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LITTLE GREEN LAKE
WISCONSIN LAKE MANAGEMENT
PLANNING GRANT PROJECT

November 1, 1994

Prepared For:

Little Green Lake Protection and
Rehabilitation District
Post Office Box 212
Markesan, Wisconsin 53946

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1.0 INTRODUCTION

1.1 Background

Little Green Lake is a eutrophic, drainage/ground-water seepage lake with a single perennial outlet located in Sections 29, 30, 31, and 32, Township 15 North, Range 13 East, in Green Lake County, Wisconsin (Figure 1). The lake has a maximum depth of 25 feet, a mean depth of 10 feet, a surface area of 466 acres, and a shoreline length of 4.2 miles (Figure 2). Its watershed consists of 3.33 square miles. Little Green Lake's shoreline is mostly developed with approximately 150 cottages/houses bordering the lake. Little Green Lake supports a gamefish population of muskellunge, walleye, largemouth bass, smallmouth bass, and panfish. Chemical analyses of surface water samples collected in the 1970's detected nutrient concentrations at levels that indicate poor water quality.

1.2 Workplan

Under the auspices of Wisconsin's Lake Management Planning Grant Program, Northern Environmental was contracted by the Little Green Lake Protection and Rehabilitation District to provide consulting services for a lake management study of Little Green Lake. Northern Environmental prepared a workplan designed to evaluate the current condition of Little Green Lake. To achieve these goals, Northern Environmental presented four tasks.

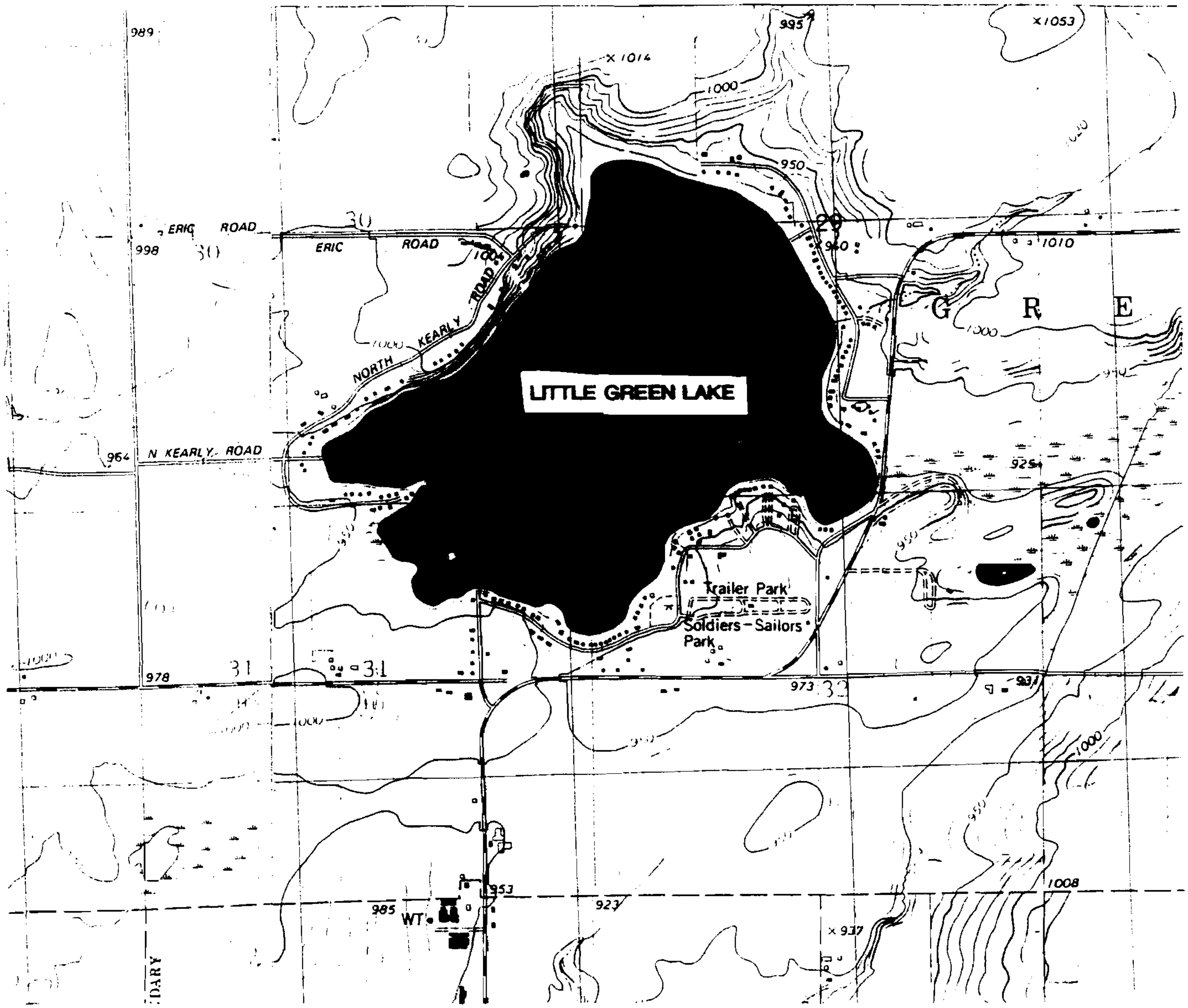
Task 1.0 Identify and enumerate the species of aquatic macrophyte vegetation in Little Green Lake.

Task 2.0 Identify non-point sources of nutrients contributing to the enhanced productivity of Little Green Lake.

Task 3.0 Evaluate the inherent chemical and physical properties of Little Green Lake.

Task 4.0 Prepare final report.

The following sections present the methods and summarize the findings of each task of the study.



SCALE 1:24 000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETRE

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

BASE MAP SOURCE: USGS MANCHESTER AND MARKESAN, WISCONSIN 7.5 MINUTE QUADRANGLE

REV.	PROJECT: LGL140844	DATE: 03/09/94	LITTLE GREEN LAKE MACROPHYTE SURVEY
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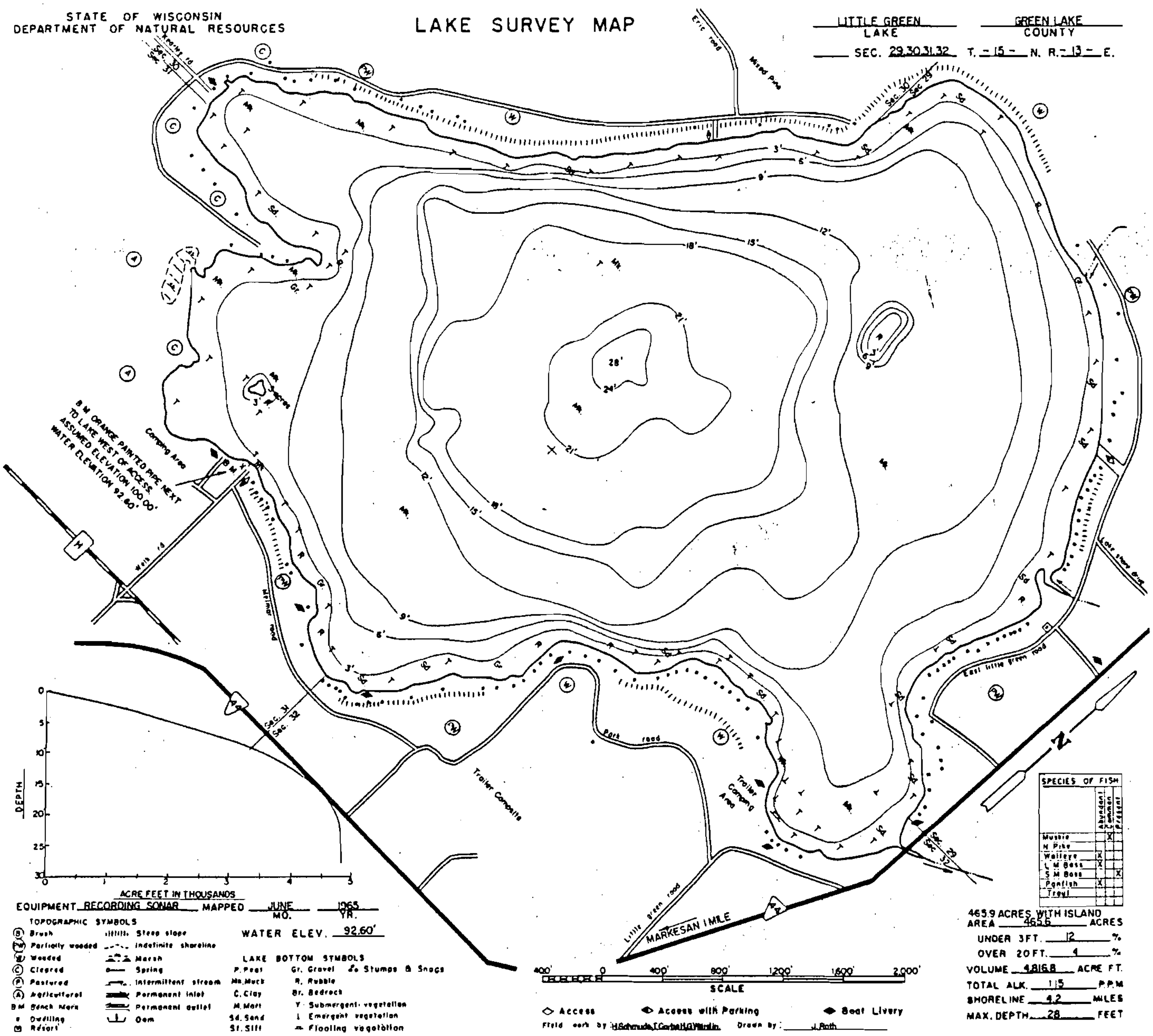
	▲ Northern Environmental *Hydrologists • Engineers • Geologists*		

FIGURE 1



SOURCE: WISCONSIN DEPARTMENT OF NATURAL RESOURCES

REV.	PROJECT: LGL140844	DATE: 03/09/94	LITTLE GREEN LAKE GREEN LAKE COUNTY, WISCONSIN
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Northern Environmental *Hydrologists • Engineers • Geologists*			LAKE SURVEY MAP

FIGURE 2

2.0 MACROPHYTE INVENTORY

Northern Environmental conducted a macrophyte survey on Little Green Lake during the summer of 1993. The purpose of the survey was to:

- Identify macrophyte species present,
- Determine maximum rooting depth,
- Evaluate depth distribution of individual species,
- Calculate transect density of each species, and
- Calculate three estimates of species abundance:

  1) Frequency of occurrence - percentage of sample stations where a species occurred relative to total number of sample stations possible (i.e., percentage of littoral zone covered by a particular species).

  2) Species mean density - a qualitative rating of the relative abundance of a particular species when it occurs.

