking (Jester et al. 1999).

During 1999, a survey was completed to determine portions of Beaver Dam Lake containing the milfoil weevil or exhibiting weevil damage to Eurasian watermilfoil plants. A total of 11 sites were surveyed in the West lake and 3 sites were surveyed in the East lake. Survey results indicate the milfoil weevil was present in 7 of 11 West Lake sites (64 percent) and 1 of 3 East lake sites (33 percent). The survey confirmed the milfoil weevil was present throughout Beaver Dam Lake and was causing damage to Eurasian watermilfoil plants throughout the lake. Both the milfoil weevil and Eurasian watermilfoil were more prevalent in the West lake than the East lake.

During 2005, a survey was completed to determine whether the milfoil weevil was present in Beaver Dam Lake. A total of 15 sites were surveyed (See Figure 7) and a total of 86 EWM stems were examined. The results indicated none of the stems contained weevils (i.e., adult, larvae, or eggs). A total of 6 stems (7 percent) noted meristem damage (i.e., damage to the tips of EWM plants which is the location of damage inflicted by weevils). All of the damaged meristems were collected from the West Lake. Hence, none of the stems collected from the East Lake were damaged. The plants were also evaluated to determine whether any of them contained Lepidoptera caterpillar because it also damages EWM stems. None of the plants contained Lepidoptera caterpillar. A total of 80 stems (93 percent) were undamaged and did not contain either weevils or Lepidoptera (See Appendix G). The data indicate very little biological control of EWM is currently occurring within West Beaver Dam Lake and no biological control of EWM is occurring within East Beaver Dam Lake.

5.4.2 Curlyleaf Pondweed (CLP)

CLP is a perennial, rooted, submersed aquatic vascular plant that is native to Eurasia, Africa, and Australia. This species has been found in the United States since 1950, and is currently found in most parts of the world (Catling and Dobson, 1985). Curlyleaf pondweed is detrimental to lakes for three reasons:

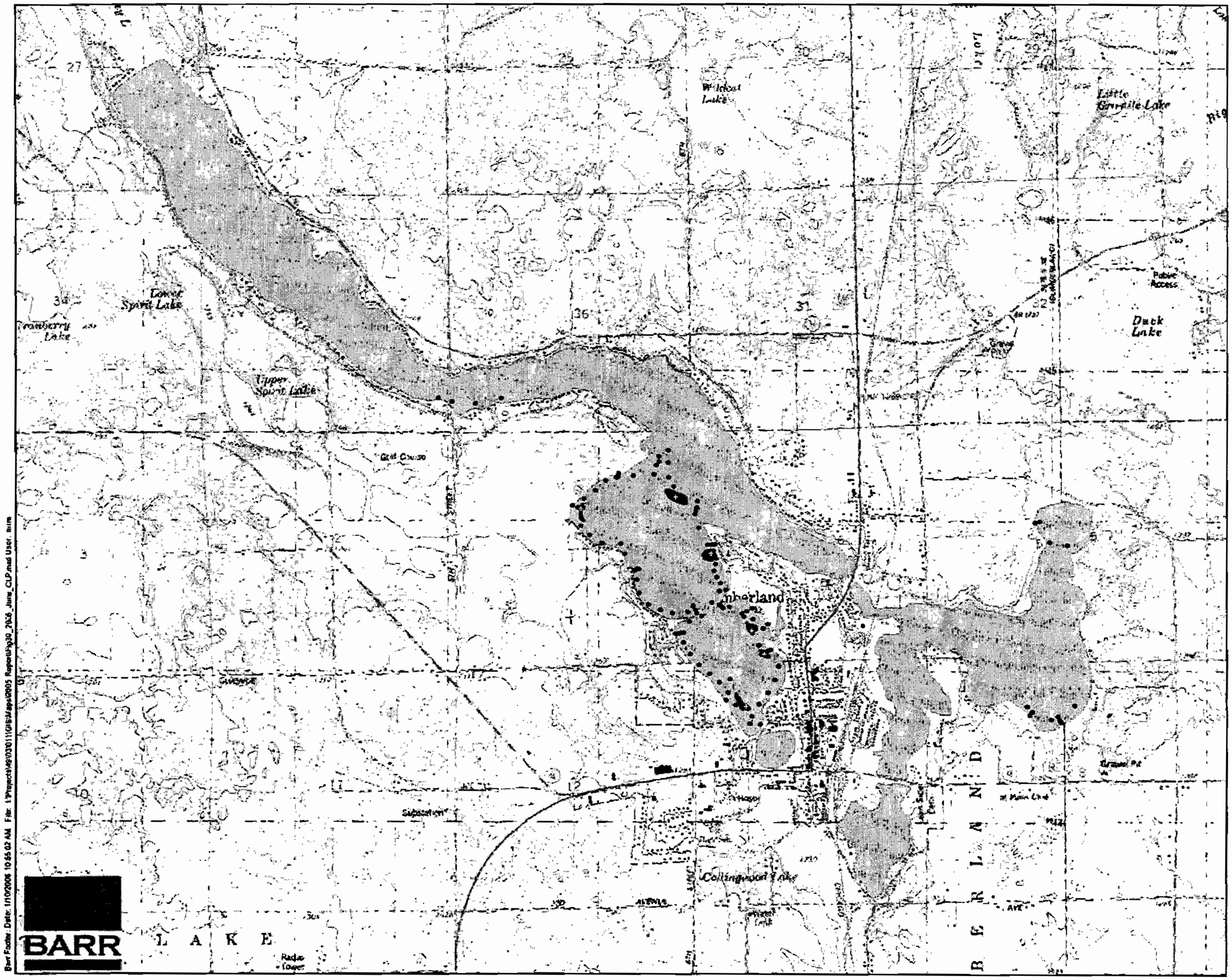
1) It tends to displace native aquatic species

2) Dense colonies of the plant may interfere with recreational activities on the lake

3) After CLP dies out in late June or early July, it decays and adds phosphorus to the lake, which degrades the lake's water quality.

In June of 1999, CLP coverage included approximately 6 acres within West Beaver Dam Lake and 12 acres within East Beaver Dam Lake. Hence, CLP coverage in June comprised 3 and 6 percent of the total aquatic plant coverage in the West and East lakes, respectively. During August, CLP coverage included approximately 38 acres within West Beaver Dam Lake and 6 acres within East Beaver Dam Lake. Hence, CLP coverage in August comprised 18 and 3 percent of the total aquatic plant coverage areas in the West and East lakes, respectively.

In June of 2005, CLP coverage of the 53 acre EWM treatment area was approximately 7 acres (See Figure 30) or 13 percent of the treatment area. In July of 2005, CLP coverage included approximately 24 acres, which is 5 percent of the lake's total aquatic plant coverage area (See Figure 31). Areas containing CLP in June also contained CLP in July. CLP coverage in July of 2005 was within the range observed during 1999 (i.e., 18 acres in June and 44 acres in August). The data indicate CLP coverage has been relatively stable during the past 6 years. Apparently the lake's native vegetation has successfully competed against CLP such that its coverage did not increase.



Legend

- June 2005 Sample Points w/ CLP
- June 2005 Sample Points w/out CLP
- June 2005 Curlyleaf Pondweed Infestation (Areas Approximate)

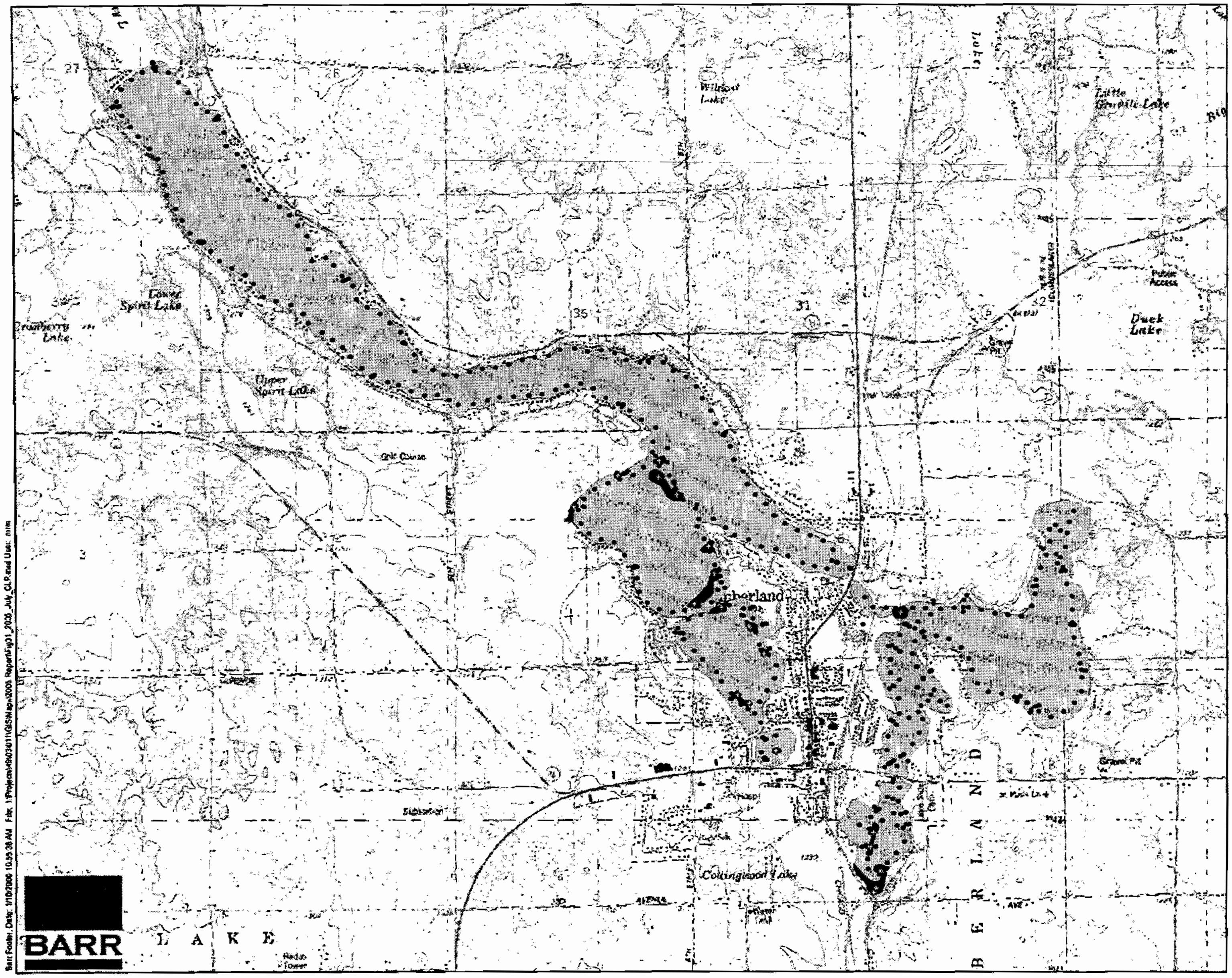
Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 30

JUNE 2005 CURLYLEAF PONDWEED
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



Legend

- July 2005 Sample Points w/ CLP
- July 2005 Sample Points w/out CLP
- July 2005 Curlyleaf Pondweed Infestation (Areas Approximate)

Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 31

JULY 2005 CURLYLEAF PONDWEED
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

6.0 Beaver Dam Lake Aquatic Plant Management Plan

An aquatic plant management plan is an orderly and effective approach to plant management. The plan defines the problem, establishes goals, evaluates possible management options, selects a feasible management option, and determines an effective monitoring program to evaluate results of the management strategy. A successful aquatic plant management plan is based upon six principles:

- Define the problem
- Establish goals
- Understand plant ecology
- Consider all the techniques
- Develop management plan
- Monitor the results

6.1 Define the Problem

Beaver Dam Lake has a healthy aquatic plant community that is of higher quality and is less tolerant to disturbance than the plant community of the median Wisconsin lake. The presence of EWM and CLP are of concern because these species are not native to this region and have caused problems in lakes throughout the United States by out competing native plants and developing objectionable dense growths (See Figure 32). The lake's CLP community is relatively stable and has changed little during the past 6 years. EWM is of greater concern because it has caused problems (i.e., displacement of native species, rapid spread, dense growths, particularly at the lake's surface) within Beaver Dam Lake in the past and will likely cause problems in the future unless managed prudently. EWM was introduced into the lake during the 1990's, spread rapidly, and covered approximately 230 acres by 1999. Annual 2,4-D treatments during 2000 through 2005 have reduced EWM coverage to approximately 89 acres in 2005. Continued management is needed to prevent an increase in EWM coverage and, if possible, attain additional reductions in EWM coverage.

Myriophyllum spicatum (Eurasian watermilfoil)

Potamogeton cripus (curlyleaf pondweed)

Figure 32 Beaver Dam Lake Aquatic Invasive Species (AIS)—Eurasian Watermilfoil (EWM) and Curlyleaf Pondweed (CLP)

Although the lake's native community is healthy and most species are not problematic, some areas of the lake note problematic growths of water lilies, pondweed, or a combination of several species. These dense growths interfere with recreational use of the lake and result in a less than ideal habitat for the lake's fishery. Prudent management of dense growths of native species is needed to support the lake's beneficial uses and the lake's fishery.

6.2 Establish Goals

The Beaver Dam Lake Management District has established 7 general and 9 specific aquatic plant management goals for Beaver Dam Lake: The specific goals are divided into 2 categories, goals for an annual maintenance program and goals for a long-term improvement program. The annual maintenance program involves an annual treatment of boat landings, swimming beaches, the area around the fishing pier, and navigation channels. The long-term improvement program is intended to attain a long-term change in areas receiving treatment.

6.2.1 General Goals

1) Preserve native species, preserve and/or improve fish and wildlife habitat, protect the lake's ecosystem, and protect and/or improve the quality of Beaver Dam Lake for all to enjoy (i.e., people, fish, wildlife)

2) Remove vegetation from public beach areas and public swimming areas to insure safe swimming conditions and from around the fishing pier to support its use for fishing.

3) Remove vegetation from public boat landings to insure public access to the lake

4) Improve navigation within the lake through areas containing dense plant beds

5) Prevent an increase in AIS density and coverage to preserve native species, preserve fish and wildlife habitat, protect the lake's ecosystem, and protect the quality of the lake for all to enjoy.

6) Reduce AIS density and coverage to the greatest extent possible to improve the lake's native plant community, improve fish and wildlife habitat, improve the lake's ecosystem, and improve the quality of the lake for all to enjoy.

7) Prevent the introduction of additional AIS to the greatest extent practicable, including education, postings, etc.

6.2.2 Specific Goals for Annual Maintenance Program

1) Inspect all boat landings, the area around the fishing pier, swimming beaches, and navigation channels each June and determine areas in need of treatment. Treat with herbicide (Reward or Aquathol K) in June.

2) Inspect navigation channels in August and harvest where needed to provide boat passageways and support use of the lake for fishing.

6.2.3 Specific Goals for Long-Term Improvement Program

1) Inspect the lake during late April or early May to determine areas in need of EWM treatment. Treat each area with a spring treatment of an appropriate herbicide or combination of herbicides to reduce the coverage of EWM for the year of treatment and for subsequent years

2) Treat areas of the lake containing CLP with an early spring endothall treatment to reduce CLP to the greatest extent possible and prevent CLP from recolonizing areas in which EWM is removed

3) Survey the lake during June to determine effectiveness of the early spring AIS treatment and to determine EWM summer treatment needs.

4) Inspect the lake during August to determine areas in need of treatment. Treat each EWM area with a summer or late season treatment of 2,4-D to reduce the coverage of EWM for the year of treatment and for subsequent years.

5) Inspect areas of water lily growth and determine treatment needs to support the lake's beneficial uses and the lake's fishery. Treat selected portions of areas warranting treatment to create boat passageways, fish cruising lanes, and areas for fishing use for the year of treatment and to reduce coverage and density of water lilies in problematic growth areas for subsequent years.

6) Inspect areas with dense pondweed growth during June and August. Harvest selected portions of areas warranting treatment to create boat passageways, fish cruising lanes, and areas for fishing use for the year of treatment and to reduce coverage and density of pondweed in problematic growth areas for subsequent years.

7) Select test sites with representative growths of EWM, CLP, water lily, and pondweed and treat with lime to reduce AIS and limit native plant density to a moderate level. Evaluate treatment results to determine whether lime slurry is more effective or less costly than other treatment alternatives.

6.3 Understand Plant Ecology

Aquatic plant management is based upon an understanding of plant ecology. Understanding the biology of aquatic plants and their habitat requirements is necessary to effectively manage plants. Effective management is necessary to maintain the delicate balance of preservation of fish and wildlife habitat and concurrently provide reasonable lake-use opportunities to area residents.

The biology of aquatic plants and their habitat requirements are inseparably interrelated. The habitat requirements of plants are divided into two general groups, the living group (biotic) and the nonliving group (abiotic). The following discussion of plant habitat requirements is based upon Nichols (1988).

The biotic group contains the predators, parasites, and other organisms which depend upon or compete with an organism for their livelihood. These interrelationships form the basis for biological plant management methods.

The abiotic factors form the basis of plant control techniques involving habitat manipulation, and include those physical and chemical attributes which are necessary for plant growth and development: light, bottom type, water, temperature, wind, dissolved gases and nutrients. Light, water, temperature, dissolved gases and nutrients relate to the plant's ability to carry out the vital processes of photosynthesis and respiration. Bottom type and wind relate to specific physical locations where a plant can grow. The following discussion will show the relationship between critical habitat requirements and possibilities for management.

Both the quantity and quality of light influence plant growth. Light in the red and blue spectral bands is used for photosynthesis; low and high light intensities inhibit photosynthesis. Management activities that make use of shade and dyes, for example, are based on limiting light intensity or changing the spectral qualities of the light. Deepening the lake through dredging or damming is another method of altering the light available to a plant, as light is naturally attenuated in water and the spectral qualities changed.

In the aquatic environment, water is available in abundance and is, therefore, often overlooked as being critical for aquatic plants. Yet, aquatic plants are adapted to growing in an environment with an abundant water supply and are, therefore, sensitive to water stress. Aquatic plants might be controlled by removing their water supply, resulting in the desiccation of the plant.

Plants are generally tolerant of a wide range of temperatures, and temperature fluctuations in the aquatic environment are smaller than in the surrounding aerial environment. Therefore, plant management schemes involving temperature effects depend on artificially exposing aquatic plants to the harsher aerial environment, where not only temperature but desiccation and other factors aid in controlling plant growth.

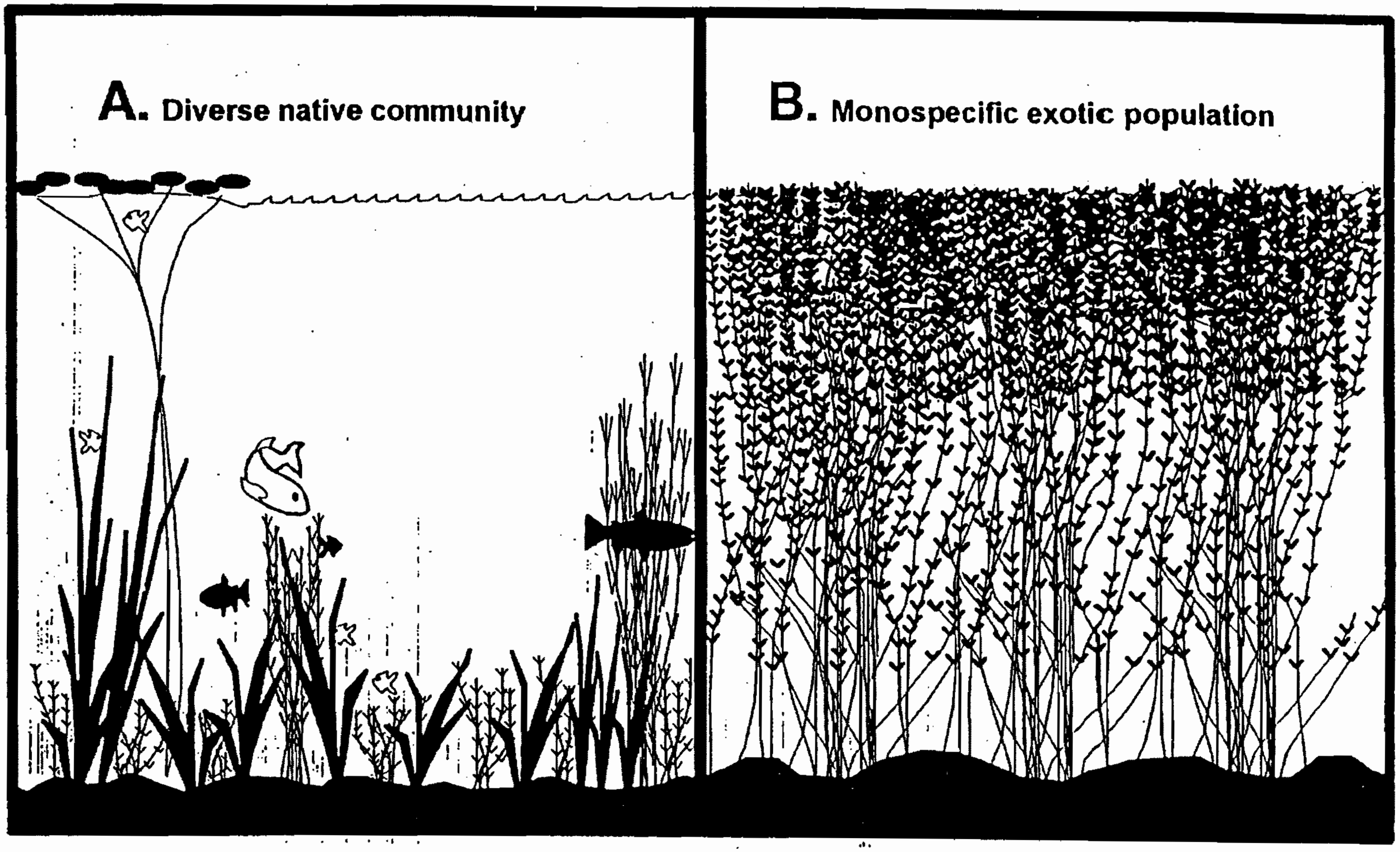
The two gases of primary importance in the aquatic system are carbon dioxide and oxygen, which are used for photosynthesis and respiration, respectively. The availability of carbon in the form of free CO_2 or bicarbonate appears to influence the distribution of some plant species (Hutchinson, 1970). Although oxygen is many times limiting in the aquatic system, most plants are adapted to living in low oxygen conditions. Because the carbon dioxide reaction is so well buffered by an equilibrium with CO_2 in the air and because the plants are tolerant to low oxygen supplies, the success of any scheme to manage plants by altering the dissolved gases in water seems doubtful.

Aquatic plant problems are caused by nutrient enrichment of the sediment. Nitrogen and phosphorus are the two nutrients of prime concern (Vollenweider, 1968; Sawyer, 1947; Stewart and Rohlich, 1967). Gerloff and Krombholz (1966) and Gerloff (1969) point out that the concentration of nutrients in the habitat may not be related to the concentration in the plant, depending on the availability of the nutrients. Plants remove nutrients in excess of their needs and store excess nutrients (i.e., luxury consumption, Gerloff 1969). These excess nutrient supplies could be used at times when the plant undergoes nutrient stress. These factors inherent in the biology of the plant will have to be overcome when developing practical, in-lake methods of nutrient limitation for aquatic plant control.

Wind and bottom type are physical conditions that may limit plant growth. Heavy winds create waves that tear and uproot the plant, and soil types that are too coarse or are not consolidated enough make rooting very difficult. Some bottom types are rich in nutrients essential for plant growth. Substrates may be altered by removing, covering, or nutrient inactivation.

By manipulating the plant's environment, management tries to induce these limiting conditions and thus restrict the growth of the plants.