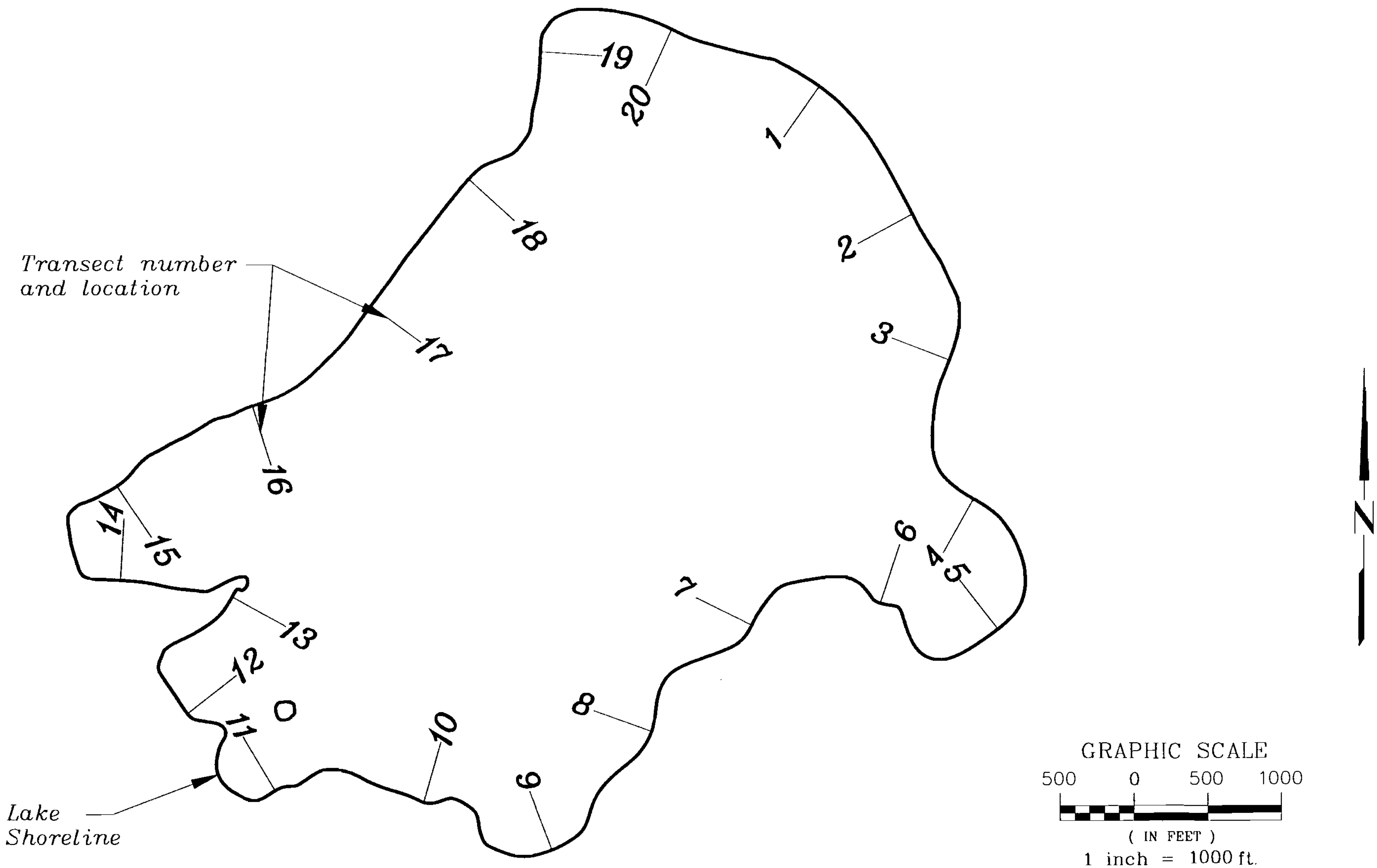
  3) Relative frequency of occurrence - percentage of sample stations where a species occurred relative to the sum of all encounters for all other species.

The following section discusses the methods of the aquatic macrophyte survey.

2.1 Methods

To identify macrophyte species present, a preliminary inventory was conducted on June 18, 1993. This preliminary inventory allowed plants to be expediently classified during the actual survey. A representative specimen was collected and placed on ice in a cooler for transportation. Each specimen species was identified, mounted, and preserved on herbarium paper for future reference. If a species specimen could not be identified, it was referred to by the generic name followed by "sp.". Various dichotomous keys and technical publications were used to classify the specimens (References 1 through 4).

The aquatic macrophyte survey was conducted between July 20, and 22, 1993 in accordance with the methodology of Jensen and Lound's macrophyte evaluation technique (Reference 5). A base map was developed with twenty transects distributed evenly around the perimeter of Little Green Lake (Figure 3). Transects extended perpendicular to the shoreline and were spaced at a distance calculated by dividing the total shoreline length by the number of established transects. Length of each transect was determined to be the distance from the shoreline to the center of the lake, or the distance to the maximum depth the particular transect would reach based upon an electronic depth finder.



DRAWN BY: CDP	PROJECT: LGL 140844	DATE: 9 MAR 1994	Little Green Lake Green Lake County, Wisconsin
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	Northern Environmental *Hydrologist · Engineers · Geologists*		FIGURE: 3

Latitude and longitude coordinates at the intersection of the shoreline and the termination of the transect were measured with a Magellan global positioning system. A compass was used to determine transect bearings. Transects proceeded in the direction of the established bearing.

Along each transect, a 10 foot diameter circle (station point) was randomly selected in each of the corresponding depth ranges:

Depth Code	Actual Depth Range (ft)		
1	0.0	-	1.75
2	1.76	-	5.00
3	5.1	-	10.00
4	10.1	-	20.00
5		>	20.10

The circle was subdivided into four quadrants (Reference 7). A density rating was determined for each quadrant by eye or with a modified rake. In areas where the bottom could be clearly observed (i.e., in water less than 1.75 feet deep), visual means were used. A dragging test was necessary to correlate visual and rake density ratings. The test was preformed in shallow water to determine how much plant matter would be collected by the teeth of the rake. A rake with an extended handle was used in depths too great for visual observations (i.e., >1.75 feet). The rake was thrown into each quadrant, allowed to settle, and was slowly retrieved. A density rating, based on the following criteria, and observations regarding substrate type were recorded along with the depth in feet.

RAKE RECOVERY OF SPECIES

Recovery	Species Density Rating
Rake teeth full in all four quadrants	5
Rake teeth partially full	
▪ in four quadrants	4
▪ in three quadrants	3
▪ in two quadrants	2
▪ in one quadrant	1

Copies of aquatic macrophyte survey data sheets are presented in Appendix A.

3.0 WATERSHED INVENTORY

The Green Lake Department of Land Conservation (GLDLC) conducted a watershed inventory for Little Green Lake during the fall of 1993. Locations of non-point sources of pollutants, estimates of sediment and nutrient delivery rates (based upon current and alternative land uses), and additional information are summarized in the following section. A copy of the GLDLC report is included in Appendix B.

A large amount of the cropland in the Little Green Lake Watershed is farmed intensively with row crops such as field corn, soybeans, wheat and farmed very intensively with crops such as peas and sweet corn. A relatively small percentage of the cropland is in soil saving rotations that include alfalfa hay. The reason for this is due to less need for hay forage which is consumed by ruminants and increased forage yields on the acres that are being grown with hay.

Modern day technology now allows farmers to farm intensively and yet conserve soil on their farmland. Conservation tillage is the method by which farmers leave the prior year crop residue on the soil surface versus the old method of soil inversion which buried the residue. A farmer who leaves a 30% residue cover can reduce his soil loss by 50%. Little Green Lake has a moderate amount of conservation tillage being applied although further efforts will be needed to be taken by the area farmers if the goals which have been established are to be met.

Residue management and hayland planting are two conservation practices that will help in reducing soil detachment. The main concern in the Little Green Lake Watershed is sediment and phosphorus entering the lake. A water quality practice that can have the greatest impact in reducing sediment delivery is water and sediment control basins.

Water and Sediment Control Basins, often called WASCOB's, are a proven conservation practice which consists of an earthen embankment which stores runoff water and then stores or slowly releases the water back along its normal course. The Land Conservation Department has had great success in already dealing with a barnyard runoff problem as well as sediment delivery to Little Green Lake. There are several more sites in the Little Green Lake Watershed that would facilitate the construction of water and sediment control basins and could contain a large percentage of the sediment and phosphorus.

The Little Green Lake Protection and Rehabilitation District has cost-shared the installation of conservation practices in the watershed for the past several years. The Land Conservation Department likewise has been able to secure cost-share dollars through the Department of Agriculture, Trade and Consumer Protection (DATCP) grant programs along with smaller amounts from a federal cost-share program (ACP). Should the Little Green Lake County Land Conservation Department prove successful in obtaining cost-share dollars through state water quality programs (ie.,Non-point Source Program DATCP, etc.), the goals on non-point source reduction will be met in a timely fashion.

The Little Green Lake Watershed is a success story waiting to happen from the standpoint of non-point pollutant reduction. The Land Conservation Department has a good working relationship with all the watershed landowners and have successfully installed conservation practices already on some of the major pollutant loading sites. It is hoped that this report will enable that story to happen so that this very important resource can be protected from further degradation.

4.0 WATER QUALITY SAMPLING AND ANALYSIS

The United States Geological Survey (USGS) is currently conducting a water quality analysis of Little Green Lake. The ongoing project began in 1991, and is scheduled to run through 1996. Based on data collected between 1991 and 1993, the USGS has stated:

- "The water quality of Little Green Lake is very poor and the lake can be classified as a very eutrophic lake or one with many nutrients,"

- "Algal growth appears to be dependent upon the amount of available phosphorous most of the time, but at times also limited by nitrogen,"

- "During summer stratification, oxygen disappears from the bottom portion of the lake which is then unable to support a fish population," and

- "During the summer anoxic period, there are large amounts of phosphorous being released."

The USGS has collected various physical, morphological, and chemical data on Little Green Lake. Data gathered during 1991 and 1992 was interpreted and summarized in two USGS progress reports (Reference 6). Copies of the progress reports are included in Appendix C. Summaries of findings for selected parameters published in the USGS provisional report are provided below.

Lake Stage Fluctuations

Lake stages fluctuated 0.75 feet, from 5.51 feet to 6.26 feet in 1991. In 1992, lake stages fluctuated 0.97 feet, from 5.22 feet to 6.19 feet.

Lake Depth Profiles

Profiles of water temperature, dissolved oxygen, pH, and specific conductance were conducted at the deepest point of the lake. No abnormalities in the data are apparent. Complete water-column mixing was observed in April 1991, April 1992, and June 1993.

The lake thermally stratifies during the summer. The bottom 7 to 10 feet become anoxic (devoid of oxygen) and are unable to support fish at that time. The pH is within acceptable limits to support aquatic life. Little Green Lake is not susceptible to the effects of acid rain because of the high buffering capacity of the lake.

Total Phosphorus

Total phosphorous concentrations near surface ranged from 0.041 micrograms per liter (μg/l) in April 1991, to 1.29 μg/l in July 1991; from 0.065 μg/l in June 1992, to 1.54 μg/l in August 1992; and from 0.029 μg/l in May 1993, to 0.178 μg/l in August 1993.

Concentrations of total phosphorus at depth ranged from 0.096 milligrams per liter(mg/l) in April 1991, to 1.29 mg/l in July 1991; from 0.070 mg/l in April 1992, to 0.440 mg/l in August 1992; and from 0.080 mg/l in June 1993, to 1.4 mg/l in July 1993. These concentrations indicate that large amounts of phosphorus are released from sediments during anoxic periods. Current total phosphorus concentrations indicate Little Green Lake is "highly" eutrophic.