Differences in growth patterns between exotic plants (i.e., not native to this area) and native plants provide a compelling reason for management of exotic species to protect native communities. Native plant communities are typically dominated by growth forms that concentrate biomass below the surface of the water (See Figure 33A), contain a high diversity of species, and have low to moderate levels of biomass. Exotic plants typically follow an extremely rapid growth pattern. Exotic species generally produce a dense canopy of vegetation at the air:water interface and develop high levels of biomass (See Figure 33B). Such a growth pattern interferes with use of the water resource by recreational-users and may eliminate the beneficial native plant community through shading (Smart, et al., 1996). Management to control the growth of exotic species is necessary to protect the native plant community and provide a reasonable use of the lake to recreational-users. The exotic species of primary concern in Beaver Dam Lake (East and West) is Eurasian watermilfoil. Curly-leaf pondweed is also present in the lake.



Source: Smart et al., 1996

Figure 33

SUBMERGED AQUATIC PLANT COMMUNITIES

6.4 Identify Beneficial Use Areas

Beneficial uses of a water body must be compatible with its capacity to sustain those uses, both human and natural. A single water body often supports many different beneficial uses. Aquatic plant growth may impair the beneficial uses of a lake and, hence, may create many use conflicts. The management challenge involves identifying the lake's beneficial uses, and realistically managing for those uses.

Beaver Dam Lake is used for a variety of recreational activities. 1999 membership survey respondents indicate the lake is used for viewing, swimming, fishing, powerboating, waterskiing, canoeing, and other recreational activities and that aquatic plants cause impairment of all beneficial uses (Barr 2000). The 2005 aquatic plant survey results confirm that aquatic plants continue to cause impairment of the lake's beneficial uses. Management of problematic aquatic plant growth areas is essential to sustain the lake's beneficial uses.

As a first step towards identifying a management plan to sustain the lake's beneficial uses, Beaver Dam Lake Protection and Rehabilitation District Board Members have identified beneficial use areas within the lake that require annual maintenance to resolve conflicts created by aquatic plant growth. Figures 34 and 35 present these beneficial use areas. The map identifies swimming beaches, boat landings, the fishing pier, and boating passageways.

In addition to areas requiring annual maintenance, areas with dense pondweed, water lilies, and/or a combination of plant species currently impair the lake's beneficial uses. A long-term improvement program is warranted to resolve conflicts created by aquatic plant growth and to sustain the lake's beneficial uses.

In addition to human uses, the lake provides habitat for fish, waterfowl, and other animals. The Wisconsin Department of Natural Resources (WDNR) has identified fish and wildlife sensitive areas in Beaver Dam Lake (See Figures 36 and 37). Sensitive areas include habitats that are integral to the lake ecosystem such as nesting sites or fish spawning areas. To protect sensitive areas, plant management within sensitive areas is restricted by the WDNR.

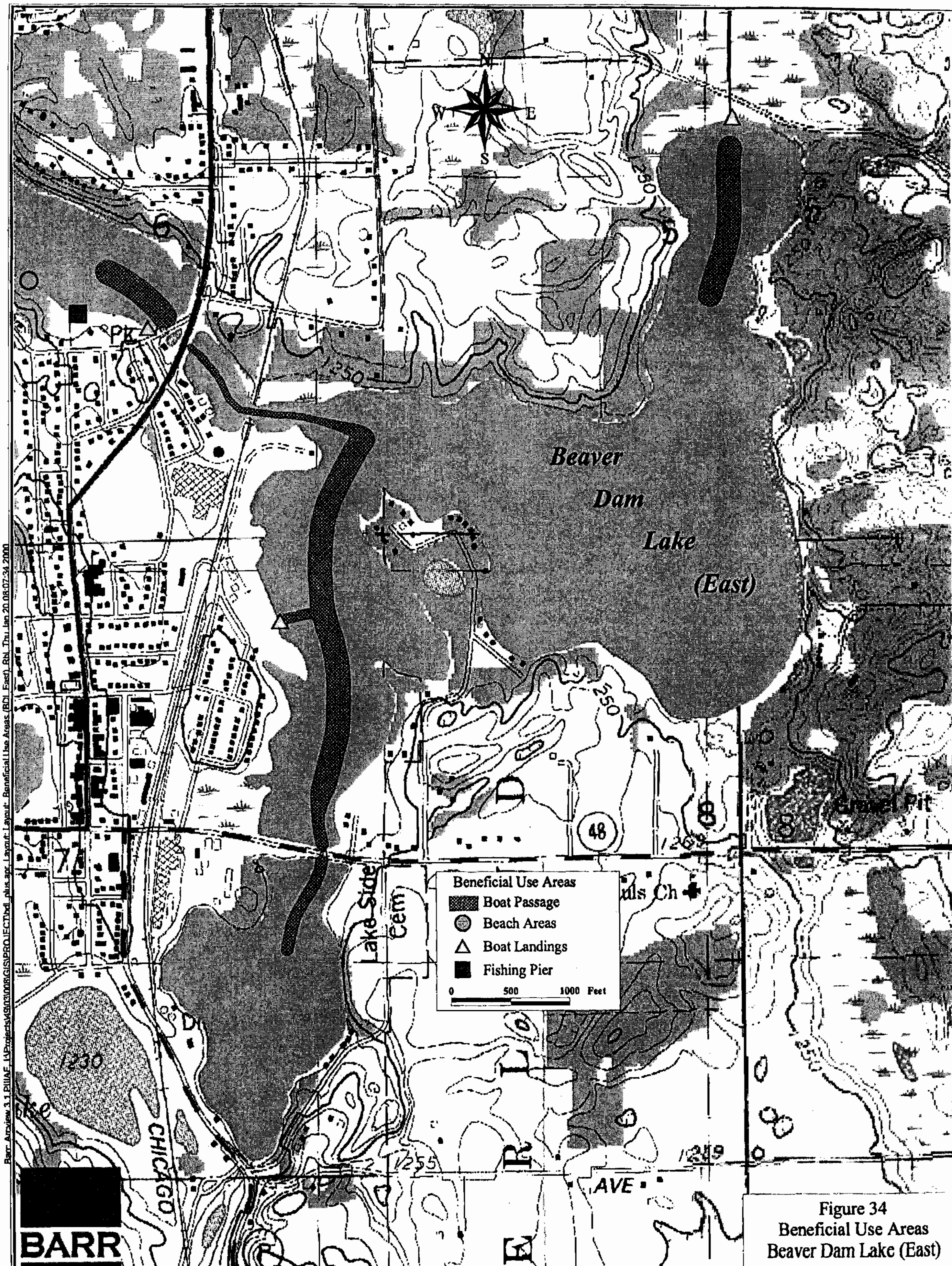


Figure 34
Beneficial Use Areas
Beaver Dam Lake (East)

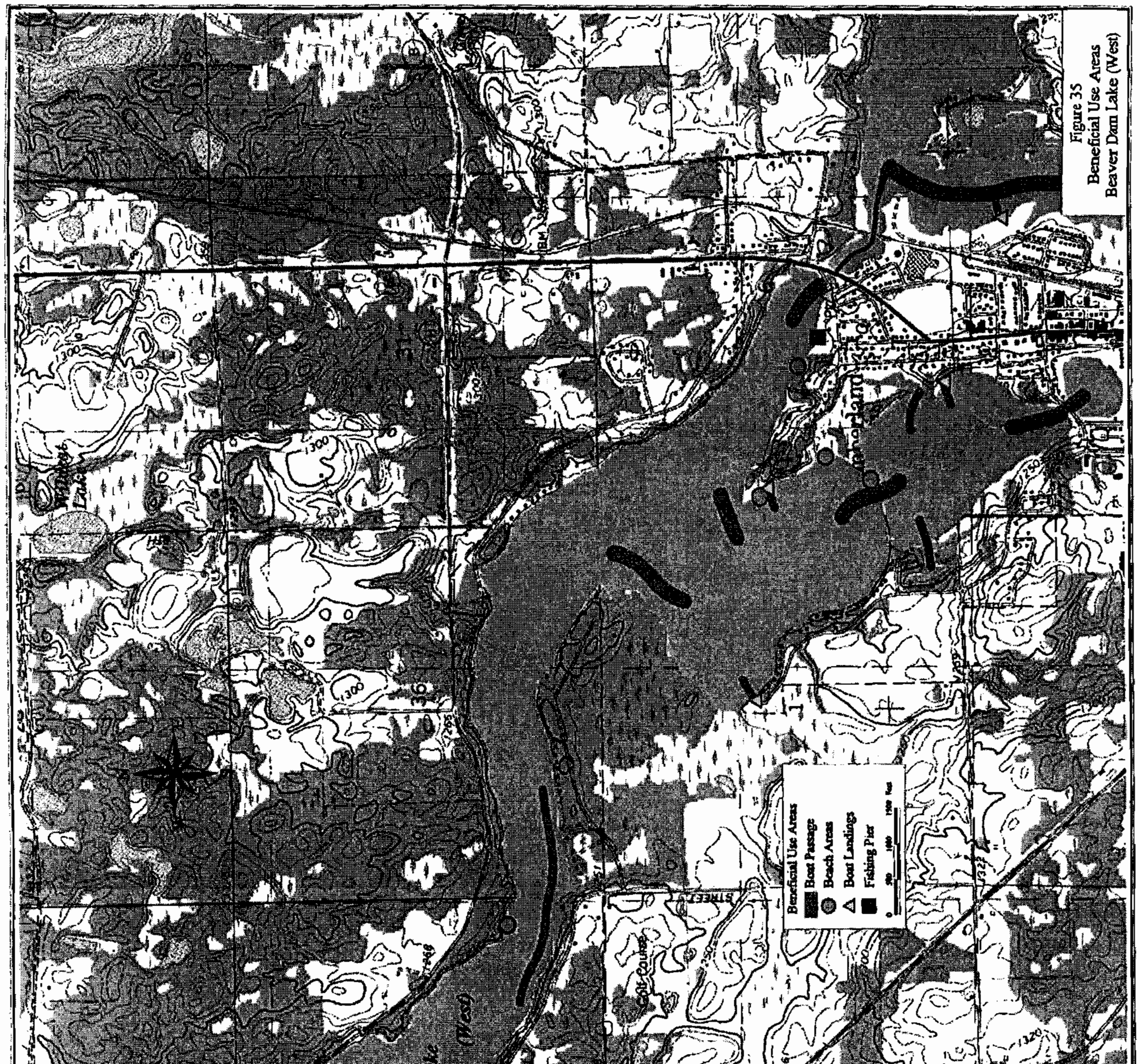


Figure 35
Beneficial Use Areas
Beaver Dam Lake (West)

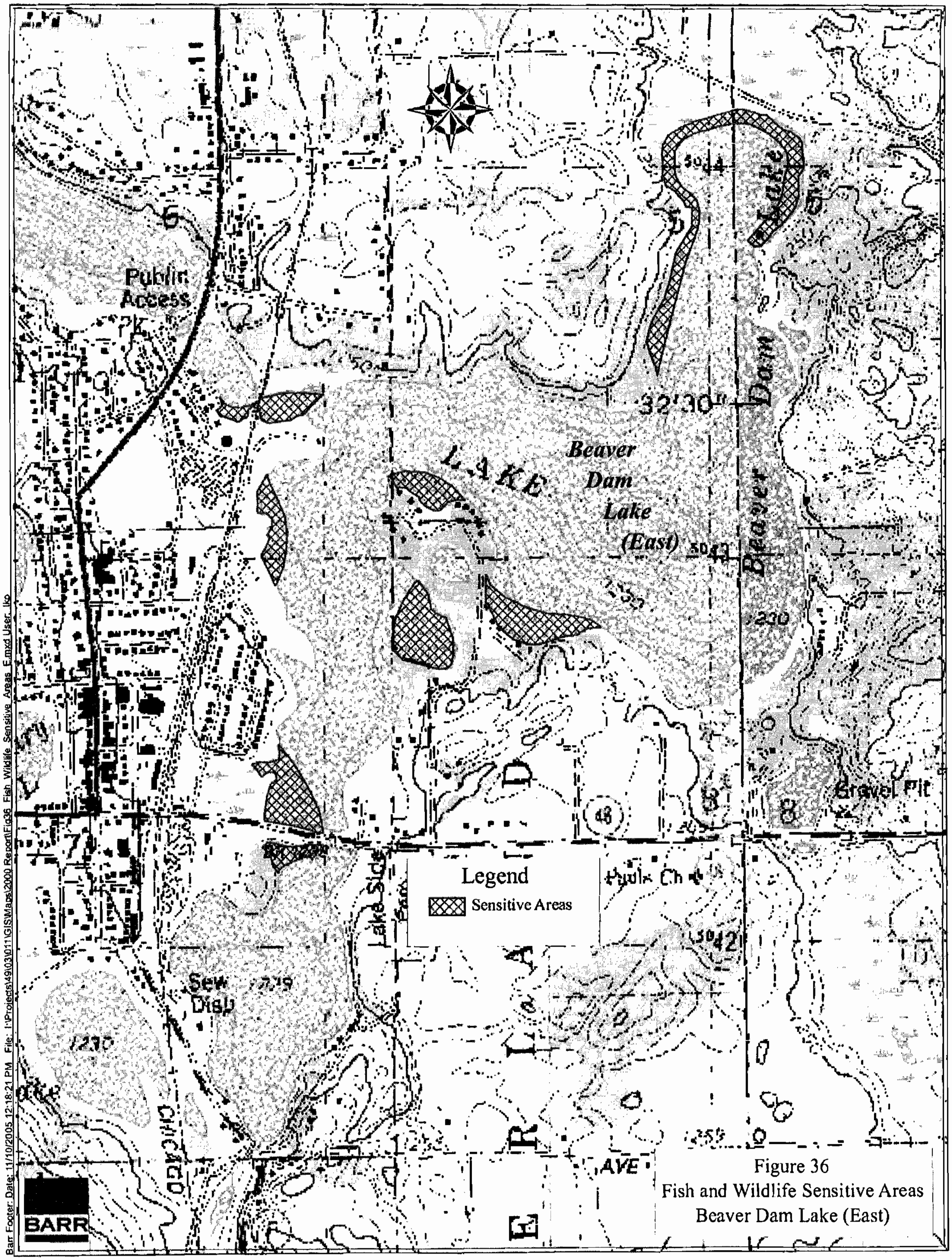


Figure 36
Fish and Wildlife Sensitive Areas
Beaver Dam Lake (East)

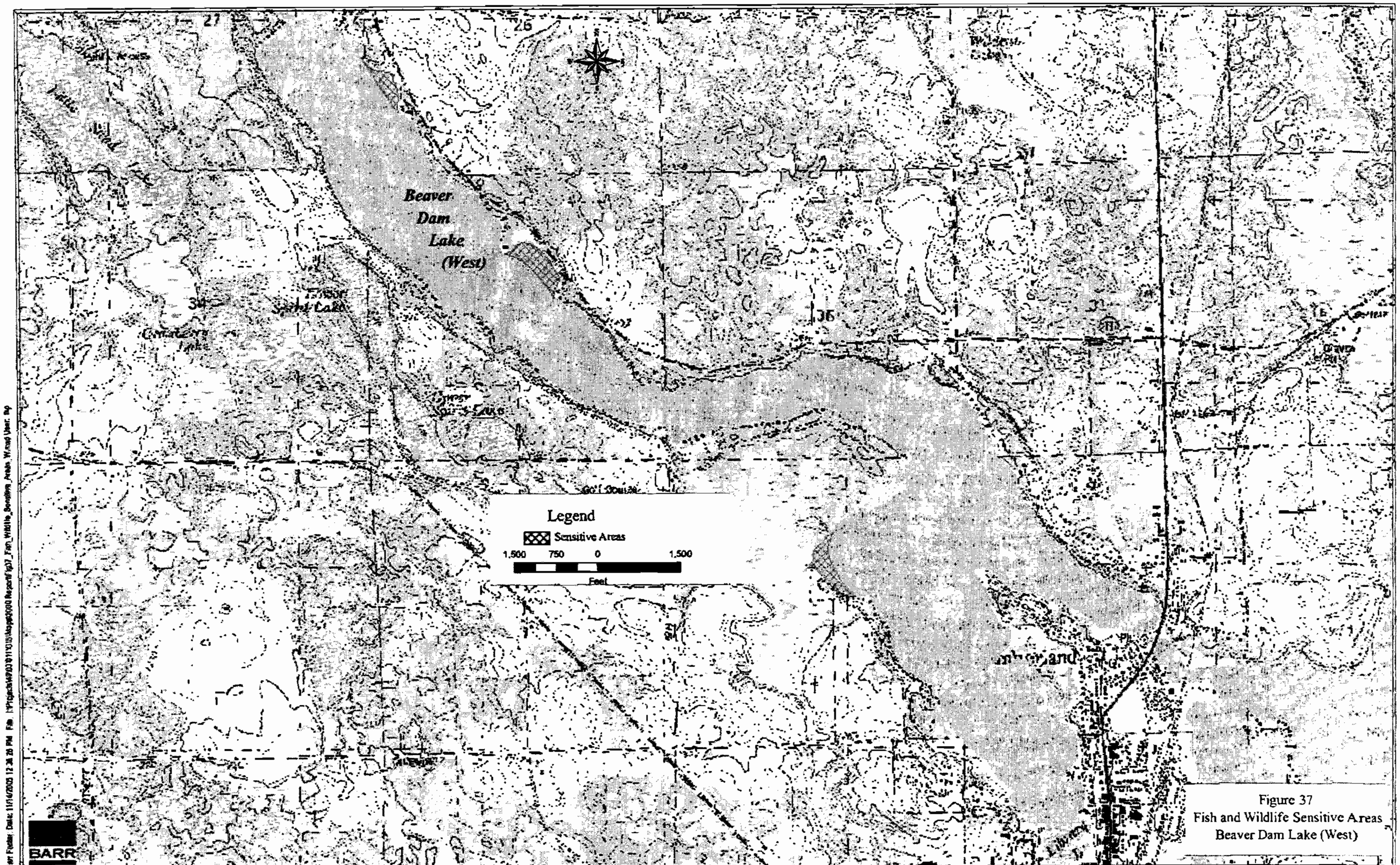


Figure 37
Fish and Wildlife Sensitive Areas
Beaver Dam Lake (West)

6.5 Consider All Techniques

Following a consideration of all possible management alternatives, a feasible management option may be identified for Beaver Dam Lake. The following discussion focuses on four types of aquatic plant management techniques currently used for aquatic plant control. They include:

1. Physical
2. Mechanical
3. Chemical
4. Biological

6.5.1 Physical

Physical tactics typically used to manage aquatic plants are light manipulation and habitat manipulation. Habitat manipulation includes such techniques as overwinter lake drawdown, dredging, sand blanketing, the use of dyes, and nutrient limitation and inactivation (Barr, 1997).

Although light manipulation has been used in lakes with some success, its greatest utility has been found in managing dense vegetation in streams through streamside shading. Shading by use of different densities of shading cloth has resulted in decreased plant biomass. Natural shade from streamside vegetation has also reduced plant biomass along the stream course (Barr, 1997). Dark colored dyes are sometimes used in small ponds and lakes to reduce aquatic plant growth. The dyes are added to the lake or pond. The resultant change in water color reduces the amount of light reaching the submersed plants, thereby limiting plant growth. Use of dyes is limited to shallow waterbodies with no outflow. Because Beaver Dam Lake is a large lake with an outflow, dyes cannot be used in the lake for plant management.

Lake level drawdown, particularly over winter, is commonly used to control nuisance aquatic plants in northern North America. Biomass studies before and after drawdown have demonstrated that drawdown was effective in controlling plants down to the depth of drawdown, but had no effect at greater depths. While drawdown is an extremely effective technique for some species, it may actually stimulate the growth of other species. (Madsen and Bloomfield, 1992). A study of Trego Flowage (Washburn County, Wisconsin) indicated the benefits of drawdown were temporary, and the same species of plants returned in about their former abundance within a few years (Barr, 1994). Consequently, drawdown as a plant management technique is not a feasible option for Beaver Dam Lake.

Another commonly-used group of physical control techniques uses benthic barriers, weed rollers, or sediment alteration to inhibit the growth of aquatic plants at the sediment surface. Barrier material is applied over the lake bottom to prevent plants from growing, leaving the water clear of rooted plants. Benthic barriers are generally applied to small areas (Barr, 1997). Negatively buoyant (i.e., sink in water) screens are available in rolls 7 feet wide and 100 feet long. The screens can be laid on the lake bottom in the spring and removed in the fall. These screens can be reused for about 10 years. Burlap has been found to provide up to 2 to 3 years of relief from problematic growth before eventually decomposing (Truelson 1985 and Truelson 1989). Bottom barriers would be appropriate for controlling aquatic plant nuisances for small applications such as adjacent to a boat dock or from small swimming areas. The barriers are safe, effective, non-chemical control using a simple technology. Bottom barriers do not result in significant production of plant fragments (critical for milfoil treatment). Bottom barriers may cause harm to fisheries and invertebrate habitat. Consequently, the WDNR should be contacted prior to barrier installation to determine whether a permit is needed. Bottom barriers are not feasible for Beaver Dam Lake because the area requiring management is large.

Weed rollers or 'Automated Unintended Aquatic Plant Control Devices' are motor-drive rollers (round bars) placed on the lake bottom and roll over and uproot plants. The rollers are 25-to-30 feet long and are centered on the end post of a dock. The rollers roll in a circular pattern, normally covering 270^0 or using a 25-foot roller over a full circular area. Weed rollers would be appropriate for controlling aquatic plant nuisances in small areas such as adjacent to a boat dock or for small swimming areas. The rollers are an effective non-chemical control using a simple technology. However, weed rollers cause harm to fisheries and invertebrate habitat. Consequently, use of rollers in Wisconsin lakes is not allowed.

Sediment inactivation has included the application of substances to sediments (i.e., such as lime slurry) that affect the nitrogen and phosphorus composition of the sediments. The growth of aquatic plants is inhibited by the reduced availability of phosphorus or a change in nitrogen in the sediments (Barr, 1997). Lime slurry is also believed to cause carbon limitation by reducing the quantity of carbon available for plants. Lime slurry is an experimental tool currently the subject of a research project by the Eau Galle Aquatic Ecology Laboratory. Use of lime slurry is a feasible option for Beaver Dam Lake and is recommended for consideration in the lake's APM Plan.

6.5.2 Mechanical

Mechanical control involves aquatic plant removal via harvesting, handpulling, hand-digging, rotovation/cultivation, or diver-operated suction dredging. Small scale harvesting may involve the use of the hand or hand-operated equipment such as rakes, cutting blades, or motorized trimmers. Individual residents frequently clear swimming areas via small scale harvesting or hand pulling or hand digging. Small scale harvesting is not a feasible option for Beaver Dam Lake because the area requiring management is too large for management by small scale methods.

Large-scale mechanical control often uses floating, motorized harvesting machines that cut the plants and remove them from the water onto land, where they can be disposed. Harvesting has not proven to be an effective means of sustaining long-term reductions in plants such as coontail and Eurasian watermilfoil (EWM) that grow from fragments. Fragments from harvesting may cause coontail or EWM to regrow to preharvest levels or to spread to new areas and increase coverage of these species within a lake. However, harvesting pondweed and water lilies is a feasible option. Because problematic growths of pondweed and water lilies are present in Beaver Dam Lake, harvesting is recommended for consideration in the lake's APM plan.

Rotovation/cultivation (underwater rototilling) are bottom tillage methods that remove aquatic plant root systems. This results in reduced stem development and seriously impairs growth of rooted aquatic plants. Derooting methods were developed by aquatic plant experts with the British Columbia Ministry of Environment as a more effective EWM control alternative to harvesting. Essentially two types of tillage machinery have been developed. Deep water tillage is performed in water depths of 1.5 to 11.5 feet using a barge-mounted rototiller equipped with a 6-10 foot wide rotating head. Cultivation in shallow water depths up to a few meters is accomplished by means of an amphibious tractor or modified WWII "DUCW" vehicle towing a cultivator. Both methods involve tilling the sediment to a depth of 4 to 6 inches, which dislodges plants including roots. Certain plants like EWM have roots that are buoyant and float on the surface where they can be collected. Treatments are made in an overlapping swath pattern. Bottom tillage is usually performed in the cold "off-season" months of winter and spring to reduce plant growth potential.