Chlorophyll *a*

Chlorophyll *a* concentrations, which indicate algal biomass, ranged from 14 μg/l in April 1991, to 134 μg/l in June 1991, from 15 μg/l in June 1992, to 140 μg/l in August 1992; and from 1.5 μg/l in May 1993, to 130 μg/l in August 1993. These chlorophyll *a* concentrations indicate Little Green Lake is "highly" eutrophic.

Secchi Disc

Secchi disc measurements, which indicate water clarity, ranged from 1.0 foot in August 1991, to 3.3 feet in April 1991; from 1.3 feet in August 1992, to 5.2 feet in June 1992; and from 0.4 feet in August 1993, to 5.8 feet in May 1993. These measurements are indicative of a eutrophic lake.

Trophic State Index

A common and widely accepted index used for evaluating the nutrient condition of Wisconsin's Lakes is Carlson's Trophic State Index (TSI) (Reference 7). The TSI is derived from three water quality parameters: secchi disk measurements, total phosphorous, and chlorophyll *a* concentrations. Based upon the TSI, data collected from Little Green Lake thus far, indicates the lake is eutrophic (Table 1).

Data collected from 1991 to 1993 and progress reports completed by the USGS are included in Appendix C. Upon completion of the project, a final report will be prepared by the USGS.

Table 1 Trophic classification of Wisconsin Lakes based upon chlorophyll a, water clarity measurements, and total phosphorous values (adapted from Lillie and Mason, 1983) (Reference 9).

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

5.0 FINDINGS

Information gathered from the survey suggests that Little Green Lake has moderate species diversity and a high amount of biomass. Eleven genera including fourteen species of vascular plants and one species of macroalgae (filamentous) were identified during the macrophyte survey. Potamogeton spp. (pondweeds) were the most diverse genus with three species present. Aquatic Macrophyte species identified in Little Green Lake are summarized in Table 2. Plant species were considered "abundant" if they had a frequency of occurrence of >30 percent, very common if they occurred in 11-30 percent of the stations, common if they occurred between 1-10 percent, and rare if they occurred in <1 percent of the stations (Reference 10) (Table 3). The single most "abundant" species was Ceratophyllum demersum, with a frequency of occurrence of 53 percent (percent of sample stations containing that species) and a relative frequency of 24 percent (the frequency of occurrence compared to the occurrence of all species). Potamogeton crispus was the second most abundant species with a frequency of occurrence of 49 percent and a relative frequency of 21 percent. Myriophyllum spicatum was the third most abundant species with a frequency of occurrence of 42 percent and a relative frequency of 19 percent. Filamentous algae was the fourth most abundant species with a frequency of occurrence of 40 percent and a relative frequency of 17 percent. The littoral zone (the depth to which light penetrates permitting photosynthesis and the colonization of aquatic macrophytes) for Little Green Lake is between 0 and approximately 14 feet.

Species mean density ratings are summarized in Table 3. The species with the highest average density was Myriophyllum spicatum. Transect density ratings were calculated by summing the individual density ratings for a particular species in a particular transect. Transect densities of the four most abundant species are summarized in Table 4. Transects with the highest density ratings occurred in the main bays; Musky Bay, Lakeview Bay, Radtke's Bay, and Kearly's Bay.

Submergent and floating vegetation were the most abundant forms of plant growth in Little Green Lake with six species of each identified (Table 2). Three emergent plant species were also identified. Depths at which particular plant species were encountered are summarized in Table 5. Submergent plant species were predominantly found in depths less than 10 feet. Small numbers of Potamogeton crispus and Ceratophyllum demersum were found in depths greater than 10 feet. Floating and emergent plants were largely found at depths less than five feet. Distribution patterns for individual plant species are illustrated on Figures 4 (A) through 4(F).

Six of the 10 plant species are considered abundant or common throughout Wisconsin (Reference 10) (Table 6). In general, the aquatic plant community of Little Green Lake is a fair food source for wildlife and waterfowl, and is also beneficial to fish by providing food, food for prey, cover, and spawning habitat (Reference 3 and 7) (Table 7). No endangered or threatened plant species were identified during this survey.

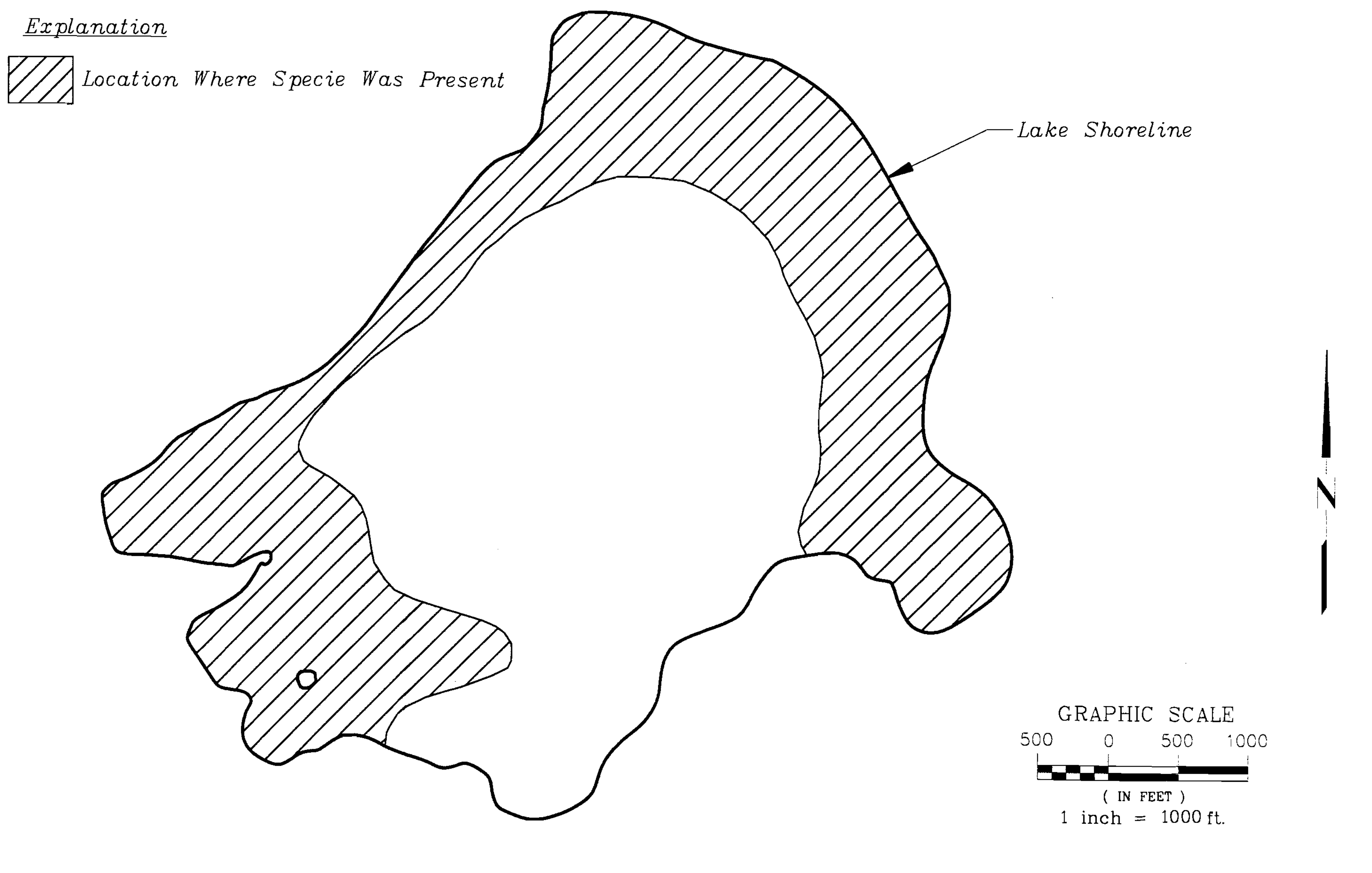
Potamogeton crispus and Myriophyllum spicatum are non-native (exotic) invasive species that were encountered during the survey. These exotic species spread rapidly and are capable of quickly out-competing native plant species within a few years. Both of these exotic species have the tendency to become a nuisance, further deteriorating recreational, wildlife, and aesthetic values of a lake.

The sediment composition (substrate) of Little Green Lake lacks diversity. Sand/gravel and muck/organics were the two basic forms of substrate encountered. Approximately 90 percent of the lake sediments encountered were comprised of muck and decaying organic deposits. It is believed that the original lake basin is comprised of sand and gravel. The original lake basin has been covered annually by deposits of silt and organic materials. Depositional processes have been accelerated with nutrient enrichment and increased sediment loads that have been imported to Little Green Lake. Nutrient enrichment of the lake is reflected in the high yield of aquatic plants. At the end of each growing season, this high amount of plant tissue dies and settles to the bottom of the lake. This sedimentation process creates the muck-like/organic substrate. Sediment loadings have also entered the lake because of human activities within the watershed. Correlation between rooting plant types and their sediment preference was not strongly evident. However, submergent and rooted floating species appeared to prefer softer sediments (i.e., silt/organics), while emergents were typically rooted in stable and firm sediments (i.e., sand and gravel).

Species composition and density varies considerably over the course of a growing season and from year to year. The July 1993 observations characterize Potamogeton crispus as "abundant", but riparians and people familiar with Little Green Lake note that the species is more evident in spring and early summer months. Potamogeton crispus has a short seasonal life cycle whereby it proliferates early in the growing season and then typically dies off by mid to late summer. Consequently, it is probable Potamogeton crispus would be the dominant species if the survey were conducted earlier in the summer. A greater abundance of Potamogeton crispus was observed during the initial collection (June 18).

Data (e.g., chemical, biological, physical, and morphological) gathered to date suggest a highly fertile aquatic environment. Nutrient and chlorophyll *a* concentrations are high and secchi disk readings are low during summer months. High chlorophyll *a* concentrations and low secchi disk measurements are indicative of high planktonic (algae) biomass. The 1993 standing crop of aquatic macrophytes in Little Green Lake was exemplified by low species diversity and high species abundance. In other words, there were a high number of individuals of the same family but a low number of different families. This information typifies an unhealthy ecosystem where cultural eutrophication has resulted in enhanced productivity. To observe and understand these inlake dynamics, Northern Environmental believes it would be beneficial to conduct additional macrophyte surveys and continue with lake chemistry monitoring.

If the Little Green Lake Protection and Rehabilitation District intends to control the macrophyte community to improve aesthetic beauty or recreational capabilities, several management strategies are available. These are described in the following section.



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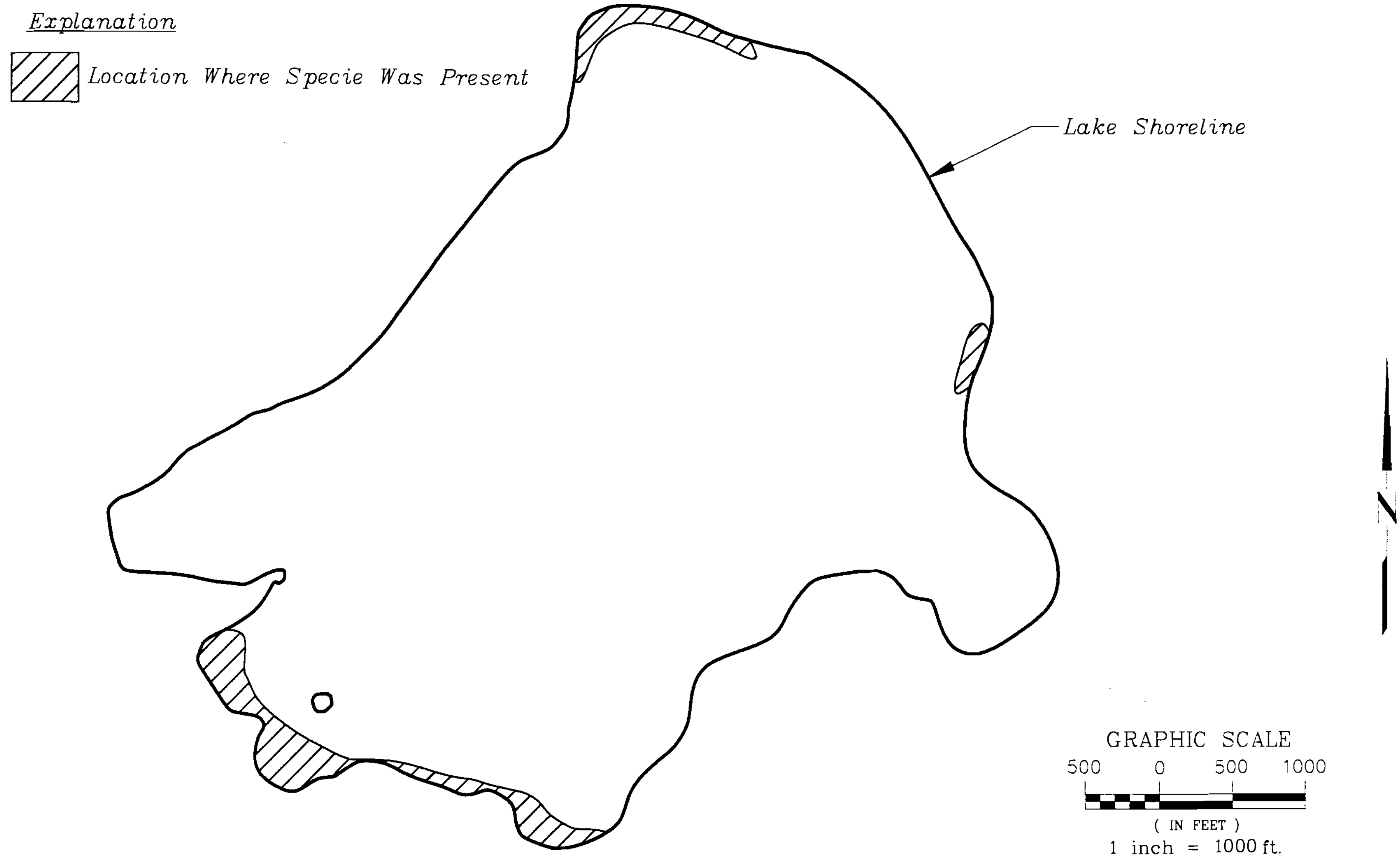
Little Green Lake
Green Lake County, Wisconsin

Distribution of
Potamogeton crispus

FIGURE: 4A



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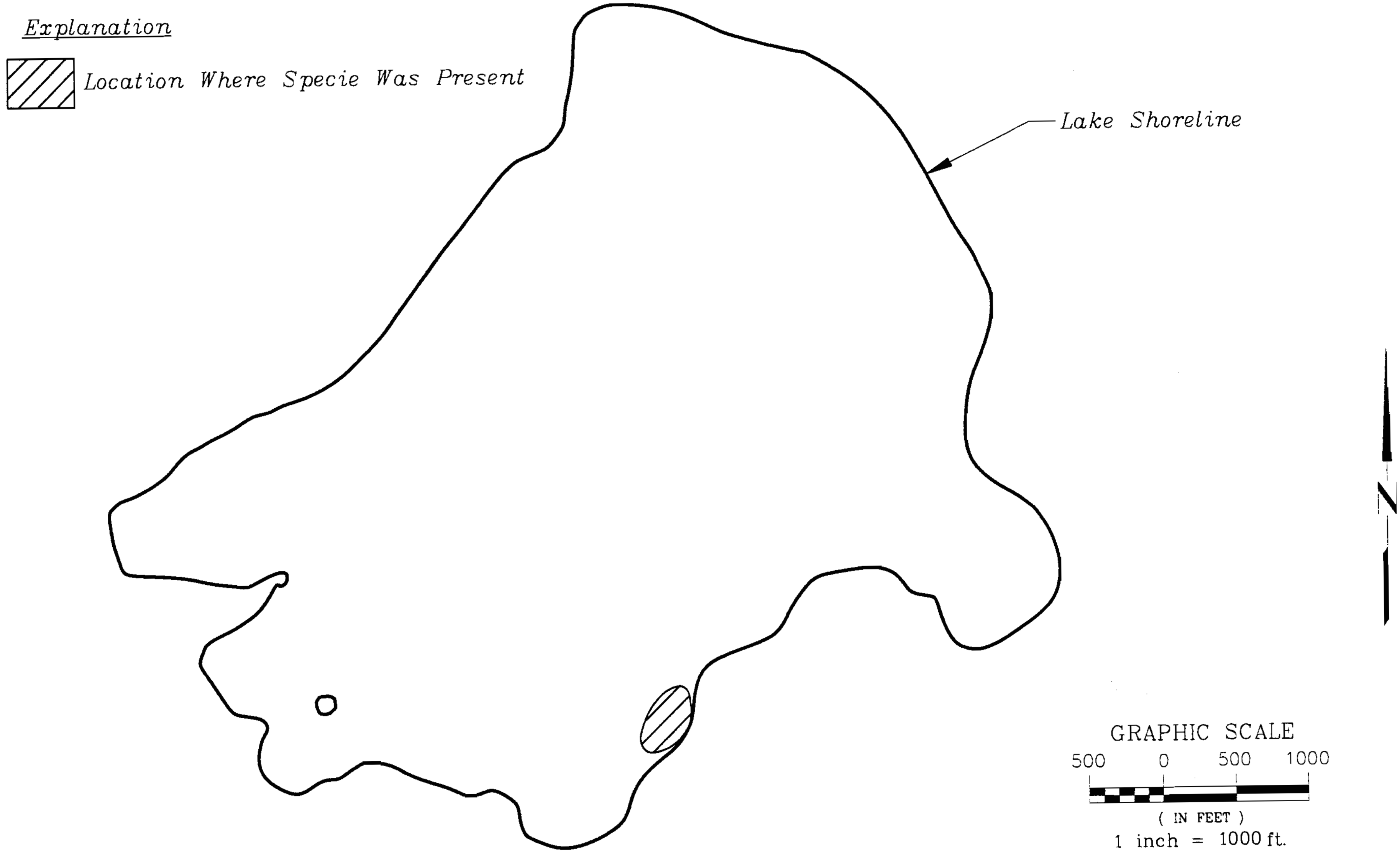
Little Grenn Lake
Green Lake County, Wisconsin

Distribution of
Elodea canadensis

FIGURE: 4B



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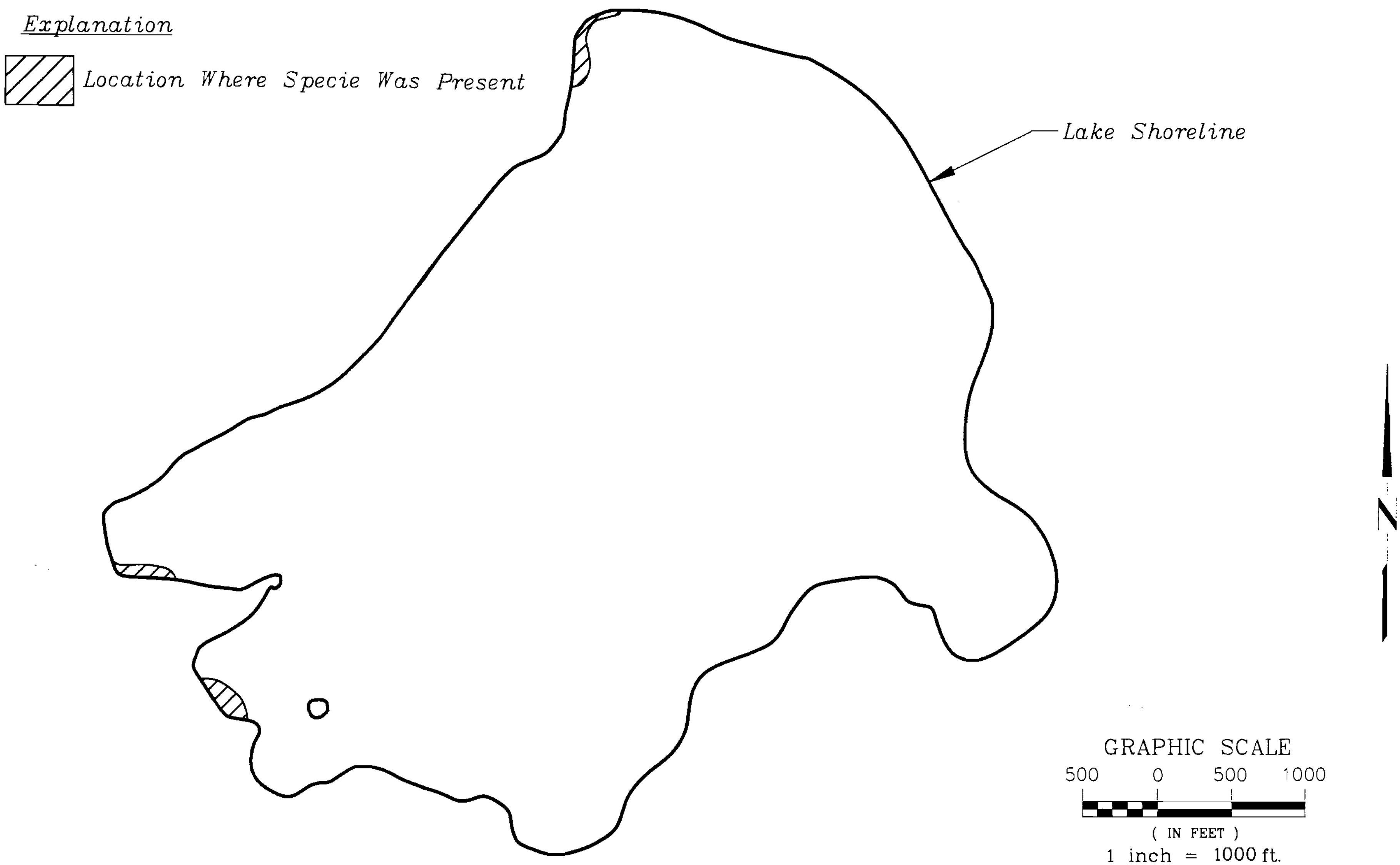
	▲ Northern Environmental *Hydrologist · Engineers · Geologists*		FIGURE: 4C