Bottom tillage has been used effectively for long-term control of EWM where populations are well-established and prevention of stem fragments is not critical. Single treatments using a crisscross pattern have resulted in EWM stem density reductions of 80-97 percent in bottom tillage treatments (Gibbons et al. 1987 and Maxnuk 1979). Depending on plant density, carryover effectiveness of rototilling can persist for up to 2 to 3 years without retreatment. Following treatment, rotovated areas in Washington and British Columbia have shown increases in species diversity of native plants, of potential benefit to fisheries (Gibbons 1994). Rototilling is not advised where bottom sediments have excessive nutrient and/or metals concentrations, because of potential release of contaminants into the overlying water. The method does result in production of plant fragments, and is not recommended for use in waterbodies with new or sparse EWM infestations or where release of fragments is a concern. Bottom tillage is not a feasible option for Beaver Dam Lake because this method results in the production of plant fragments that would result in the spread of EWM.

Diver dredging utilizes a small barge or boat carrying portable dredges with suction heads that are operated by scuba divers to remove individual rooted plants (including roots) from the sediment. Divers physically dislodge plants with sharp tools. The plant/sediment slurry is then suctioned up and carried back to the barge through hoses operated by the diver. On the barge, plant parts are sieved out and retained for later off-site disposal. The water sediment slurry can be discharged back to the water or piped off-site for upland disposal. Diver dredging can be highly effective under appropriate conditions (Gibbons 1994). Efficiency of removal is dependent on sediment conditions, density of aquatic plants and underwater visibility (Cooke et al. 1993). As it is best used for localized infestations of low plant density where fragmentation must be minimized, the technique has great potential for EWM control. Depending on local conditions, EWM removal efficiencies of 85-97 percent can be achieved by diver dredging (Maxnuk 1979). Diver dredging is not feasible for Beaver Dam Lake because the area of EWM infestation is too large.

6.5.3 Chemical

Chemical aquatic vegetation management programs are widespread, being the preferred method of control in many areas. Chemical control involves the use of a herbicide (i.e., a plant-killing chemical) that is applied in liquid, granular, or pellet form. Herbicides are of two types, systemic herbicides and contact herbicides. Systemic herbicides, such as 2, 4-D, fluoridone, and glyphosate, are absorbed by and translocated throughout the plant, capable of killing the entire plant (roots and shoots). In contrast, contact herbicides, such as diquat and endothal, kill the plant surface with which it comes in contact, leaving roots alive and capable of regrowth. The aquatic plants (sometimes only stems and leaves) die and decompose in the lake. To reduce human exposure to the chemicals, temporary water-use restrictions are imposed in treatment areas whenever herbicides are used. Only herbicides for aquatic use are allowed, and any use of a herbicide requires a WDNR permit. Use of the herbicides Diquat (Reward), endothal (Aquathol K), 2,4-D, and glyphosate are feasible for Beaver Dam Lake.

6.5.4 Biological

Biological control involves the use of a biological control agent to control aquatic plant growth. Biological controls include predation by herbivorous fish, mammals, waterfowl, insects and other invertebrates, diseases caused by microorganisms and competition from other aquatic plants (Little, 1968). The most widely used biological control agent is herbivorous fish, particularly grass carp. Use of grass carp as a biological control agent is not allowed in Wisconsin. Weevils have been used experimentally to control EWM (Creed, et al., 1995; Newman, et al., 1995; Newman 1999). Because weevils were introduced into Beaver Dam Lake previously and currently appear to be absent from Beaver Dam Lake, introduction of weevils to the lake is not a feasible aquatic plant management alternative.

Mechanical, physical, and chemical aquatic plant control techniques and estimated costs are summarized in Table 5. The costs are somewhat dated (i.e., based upon 1997 dollars), but provide a relative cost comparison between the various techniques.

Table 13 Control Techniques for Aquatic Plants: Procedure, Cost, Advantages and Disadvantages (Modified from a Summary Prepared by the Vermont DNR in 1997)

Control Technique	Procedure	Cost	Advantages	Disadvantages
Mechanical and Physical Removal			+Immediate plant removal and creation of open water +No interference with water supplies or water-use	-- Creates plant fragments – Usually disturbs sediments, affecting biota and causing short-term turbidity – Plant disposal necessary
Harvesting	Plant stems and leaves cut up to 8 ft below water surface, collected and removed from lake	Cut from 1 to 2 ac/day @ $1,200/day New machine: $80,000-100,000+	+Relatively low operational cost	– Can get regrowth within 4 weeks – Removes small fish, turtles, etc. – Plant fragments may cause spread of Eurasian watermilfoil
Hydro-raking	Mechanical rake removes plants up to 14 ft below water surface and deposits them on shore	Rake up to 1 ac/day @ $1,500–$2,000/ac	+Longer lasting control than harvesting because of root removal	– Regrowth by end of growing season
Rotovating	Sediment is "tilled" to a depth of 4"-6" to dislodge plant roots and stems Can work in depths up to 17 ft	Can do up to 2-3 ac/day @$700–$1,200/ac Cost of new machine is $100,000+	+Immediate 85% – 95% decrease in stem density +Up to 2 years control +Frequently done in fall when plant fragments not viable	
Hydraulic Dredging	Steel cutter blade dislodges sediment and plants; removed by a suction pump	$2,500/ac and up Cost of new machine is $100,000+	+90% effective at root removal, with plant regrowth probable within 1 year	– Expensive

Table 13 Control Techniques for Aquatic Plants: Procedure Cost, Advantages, Disadvantages
(Modified from a Summary Prepared by the Vermont DNR in 1997) (Continued)

Control Technique	Procedure	Cost	Advantages	Disadvantages
Diver-operated Suction Harvesting	Scuba divers use 4" suction hose to selectively remove plants from lake bottom Plants disposed of on shore	Cost is $800–$10,000/ac depending on cost of divers, type of sediments, travel time, etc. Cost of new machine $20,000+	+Up to 97% effective at removing plant roots and stems +1–2 years of control +Can work in areas with underwater obstruction	– Effectiveness varies greatly with type of sediment – Slow and labor intensive – Expensive – Potentially hazardous because of scuba
Handpulling	Plants and roots are removed by hand using snorkeling and wading Plants disposed of on shore	Variable, depending on volunteers; divers cost $15-$60/hr	+Most effective on newly established populations of EWM that are scattered in density +Volunteers can keep cost down +Long term control if roots removed	– Too slow and labor intensive to use on large scale – Short-term turbidity makes it difficult to see remaining plants
Chemical Treatment			+ Doesn't interfere with underwater obstructions	– Affects water-use; can be toxic to biota – Plants remain in lake and decompose, which can cause oxygen depletion late in the season
2,4-D (Aquakleen, Aquacide, Navigate)	Systemic herbicide available in liquid and pellet form that kills plants by interfering with cell growth and division Can be applied at surface or subsurface in early spring as soon as plants start to grow, or later in the season	$350–$700/ac depending on plant density and water depth; cost does not include collection or analysis of water samples, which may be required	+Under favorable conditions can see up to 100% decrease +Kills roots and root crowns +Fairly selective for EWM	– Plants decompose over 2-3 weeks

Table 13 Control Techniques for Aquatic Plants: Procedure Cost, Advantages, Disadvantages (Modified from a Summary Prepared by the Vermont DNR in 1997) (Continued)

Control Technique	Procedure	Cost	Advantages	Disadvantages
Tripclopyr (Garlon 3A)	Liquid systemic herbicide that kills plants by interfering with hormones that regulate normal plant growth	$75/gal or $1200-$1700/ac, depending on water depth, concentration of chemical, etc.	+Effectively removes up to 99% of EWM biomass 4 weeks after treatment +Fast-acting herbicide +Kills roots and root crowns +Fairly selective for EWM	– No domestic-use of water within 1 mile of treated area for 21 days after treatment – No fishing in treated area for 30 days after treatment – Expensive
Fluridone (Sonar)	Systemic herbicide available in liquid and pellet form that inhibits a susceptible plant's ability to make food Can be applied to surface or subsurface in early spring as soon as plants start to grow	$500-$1500/ac depending on water depth and formulation	+Can be applied near water intakes if concentration is less than 20 ppb +Under favorable conditions susceptible species may decrease 100% after 6-10 weeks +Control lasts 1-2 years depending supplemental hand removal +Because slow-acting, low oxygen generally not a problem	– Long contact time required; may take up to 3 months to work – Potential risk to human health remains controversial – Not selective for milfoil – Spot treatments generally not effective
Endothal (Aquathol and Aquathol K)	Granular (Aquathol) and liquid (Aquathol K) kills plants on contact by interfering with protein synthesis Can be applied to surface or subsurface when water temperature is at least 65°F	$300-$700/ac depending on treatment area and use of adjuvants	+Under favorable conditions can see up to 100% decrease +Fast-acting herbicide	– Regrowth within 30 days – Not selective for milfoil – Does not kill roots; only leaves and stems that it contacts – No swimming for 24 h, no fishing for 3 days

Table 13 Control Techniques for Aquatic Plants: Procedure Cost, Advantages, Disadvantages (Modified from a Summary Prepared by the Vermont DNR in 1997) (Continued)

Control Technique	Procedure	Cost	Advantages	Disadvantages
Diquat (Reward)	Liquid kills plants on contact by interfering with photosynthesis Can be applied to surface or subsurface when water temperature is at least 65°F	\$200-\$500/ac	+Fast-acting herbicide +Relatively cheap per acre	– Retreatment within same season may be necessary – Not selective for milfoil – Does not kill roots; only leaves and stems that it contacts – No swimming for 24 h, no drinking for 14 days – Toxic to wildlife

6.6 Beaver Dam Lake Aquatic Plant Management Plan

The Beaver Dam Lake Aquatic Plant Management (APM) Plan outlines management practices required to attain and sustain the lake's beneficial uses. The APM Plan is divided into 2 sections:

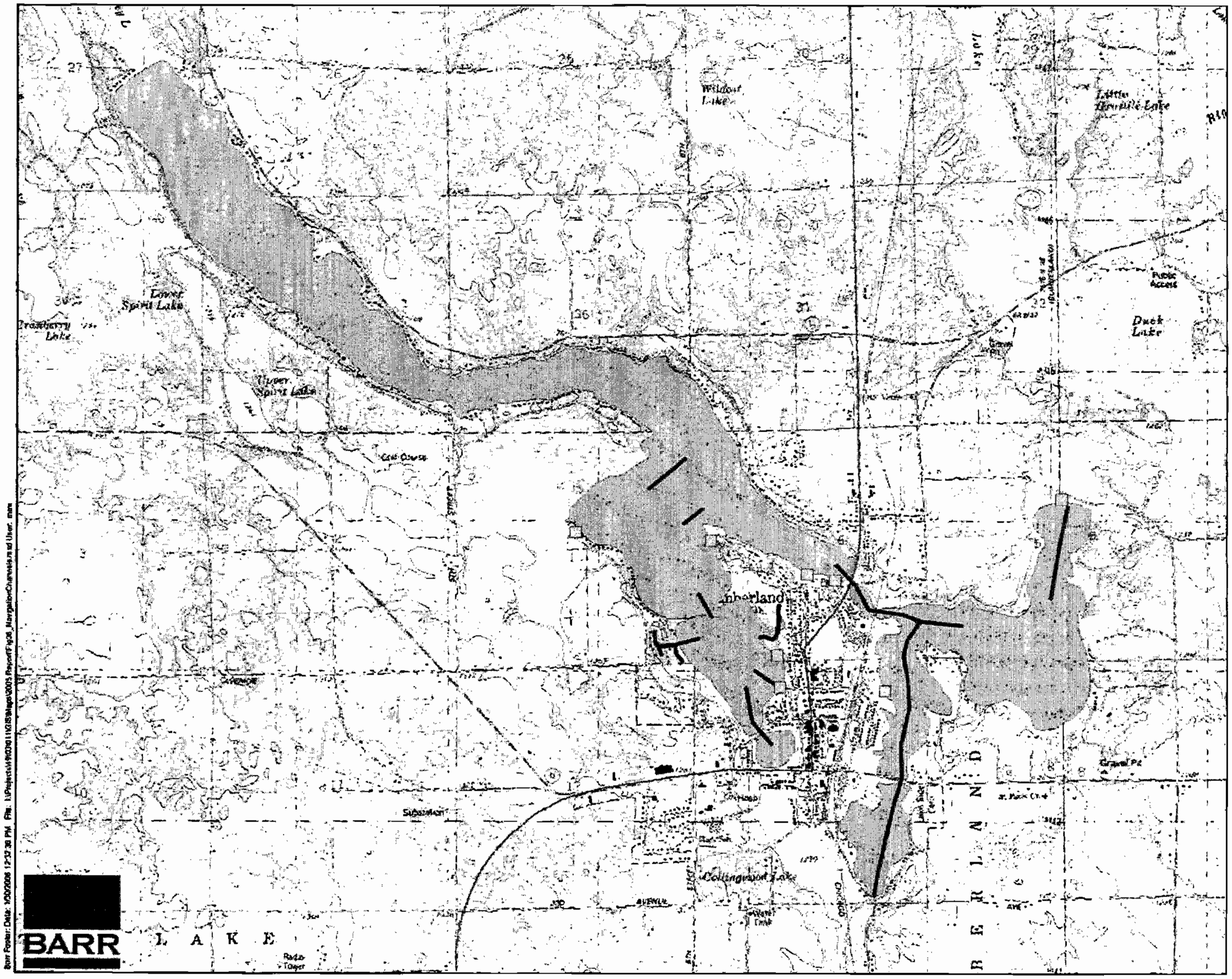
- Annual Maintenance Program
- Long-Term Improvement Program

6.6.1 Annual Maintenance Program

The annual maintenance program will sustain the lake's beneficial uses by treatment of swimming beaches, boat landings, and navigation channels each year. The program is a nuisance relief program and long-term change is not an expected result of this program. The program uses treatment methodologies used in previous years. Treatment areas are expected to be the same or similar to areas treated in previous years. Program details follow.