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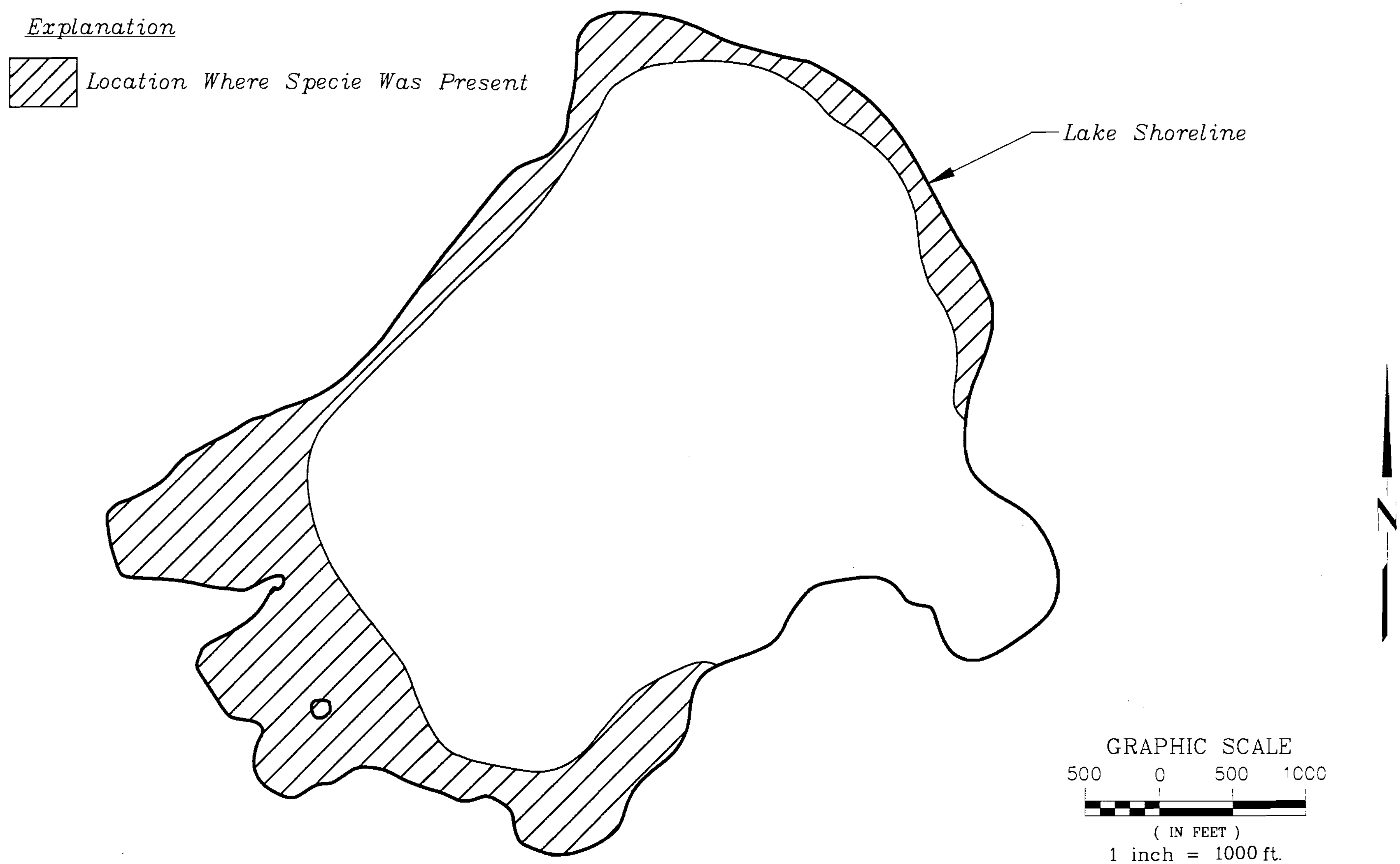
Little Green Lake
Green Lake County, Wisconsin

Distribution of
Lemna minor

FIGURE: 4D



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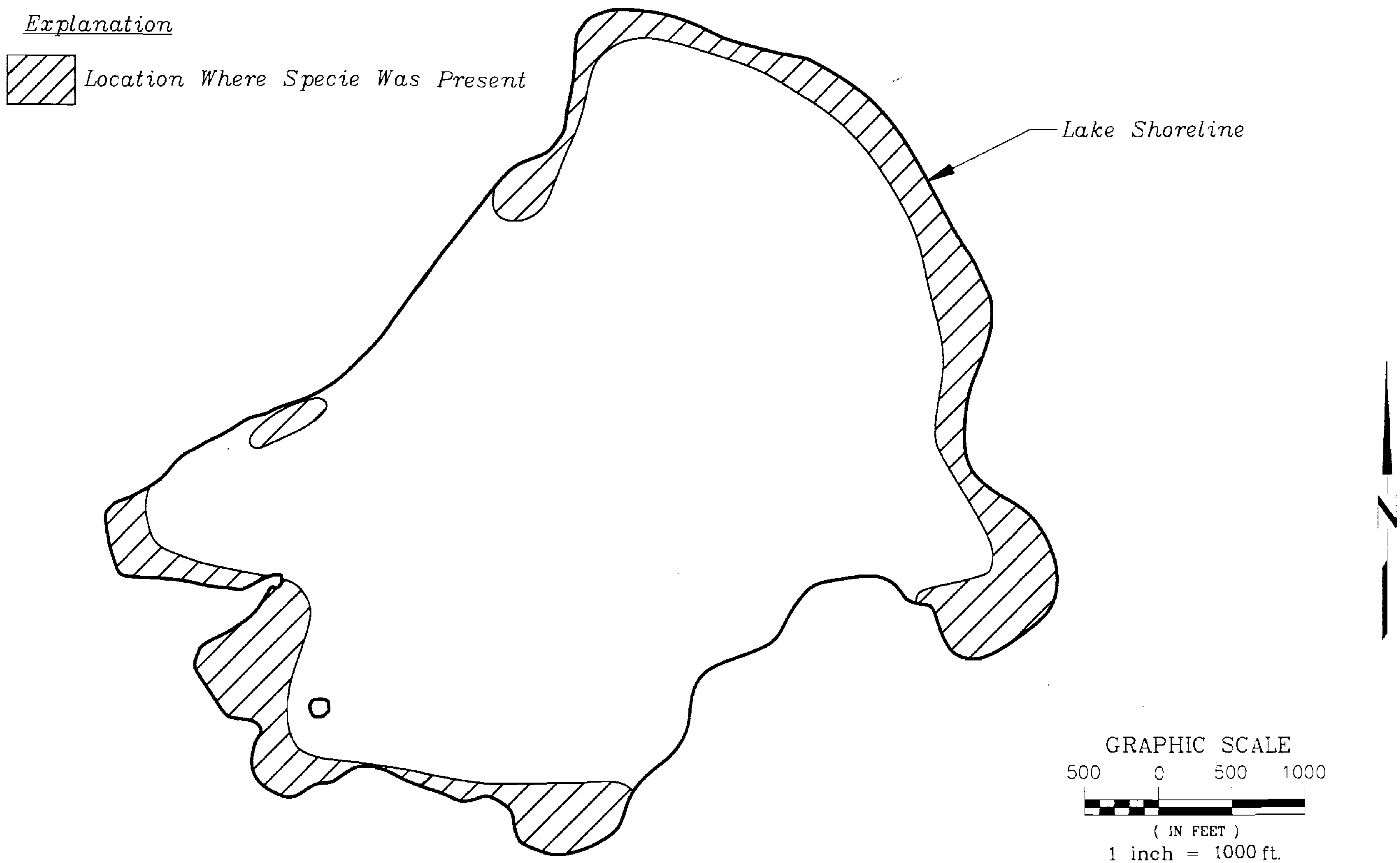
Little Green Lake
Green Lake County, Wisconsin

Distribution of
Ceratophyllum demersum

FIGURE: 4E



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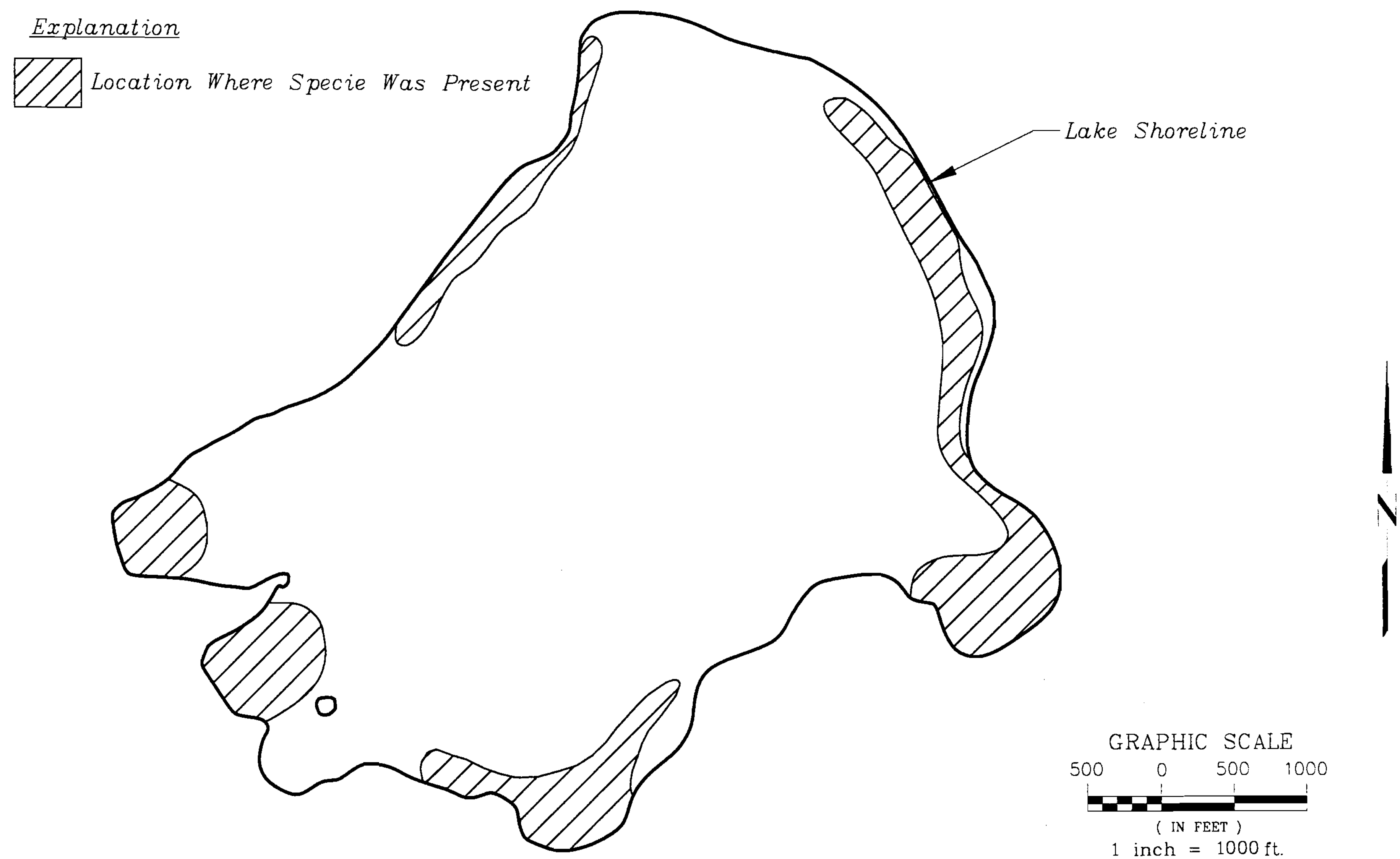
Little Green Lake
Green Lake County, Wisconsin

Distribution of
Myriophyllum spicatum

FIGURE: 4F



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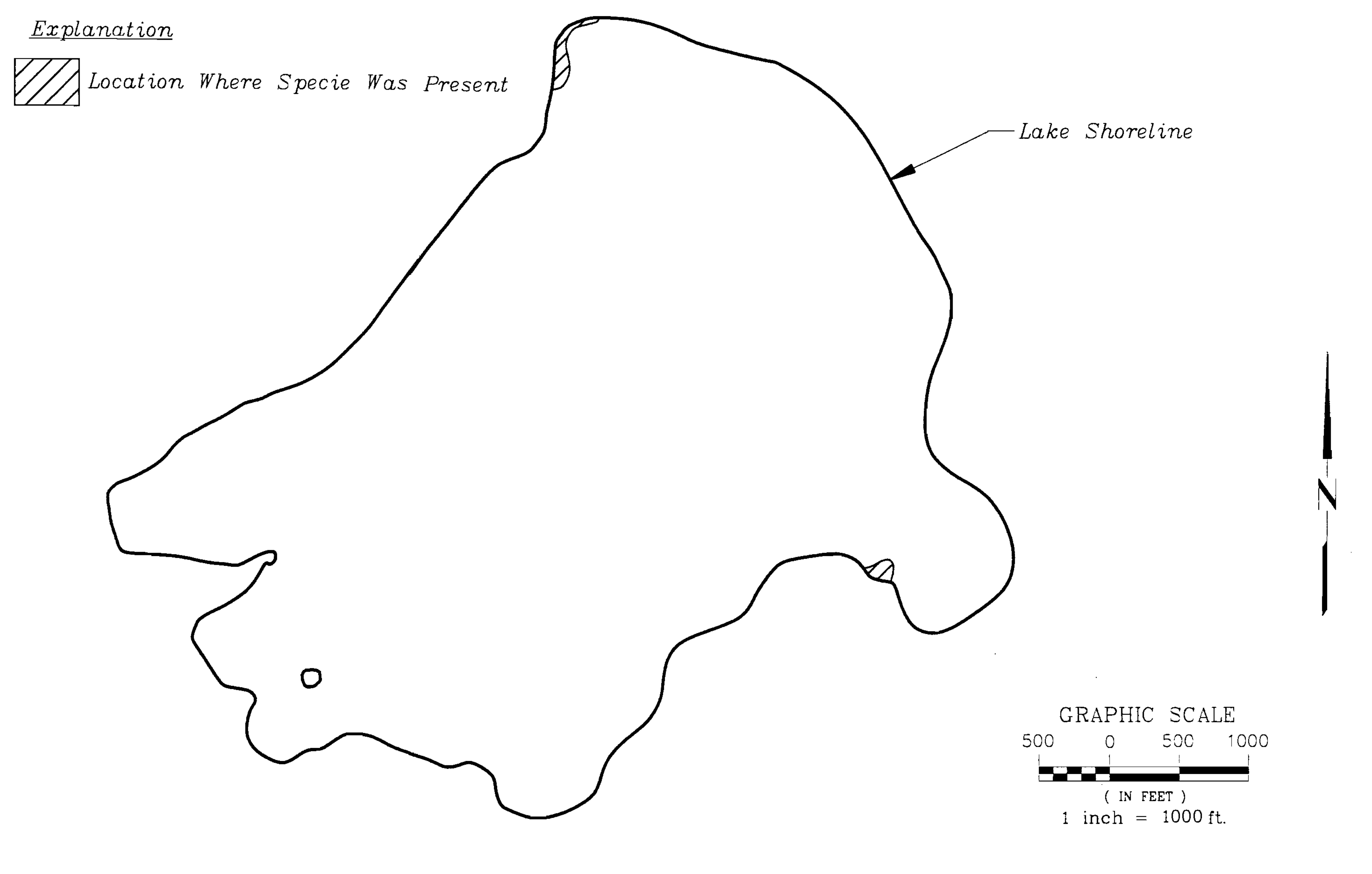
Little Green Lake
Green Lake County, Wisconsin

Distribution of
Filamentous Algae

FIGURE: 4G



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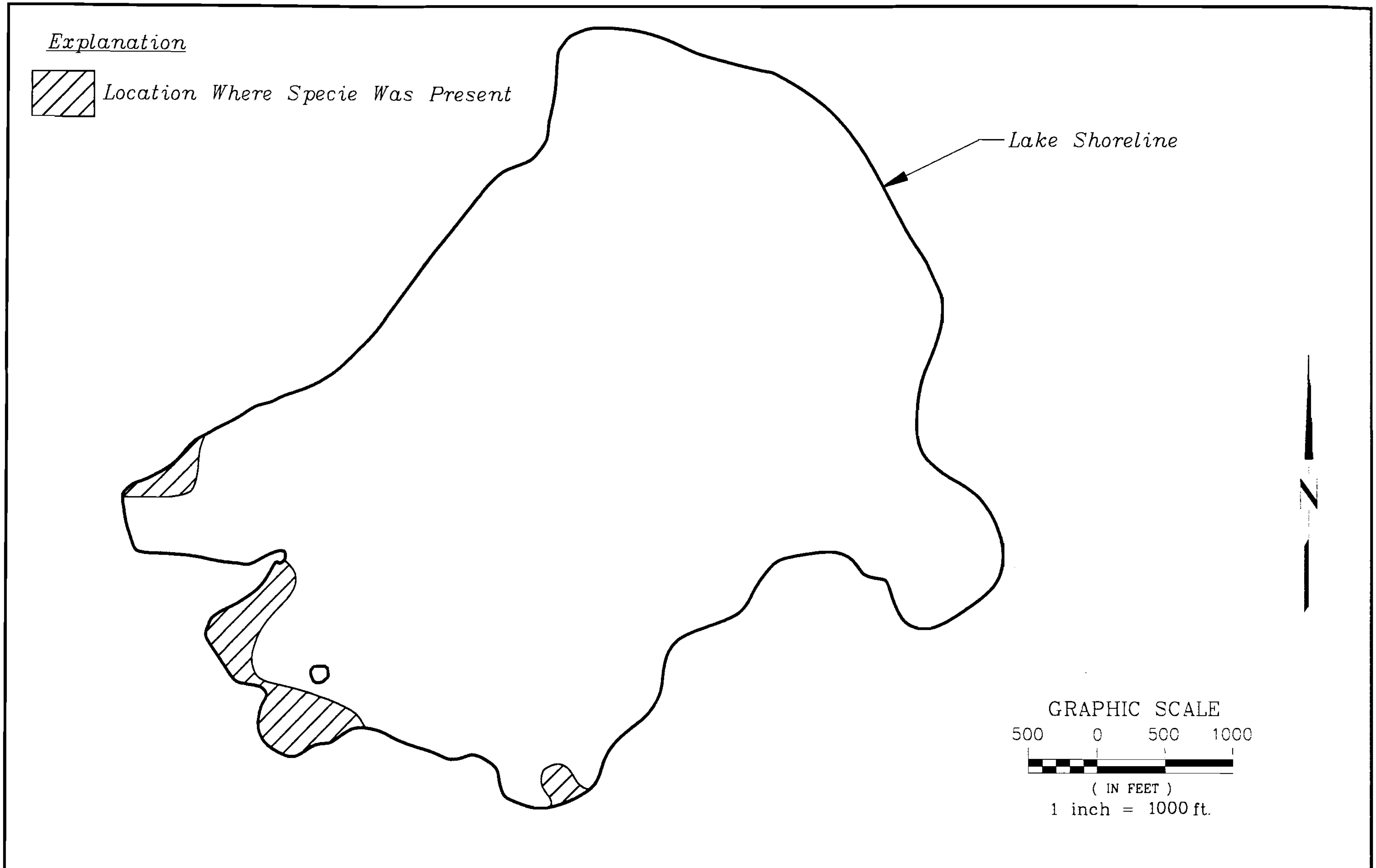
Little Green Lake
Green Lake County, Wisconsin

Distribution of
Typha sp.

FIGURE: 4H



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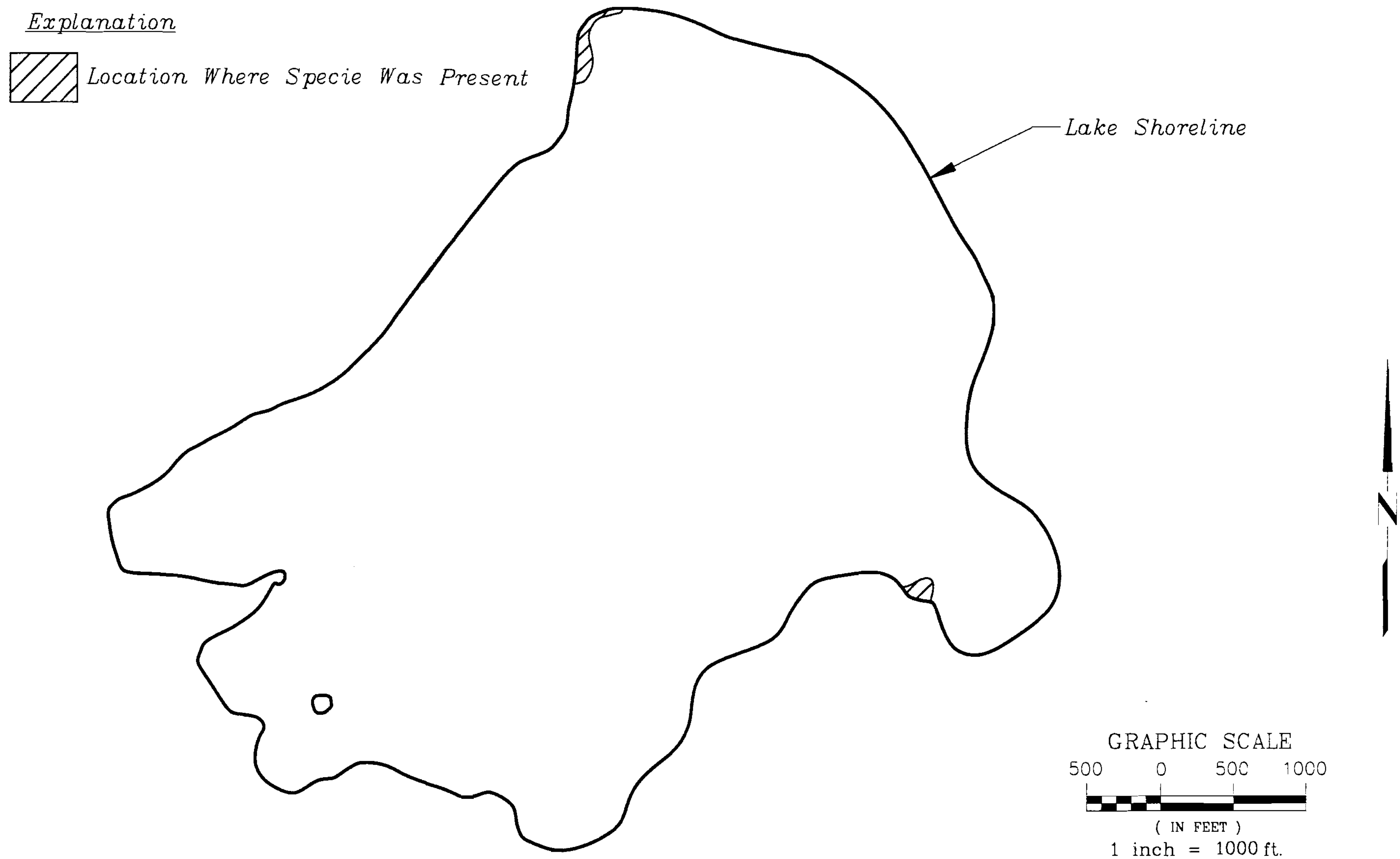