1) Boat landings, swimming beaches, the area around the fishing pier, and navigation channels (See Figures 34, 35, and 38) will be inspected each June to identify areas in need of herbicide treatment. The Beaver Dam Lake Management District and/or its appointed representative will work with WDNR staff to attain a treatment permit for warranted treatment areas.
2) Areas in need of treatment will be treated in June with diquat (Reward) or endothal (Aquathol K). Endothal will be used to treat areas predominantly comprised of pondweed and Diquat will be used to treat areas not predominantly comprised of pondweed.
3) Boat landings, swimming beaches, the area around the fishing pier, and navigation channels will be inspected each July to determine late summer treatment needs.
4) Areas in need of treatment will be harvested during August. Harvested plant materials will be disposed of at a city owned disposal site located near the lake.

Based upon treatment records during 2000 through 2005, an annual treatment area of approximately 10 to 18 acres is estimated.



Legend

Boat Landing

Navigation Channel

Miles

0.5 0 0.5

Feet

1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 38

NAVIGATION CHANNELS AND
BOAT LANDING TREATMENT AREAS
2005 Aquatic Plant Management Plan
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6.6.2 Long-Term Improvement Program

While the annual maintenance program is not expected to result in long-term change, the goal of the long-term improvement program is long-term change. The long-term improvement program is comprised of projects to reduce problematic plant density to attain favorable long-term changes. The long-term improvement program is comprised of:

- AIS Management
- Pondweed and Water Lily Harvesting
- Water Lily Management

6.6.2.1 AIS Management

AIS management will, at a minimum, prevent increased coverage and density of AIS in the lake, and at a maximum, greatly reduce current levels of coverage and density. EWM and CLP are the species targeted by the AIS management program. The AIS management area encompasses an area of approximately 211 acres. Within this area is found approximately 89 acres of EWM and 24 acres of CLP, with some overlap between the 2 species. Treatment of a buffer surrounding the AIS infested areas is proposed in addition to treatment of the AIS infested area to insure treatment effectiveness. Beaver Dam Lake is large (1,169 acres) and the AIS in the lake are generally located in small patches scattered throughout the lake. If treatment is strictly restricted to the area containing the AIS plants, mixing of the herbicide with lake waters may dilute the herbicide before sufficient contact between the herbicide and plants have occurred to effectively treat the targeted plants. Selecting treatment areas that include a buffer addresses the mixing concern and approximately doubles the treatment area.

The treatment of AIS within Beaver Dam Lake is complex and requires a complex treatment plan. The following treatment plan includes the employment of 4 types of treatment during 2006. The four types of treatment are expected to be used again in 2007 and a fifth type of treatment will be added during 2007. The treatment plan for subsequent years is expected to be similar to the treatment plan for 2006 and 2007. However, the treatment area is expected to diminish, due to treatment success. Annual plant surveys and lake inspections will determine treatment areas and treatment details for subsequent years. Details of the five types of treatment that comprise the Beaver Dam Lake AIS treatment plan follow.

Type 1—The Type 1 treatment area is a 41 acre area infested with EWM and located in the rice beds area of Williams Bay, midway between two basins that are 80 and 90 feet deep, respectively (See Figure 39). Herbicide applied to this area is vulnerable to mixing and dilution because of the large volume of water near the treatment area. Because EWM treatment effectiveness is dependant upon contact time, a treatment strategy was devised to maximize herbicide contact time at this site. The treatment strategy includes the use of 2,4-D, the use of the maximum allowable dose (200 pounds per acre), and the splitting of this dose into 2 separate applications timed several hours apart. The split treatment will increase contact time between the herbicide and the EWM plants and the maximum dose will maximize plant contact and mitigate dilution. An initial application at a dose of 100 pounds per acre will be made to the Type 1 treatment area. Then, several hours later a second application at a dose of 100 pounds per acre will be made. Treatment will occur in the early season/summer time frame, most likely occurring in early spring (late April to late May).

Native vegetation is not expected to be harmed by the herbicide treatment because 2,4-D is fairly selective for EWM. To further safeguard native vegetation, the herbicide will be applied during spring when the native species are still seasonally suppressed. 2,4-D is a biodegradable compound whose residues are not persistent in water. It has a relatively short half life, averaging 10 days in water. Both UV light and microorganisms living in the water and sediments convert the herbicide to carbon dioxide, water, and chlorine. Because 2,4-D will be applied during spring, it is expected to biodegrade before native vegetation begins its seasonal growth.

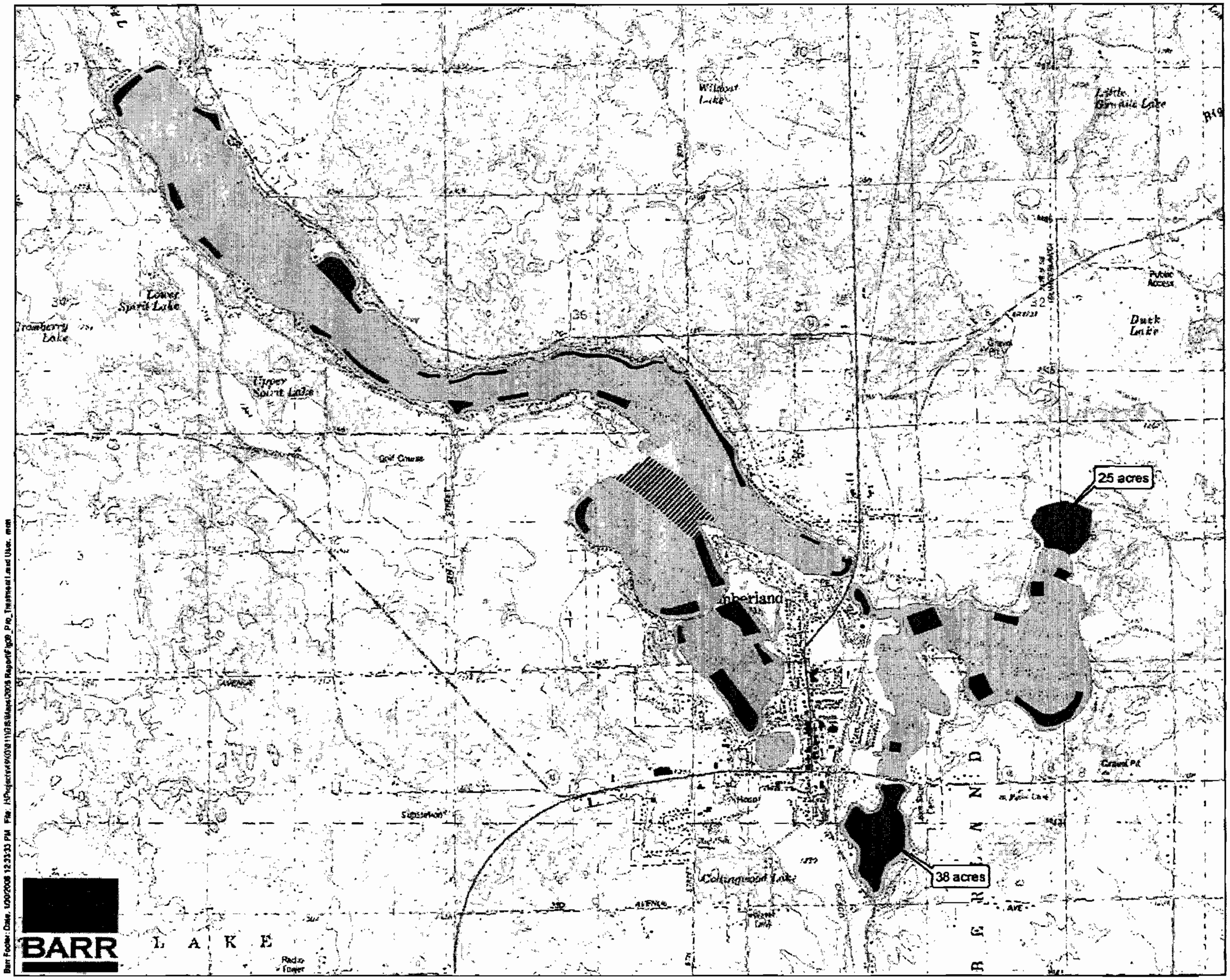

Figure 39

A.I.S. TREATMENT AREAS
2005 Aquatic Plant Management Plan
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Type 2—The Type 2 treatment area is a 97 acre area infested with both EWM and CLP (See Figure 39). The area includes 2 areas in East Beaver Dam Lake, a 25 acre area located in the northeast arm of Norwegian Bay and a 38 acre area located within Cemetery Bay. Also included are several areas within West Beaver Dam Lake (i.e., within Williams Bay and Rabbit Island Bay) totaling 34 acres in area. Type 2 areas are popular recreation sites within Beaver Dam Lake. Sites in the East Lake are primarily used by fishermen while sites in the West Lake are used by both fishermen and boaters. During 2005, EWM appeared to be returning to sites within Norwegian Bay and Cemetery Bay that had been successfully treated in previous years. Aggressive treatment of the bays is recommended to attain the District goals of preventing increased EWM coverage and, if possible, reduce current EWM coverage. West Beaver Dam Lake Type 2 sites have been treated approximately annually for several years with 2,4-D. A treatment using a combination of low rates of 2 herbicides, each individually effectively in the treatment of EWM at higher application rates, has been selected to more aggressively and more effectively treat these areas. The sites will be treated with 0.5 mg/L acid equivalent of 2,4-D granular or liquid along with 1 ppm of endothall applied as Aquathol K. John Skogerboe, a research scientist with the U.S. Army Engineer Research and Development Center (ERDC), has used this combination of herbicides to effectively treat EWM and to treat CLP and EWM when they occur together. Treatment of Type 2 areas will occur in early spring, during late April or early May when water temperatures reach 12 to 15 °C.

Type 3—The Type 3 treatment area is comprised of 25 individual treatment areas, 17 areas in West Beaver Dam Lake and 8 areas in East Beaver Dam Lake, totaling 74 acres in area (See Figure 39). Each of these areas is small and, consequently, each area is vulnerable to mixing and dilution effects during treatment. Hence, the maximum allowable dose of 2,4-D, 200 pounds per acre, will be used to treat these areas to maximize effectiveness and to mitigate dilution and mixing effects. Treatment will occur in the early season/summer time frame, most likely occurring in spring (late April to late May) and possibly occurring in June).

Type 4—The type 4 treatment area is comprised of two areas, one located in Williams Bay (i.e., in the Rice Beds area) and one located in Rabbit Island Bay (See Figure 39). The areas total 43 acres. Treatment will use 2,4-D at the maximum allowable dose and a split treatment to maximize contact time. A late season treatment will occur in these areas in addition to an early season/summer treatment of either Type 1 or Type 2. The late season treatment is intended to reduce the infestation in this area in the subsequent year. Type 4 treatment results will be compared with Type 1, Type 2, and Type 3 treatment results to determine the effectiveness of an additional late season treatment.

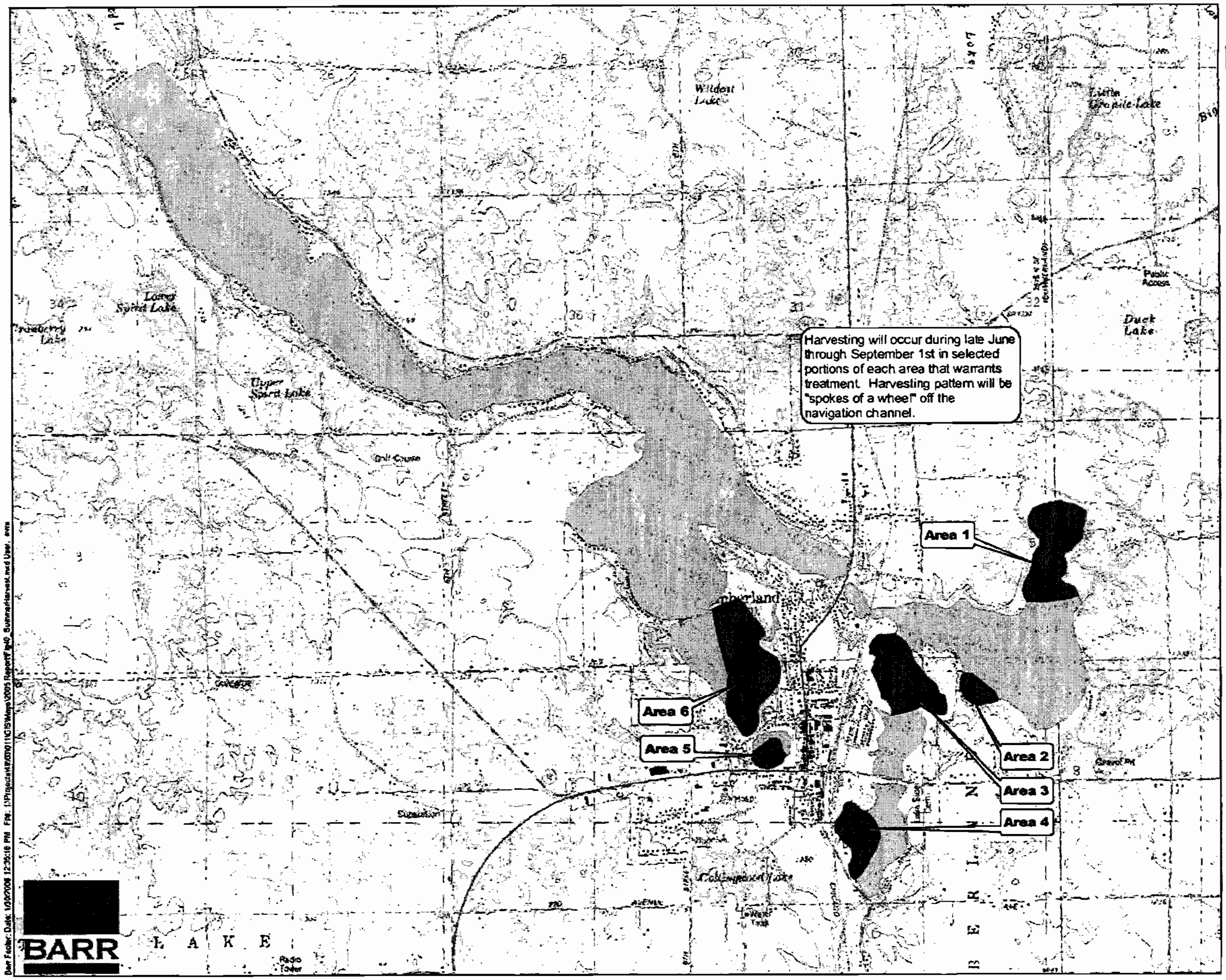
Type 5—The type 5 treatment area will be selected in 2006 and will be treated in 2007. The type 5 treatment is the use of lime slurry to treat EWM and CLP. Lime slurry is an experimental tool that is currently the focus of a research project by Bill James, ERDC. It is anticipated that the use of lime slurry in Beaver Dam Lake will occur as a part of a larger ERDC research project and that the treatment sites will be selected by ERDC.

6.6.2.2 Pondweed and Water Lily Harvesting

Annual problematic growths of pondweed and water lilies within portions of Rabbit Island Bay and Library Bay in West Beaver Dam Lake and portions Cemetery Bay and Norwegian Bay in East Beaver Dam Lake prevent navigation within these areas during the late summer period. Late summer vegetation growths in these areas also prevent these areas from being accessible by fishermen during the subsequent spring fishing opener. Problematic growths of pondweed and water lilies in Rabbit Island Bay, Library Bay, Norwegian Bay, and Cemetery Bay will be managed by a late summer harvesting program.

Harvesting will occur in selected portions of the problematic areas (See Figure 40) to create navigation channels for boat passage, areas for fishing use, and concurrently create fish cruising lanes to support the lake's fishery. During June, areas 1 through 5 on Figure 40 will be inspected to determine treatment needs. Following the inspection, the Beaver Dam Lake Management District will determine specific areas to be harvested. Harvesting will occur in a maximum of 60 acres each year. Beaver Dam Lake and/or an appointed representative will work with WDNR to obtain a harvesting permit. Harvesting will occur during late June through September 1.

The harvesting pattern used in the selected areas will be a "spokes on a wheel" pattern. The wheel spokes will be harvested near navigation channels. The spokes on a wheel pattern will support the lake's beneficial uses by creating open areas for boat passage, open areas for fishermen to use for fishing, and fish cruising lanes to support forage efforts by predator fish (e.g., smallmouth bass) (Marshall 1990). Harvesting will also increase the lake's invertebrate population. Studies have shown that larger quantities of invertebrates live at the edge of dense macrophyte beds than in the middle. Cutting channels through plant beds will increase the edge area, thus increasing invertebrate numbers. Increased invertebrate numbers results in increased quantities of food for the lake's fish (Pellet 1998).



Legend

Proposed Summer Macrophyte Harvest Area (187 acres)

Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 40

SUMMER HARVESTING AREA
2005 Aquatic Plant Management Plan
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The summer harvesting program is intended to be a long-term improvement program. Regrowth of pondweed and water lilies in harvested areas is expected to be less prolific because of harvesting effects. In addition, removal of harvested plants from the lake removes nutrients from the lake. Removal of nutrients translocated by plants from lake sediments during plant growth is expected to result in a long-term reduction of sediment fertility due to harvesting effects.

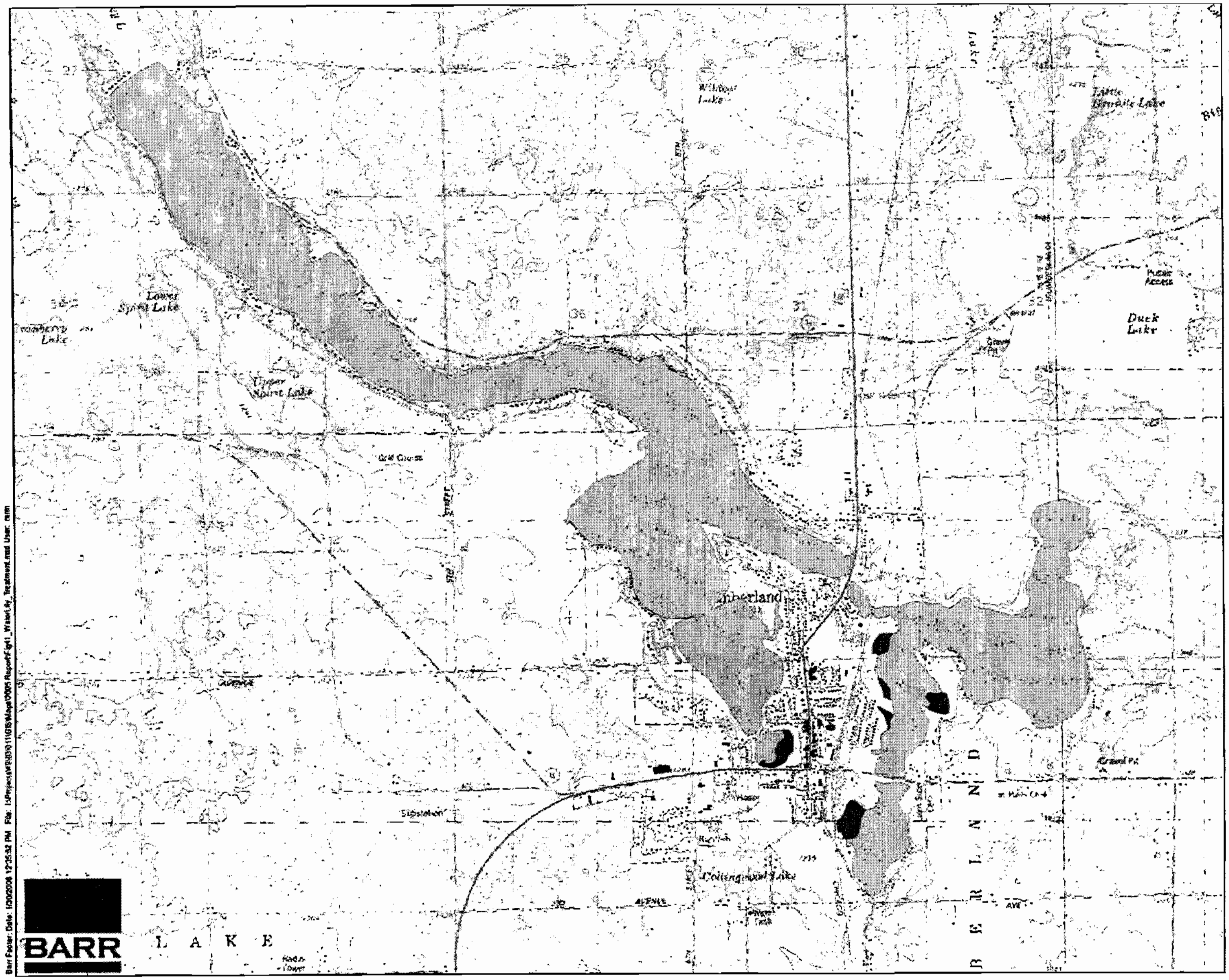
6.6.2.3 Water Lily Management

Problematic growths of water lilies occur annually in Library Bay in West Beaver Dam Lake and portions of Cemetery Bay and Norwegian Bay in East Beaver Dam Lake. Selected areas within problematic water lily growth areas will be treated annually with a glyphosate based herbicide. A solution of 1.25 percent glyphosate based herbicide with a non-ionic surfactant will be applied to the surface of each water lily selected for treatment. The herbicide must be sprayed onto the plant and remain on the plant for at least 4 to 6 hours to be effective. Treatment will occur during the mid-August to mid-September period.

During July, the areas shown on Figure 41 will be inspected to determine warranted treatment areas. A maximum of 10 acres of water lilies will be treated annually. Following the inspection, the Beaver Dam Lake Management District and/or an appointed representative will work with WDNR to attain a treatment permit. It is anticipated that the treatment pattern will resemble a "spokes on a wheel" pattern. This treatment pattern will support the lake's beneficial uses by creating open areas for boat passage, open areas for fishermen to use for fishing, and fish cruising lanes to support forage efforts by predator fish (e.g., smallmouth bass) (Marshall 1990). Treatment will occur during the mid-August to mid-September period. The late summer water lily management program is intended to be a long-term improvement program. Regrowth of water lilies in treated areas is expected to be less prolific because of treatment effects.