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Northern Environmental
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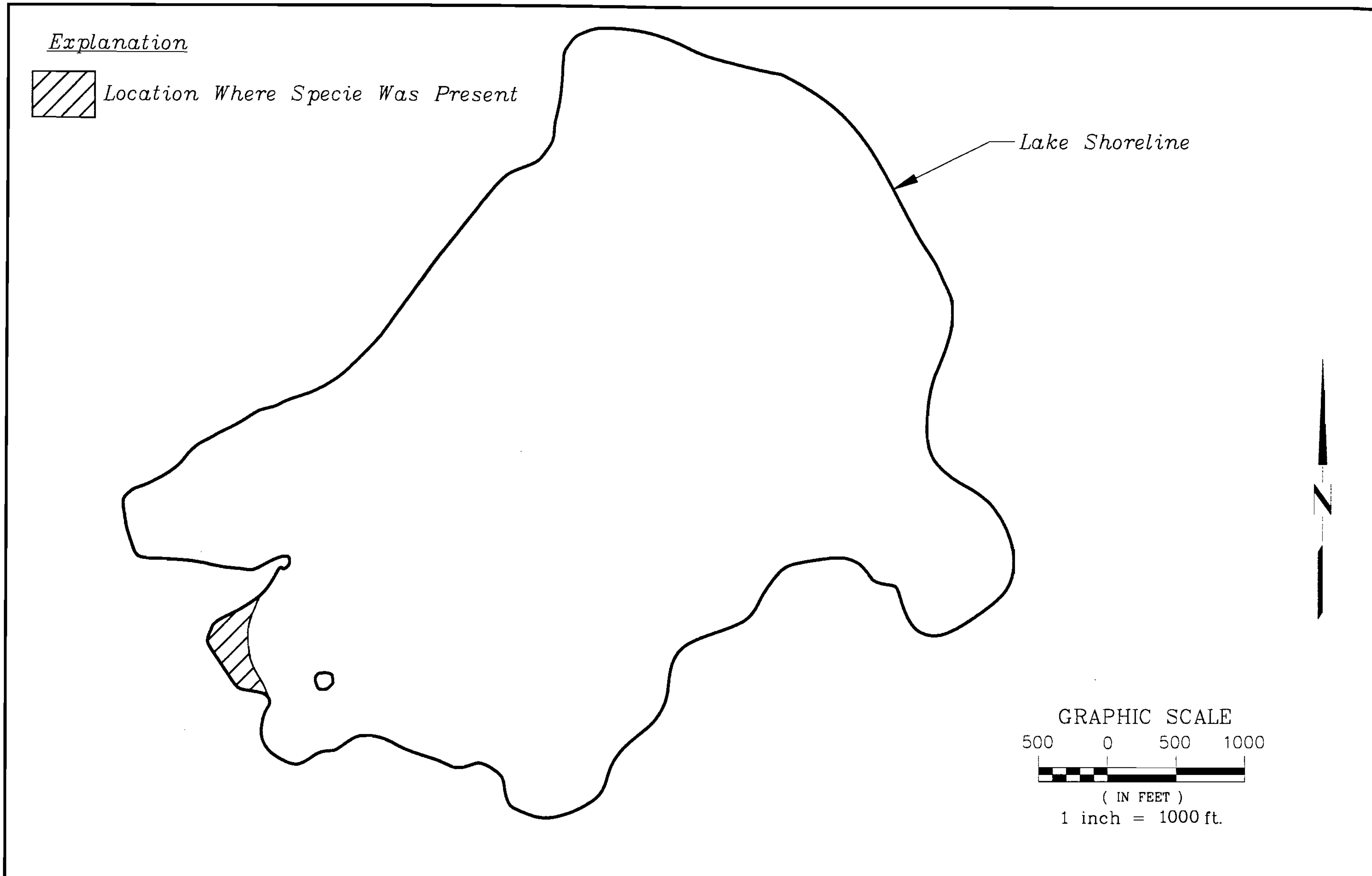
Little Green Lake
Green Lake County, Wisconsin

Distribution of
Polygonium amphibium

FIGURE: 4J



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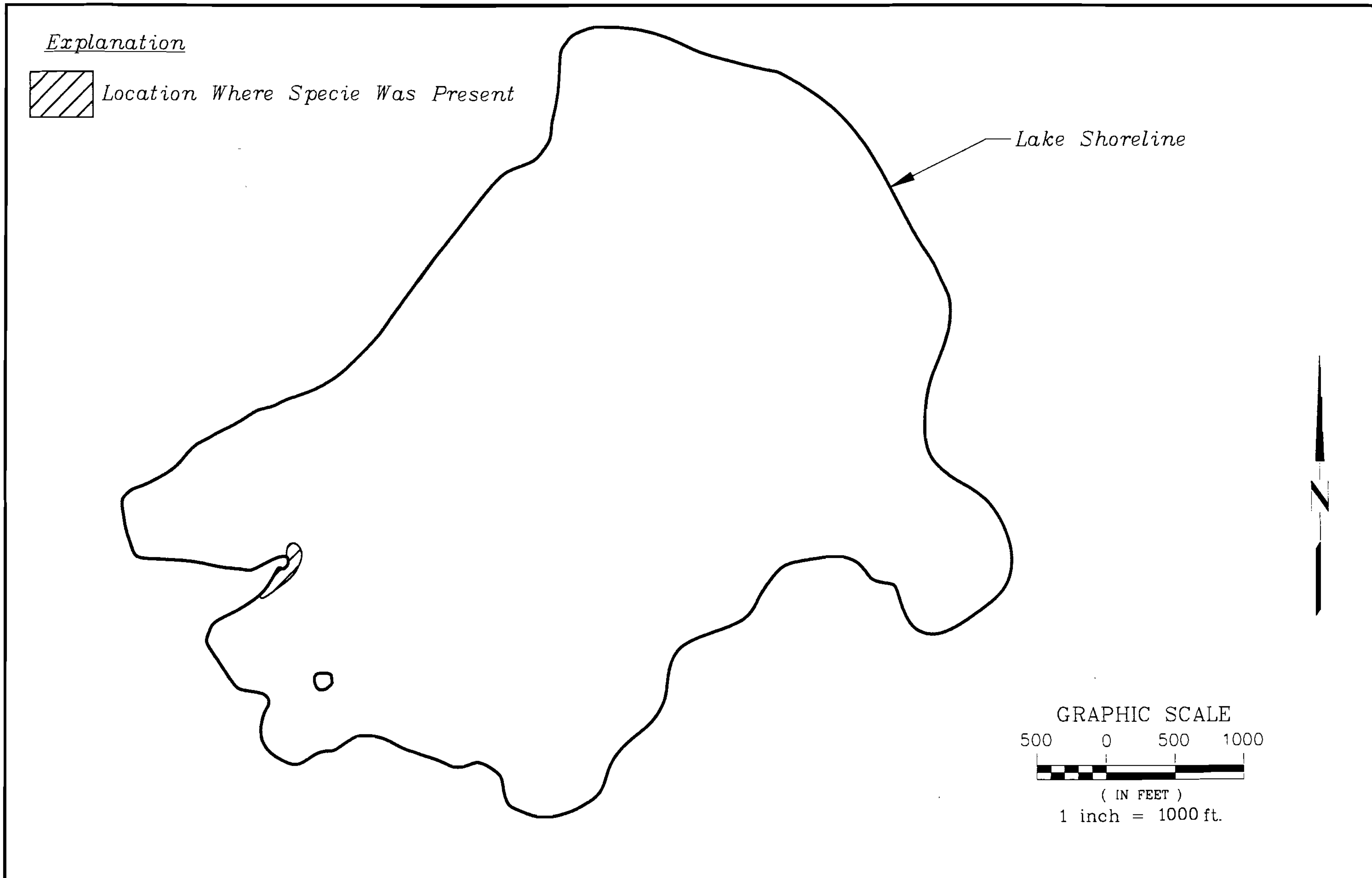
Distribution of
Spirodela polyrhiza

FIGURE: 4K



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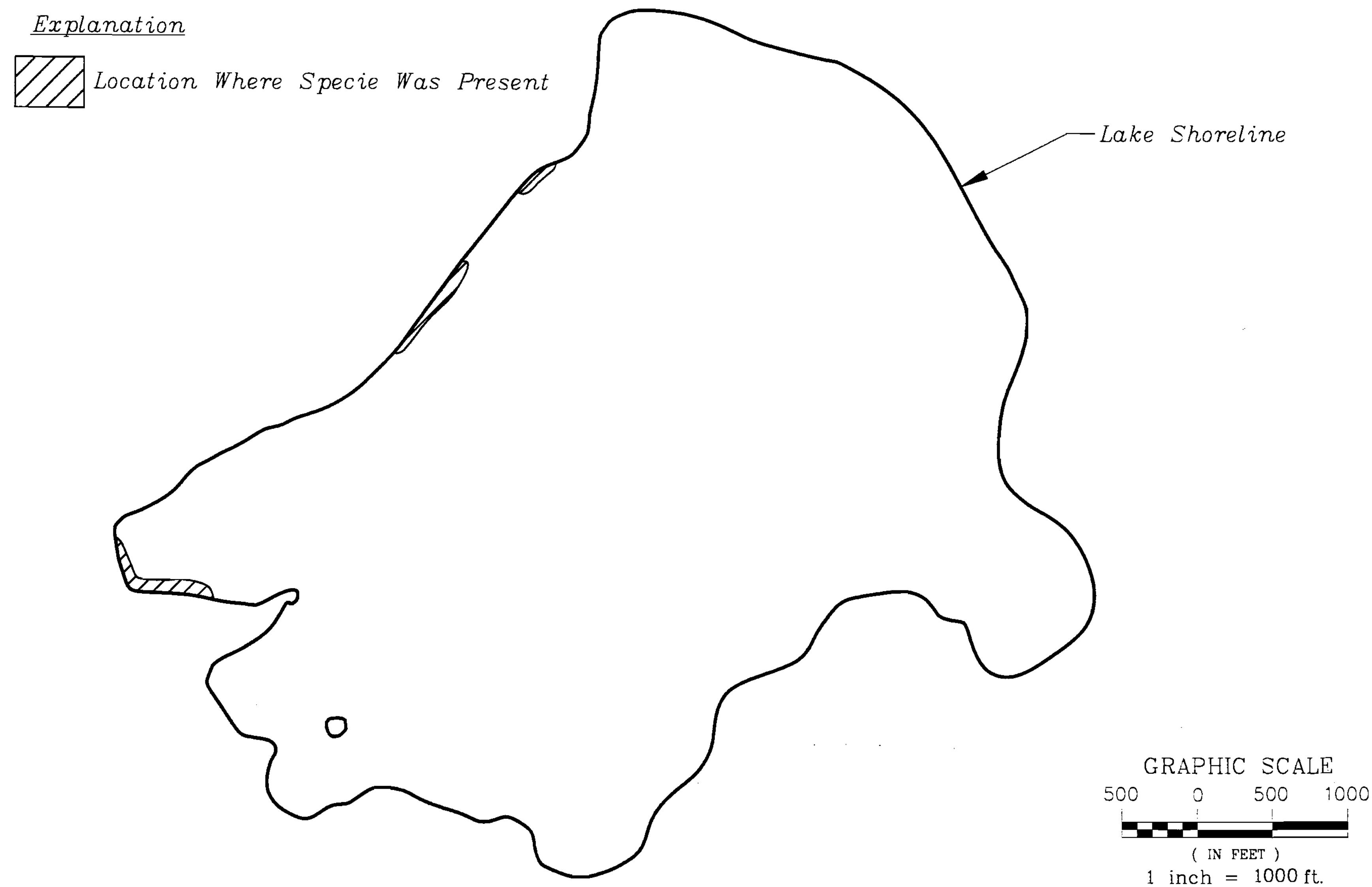
Distribution of
Potamogeton zosteriformes