6.6.2.4 Bulrush Protection and Restoration

The entrance to Williams Bay, also known as the rice beds area of the lake, historically has noted a substantial growth of bulrushes. Over time, bulrush coverage has diminished. The reduced bulrush coverage is likely due to increased EWM coverage and boat traffic. EWM displaces native vegetation and boat traffic can tear up and destroy bulrushes. In conjunction with the lake's AIS treatment program, the Beaver Dam Lake Management District will implement an education program to protect and, if possible, restore the lake's bulrushes at the entrance to Williams Bay. Boats and pontoons will be encouraged to avoid traveling through the bulrush areas and to stay within suggested navigation channel areas when entering and leaving Williams Bay.



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Proposed Water Lily Treatment Areas (24 acres)

Miles

0.5 0 0.5

Feet

1,000 0 1,000 2,000 3,000 4,000

1:24,000

Figure 41

WATER LILY TREATMENT AREAS
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011

6.6.3 Education Program

The Beaver Dam Lake Management District will continue its efforts to prevent the introduction of additional EWM and additional non-native species to Beaver Dam Lake and prevent the spreading of EWM to other lakes. A sign posted at the public boat landing within the city park currently instruct lake users to inspect their boats and remove vegetation from boats. Following this practice avoids introducing additional EWM or other unwanted species to Beaver Dam Lake and avoids taking EWM from the lake to other lakes. In the future, the District will continue to maintain the sign at the boat launch within the city park (i.e., repair or replace as needed) to insure that lake users are educated as to the importance of cleaning vegetation from boats before entering and leaving the lake.

An education component will be included in the District's newsletter and annual meeting to educate residents as to the dangers posed by non-native species. Residents will be instructed to not introduce plants to Beaver Dam Lake. Studies of plants obtained from mail order distributors indicate that non-native species are routinely present in such orders. Educating lake residents to not introduce plants to Beaver Dam Lake will safeguard the lake from unintentional introductions of non-native plant species by residents desiring to plant attractive water plants near their homes.

6.6.4 Beaver Dam Lake Treatment Effectiveness Monitoring Program

The purpose of the Beaver Dam Lake treatment effectiveness monitoring program is to determine changes in EWM coverage and changes in the lake's native plant community. A post-treatment survey will be completed during June of 2006 to determine presence or absence of EWM and to determine the response of the native plant community to the herbicide treatment and resultant changes in EWM coverage. The same locations surveyed in 2005 will again be surveyed in 2006. The same methodology used in the 2005 survey will again be used in 2006. Because EWM is a perennial, areas with EWM coverage during June of 2006 would be expected to contain EWM during the spring of 2007. Hence, the June 2006 monitoring event will tentatively determine the 2007 treatment area. The 2006 monitoring program, hence, will double as a post-treatment monitoring program for 2006 and a pre-treatment monitoring program for 2007.

EWM completes 2 or 3 growth cycles annually and auto fragments at the conclusion of each growth cycle. Following autofragmentation of each individual EWM plant within the lake, individual plant pieces grow, forming a new plant. This growth pattern results in the spread of EWM throughout each growing season. Although the June survey will provide a tentative treatment area for the subsequent year, additional inspection of the treatment area is required shortly before treatment to finalize the treatment areas.

A report summarizing survey results will be completed. The project report will discuss the effectiveness of the treatment program and present data from the program in both tabular format and data summary maps. The report will describe sample methodology, discuss the post-treatment coverage and density of EWM and CLP, and provide recommendations for the selection of EWM and CLP areas for treatment in the subsequent year, if warranted. A comparison of current and previous aquatic plant survey data will be provided and the effects of the current year's treatment on native plants will be discussed.

6.6.5 Future Monitoring Programs

The 2006 aquatic plant survey will determine the effectiveness of the early spring treatment of EWM. The survey will also indicate where retreatment is needed during 2007. If retreatment occurs in 2007, monitoring to determine treatment effectiveness will occur during June of 2007. Sample results will be compared with data collected in previous year(s) to determine treatment effectiveness. In addition, the data will determine treatment needs and details for the following year.

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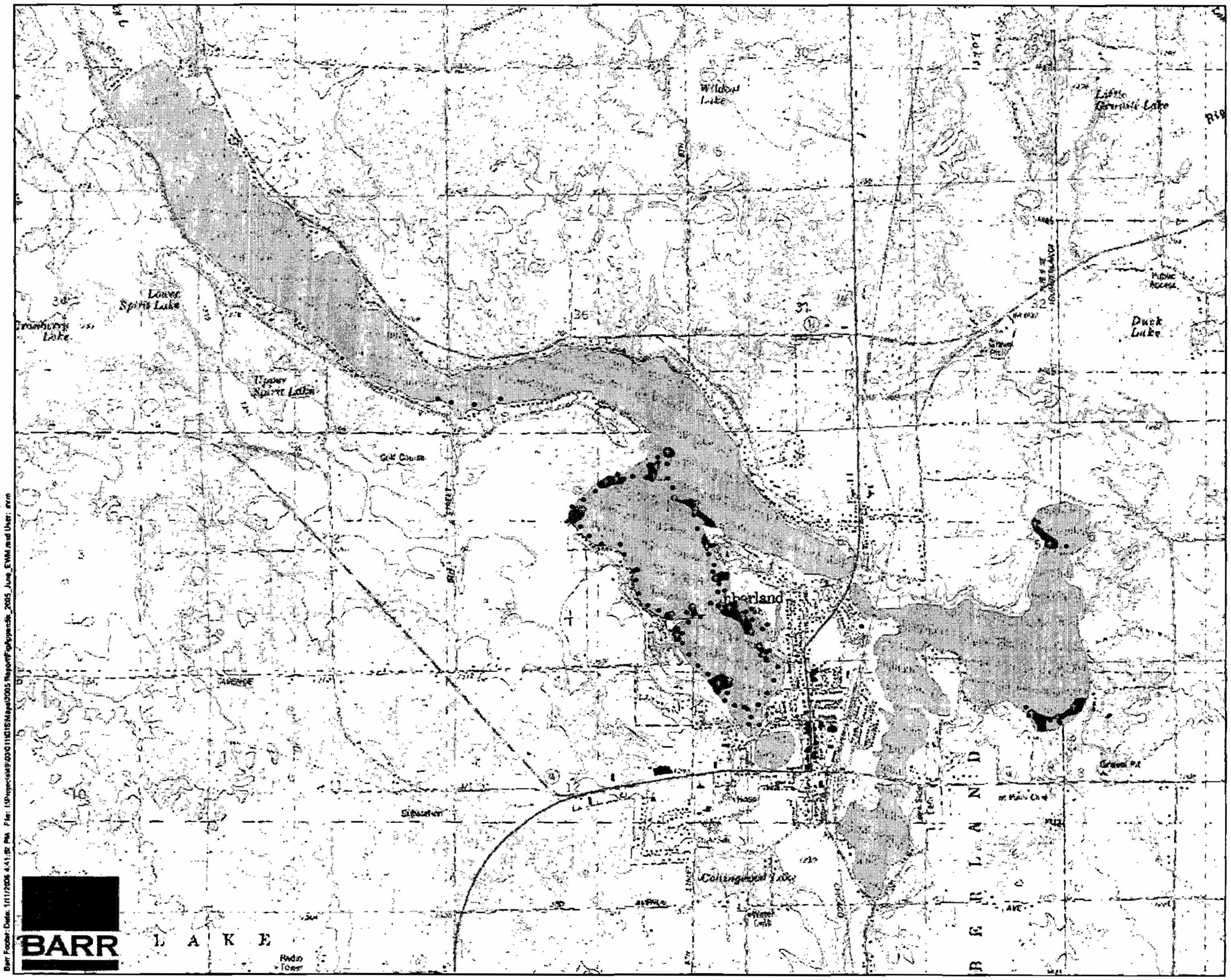
Appendix J
2005 Eurasian Watermilfoil June and July Maps



Legend

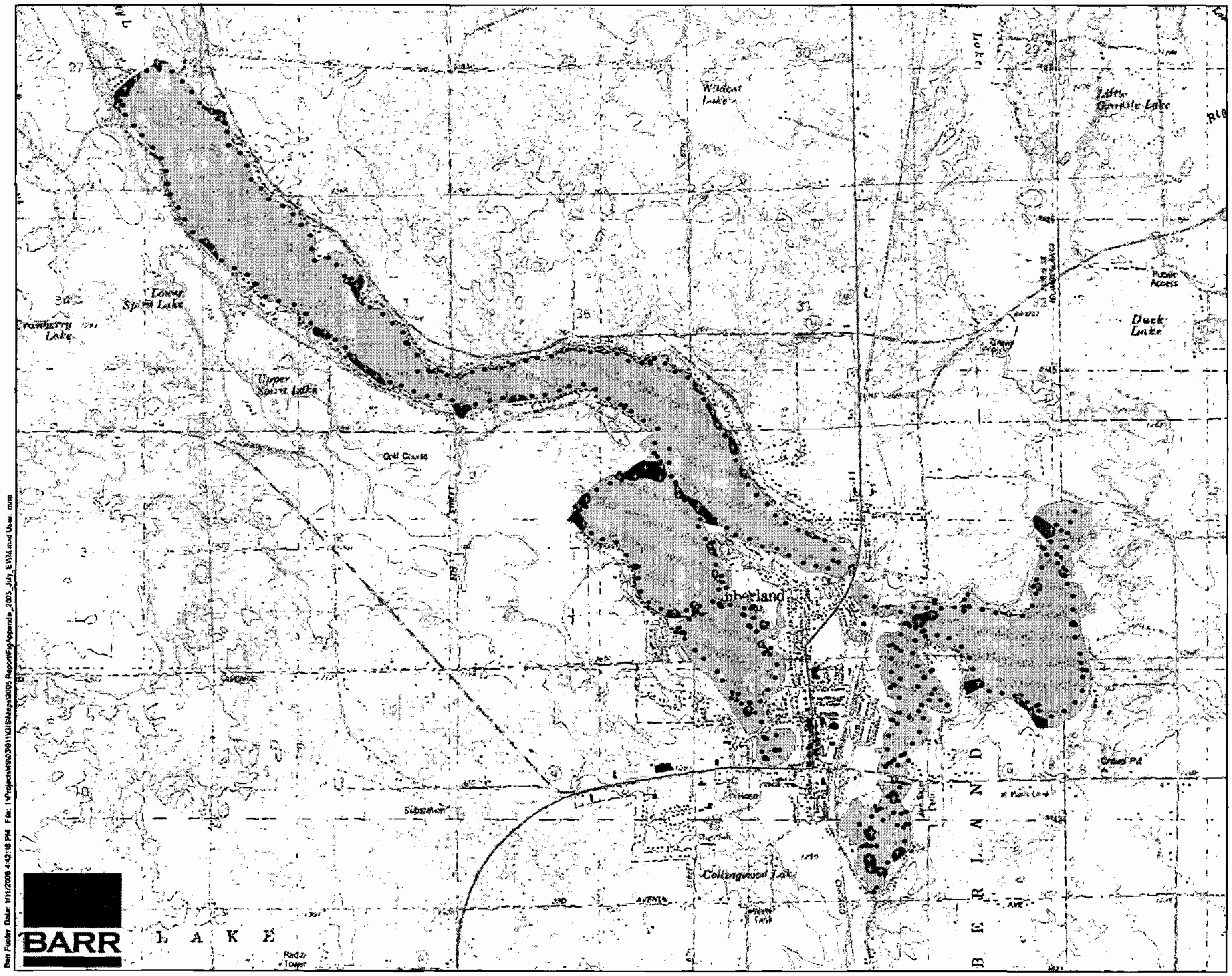
- June 2005 Sample Points w/ EWM
- June 2005 Sample Points w/out EWM
- June 2005 Eurasion Watermilfoil Infestation (Areas Approximate)

Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

JUNE 2005 EURASIAN WATERMILFOIL
2005 Aquatic Plant Management Plan
Beaver Dam Lake
Barron County, WI
Job No. 49-03-011



Legend

- July 2005 Sample Points w/ EWM
- July 2005 Sample Points w/out EWM
- July 2005 Eurasion Watermilfoil Infestation (Areas Approximate)

Miles
0.5 0 0.5

Feet
1,000 0 1,000 2,000 3,000 4,000

1:24,000

JULY 2005 EURASIAN WATERMILFOIL
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