FIGURE: 4L



DRAWN BY: CDP	PROJECT: LGL 140844	DATE: 9 MAR 1994	Little Green Lake Green Lake County, Wisconsin
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	Northern Environmental Hydrologist · Engineers · Geologists		FIGURE: 4M

Table 2 Aquatic Macrophyte Species Identified In Little Green Lake, 1993

Species	Species Identification Number	Common Name
Potamogeton crispus *	1	Curlyleaf pondweed
Elodea canadensis *	2	Common waterweed
Potamogeton pecinatus *	3	Sago pondweed
Lemna minor **	4	Small duckweed
Ceratophyllum demersum *	5	Coontail
Myriophyllum spicatum *	6	Eurasian milfoil
Filamentous algae **	7	None
Typha sp. ***	8	Cattail
Polygonum amphibium **	9	Water smartweed
Scirpus spp.***	10	Bulrush
Lemna trisulca **	11	Forked duckweed
Spirodela polyrhiza **	12	Great duckweed
Potamogeton zosteriformes *	14	Flat-stem pondweed
Scirpus validius ***	15	Great bulrush
Nuphar microphyllum **	16	Yellow water lilly

NOTE:
* = Submergent Plant Growth
** = Floating Plant Growth
*** = Emergent Plant Growth

here was no species #13; it was identified as being Potamogeton crispus
Nuphar microphyllum and scirpus sp. were encountered in the initial collection of plants, but were not seen on any of the transects.

LGL140844.0844T1-1
February 23, 1994

Table 3 Summary of 1993 Little Green Lake Macrophyte Survey

Species	Maximum Rooting Depth (feet)	Frequency of Occurrence (percent)	Species Mean Density Rating*	Relative Frequecy (percent)
Potamogeton crispus	11.3	49	2.5	21
Elodea canadensis	3.9	9	2.8	4
Potamogeton pectinus	4.3	2.5	1.0	1
Lemna minor	—	2.5	2.5	1
Ceratophyllum demersum	14.4	53	2.7	24
Myriophyllum spicatum	7.5	42	3.3	19
Filamentous algae	—	40	2.9	17
Typha sp.	1.2	2.5	2.0	1
Polygonum amphibium	0.9	1.2	1.0	1
Lemna trisulca	—	7.5	2.7	4
Spirodela polyrhiza	—	1.2	1.0	1
Pltamogeten zosteriformes	1.5	2.5	1.5	1
Scirpus validius	1.5	4.2	1.7	2

NOTE:

* = Average density rating for all points where a particular specie occurred
— = Not a rooted plant specie

LGL140844.0844T1-2
February 25, 1994

Table 4 Transect Densities of the Four Most Abundant Species Encountered In Little Green Lake, Macrophyte Survey 1993

	Species and Density Ratings			
Transect #	Ceratophyllum demersum	Potamogeton crispus	Myriophyllum spicutum	Filamentous algae
Transect 1	2	1	7	4
Transect 2	2	3	5	6
Transect 3	1	6	7	7
Transect 4	2	1	5	6
Transect 5	10	6	12	12
Transect 6	1	1	—	1
Transect 7	—	—	—	—
Transect 8	3	—	1	1
Transect 9	11	5	13	12
Transect 10	2	3	8	4
Transect 11	6	4	7	6
Transect 12	9	4	9	5
Transect 13	8	11	8	—
Transect 14	11	9	6	6
Transect 15	9	8	—	—
Transect 16	12	12	5	—
Transect 17	4	6	—	3
Transect 18	5	8	5	10
Transect 19	6	7	4	3
Transect 20	8	7	2	—

NOTE: — = species not encountered

LGL140844.0844T1-3
February 23, 1994

Table 5 Depths at Which Particular Species Were Encountered, Little Green Lake Macrophyte Survey, 1993

Species	Depth Code	Percent Occurrence
Potamogeton crispus	1	27
	2	21
	3	47
	4	5
	5	0
Elodea canadensis	1	55
	2	33
	3	12
	4	0
	5	0
Potamogeton pectinatus	1	50
	2	50
	3	0
	4	0
	5	0
Lemna minor	1	100
	2	0
	3	0
	4	0
	5	0
Ceratophyllum demersum	1	38
	2	33
	3	24
	4	5
	5	0
Myriophyllum spicatum	1	45
	2	45
	3	10
	4	0
	5	0
Filamentous algae	1	40
	2	43
	3	10
	4	7
	5	0
Typha sp.	1	100
	2	0
	3	0
	4	0
	5	0
Polygonum amphibium	1	100
	2	0
	3	0
	4	0
	5	0
Lemna trisulca	1	14
	2	72
	3	14
	4	0
	5	0
Spirodela ployrhiza	1	100
	2	0
	3	0
	4	0
	5	0
Potamogeton zosteriformes	1	100
	2	0
	3	0
	4	0
	5	0
Scirpus validius	1	100
	2	0
	3	0
	4	0
	5	0

Table 6 Species Status of Wisconsin Lake Plants, Little Green Lake

Species	Species Status
Potamogeton crispus	C, N
Elodea canadensis	A
Potamogeton pecinatus	A
Lemna minor	I
Ceratophyllum demersum	A
Myriophyllum spicatum	I, N
Polygonum amphibium	I
Lemna trisulca	I
Spirodela polyrhiza	I
Potamogeton zostiformis	A
Scirpus validus	C
Nuphar microphyllum	I

Note:

A = Abundant C = Common I = Infrequent

N = Non-Native

R = Rare

No information available on Filamentous algae, Typha sp., or Scirpus sp.
Source: Nichols, Stanley A. and James G. Vennie, *Attributes of Wisconsin Lake Plants*, Wisconsin Geological and Natural Survey Information Circular 73, 1991.

LGL140844.0844T1-5
March 9, 1994

Table 7 Wildlife and Environmental Values of Wisconsin Lake Plants, Little Green Lake

Species Name	Waterfowl			Other Birds		Muskrat	Substrate	Nuisance	Fish
	Food Part*	Food Value**	Cover***	Food Part*	Cover***	Food***	Stabiliz.***	Potential***	Value****
Potamogeten crispus	S,T	P	-	-	-	-	-	X	F,C
Elodea canadensis	F	F	-	-	-	-	-	X	-
Potamogetin pectinatus	-	E	-	-	-	-	-	X	F,C
Lemna minor	-	G	-	-	-	-	-	X	F
Ceratophyllum demersum	S,F	F	X	-	-	-	-	X	F,S
Myriophyllum spicatum	S,F	P	-	-	-	-	-	X	F,C
Typha sp.	T,F	P	X	S	X	X	X	X	F
Polygonum amphibium	S	E	-	-	-	-	X	X	-
Scirpus spp.	-	-	X	S,T	X	X	X	X	F,C
Lemna trisulca	-	G	-	-	-	-	-	-	-
Spirodela polyrhiza	-	G	-	-	-	-	-	X	F
Potamogeten zosteriformes	S	F	-	-	-	-	-	-	-
Scirpus validus	-	-	-	-	-	-	X	-	F,C
Nuphar microphyllum	S	F	-	S	-	-	-	-	-

NOTE:
* S: Seeds or Comparable Structure; T: Tubers or roots; F: Foliage and stems; -: Information unknown or unreported
** E: Excellent; G: Good; F: Fair P: Poor -: Information unknown or unreported
*** X: Plant is functional in specified category; -: Information unknown or unreported
**** F: Direct food or supports fish food fauna; C: Cover S: Spawning habitat; -: Information unknown or unreported
No information available on: Filamentous algae

Source: Nichols, Stanley A. and James G. Vennie, *Attributes of Wisconsin Lake Plants*, Wisconsin Geological and Natural Survey Information Circular 73, 1991.

LGL140844.0844T1-6
February 23, 1994

6.0 MACROPHYTE MANAGEMENT TECHNIQUES

Habitat Manipulation

Habitat manipulation involves altering the physical environment in which vegetation grows. Four habitat manipulation strategies are described below.

1) Aquatic Plant Screens
Aquatic plant screens are plastic, rubber, or fiberglass barriers intended to inhibit light penetration and prevent plants from rooting. Installation requires securely anchoring the screens to the substrate in spring before plants begin growing. Aquatic plant screens work well in shallow areas or locations where other methods are not viable. However, the barriers do not effectively control algae or free-floating plants.

2) Shading
Soluble dyes, artificial structures, or overhanging terrestrial vegetation can be utilized to shade a water body and limit aquatic macrophyte growth. These methods often do not effectively inhibit plant growth. Dyes are diluted by wave action, precipitation, or inflowing water, requiring repeated treatments. Man-made structures and overhanging vegetation will partially inhibit light penetration, but shade tolerant species may still grow.

3) Drawdown
Drawdown is the process where water levels are lowered to expose the lakebed. Exposing the lake bed desiccates and compacts bottom sediments. Freezing and desiccation destroys root systems. This technique is not physically possible in many cases.

4) Dredging
Dredging involves physically removing sediments and nutrients which benefit rooted plants. Increased depth will reduce or eliminate rooted vegetation. Dredging is expensive and disposal of the sediments can be difficult.

Physical Harvesting

Aquatic vegetation can be controlled by various physical harvesting methods. Three physical harvesting techniques are described below.

1) Hand Harvesting
Hand harvesting is a labor intensive method used to remove emergent, floating, or submergent aquatic plants from the substrate. In order to effectively extract the root systems, plants should be pulled from their base. Hand harvesting is usually the simplest method for small shallow water areas.

2) Hand Held Weed Cutters
Hand held weed cutters are specially designed rakes or cutters. These hand held tools are easy to operate. The rakes and cutters are thrown out and slowly retrieved. Rakes can remove the entire root systems. Cutters usually leave root systems to regenerate. Both tools are most effective in shallow water. Hand held weed cutters can be used in deeper areas, but are not as effective in shallow water.

3) Dragging
Dragging is an inexpensive method in which individuals can fabricate their own draglines. Draglines are constructed of rope, wire, or chains which can be placed into the water from either shore or a boat, and then pulled in manually or towed. This method is effective for removal of nuisance vegetation in shallow and deep areas.

Biological Controls

Natural controls can be utilized to reduce or control aquatic vegetation. These methods often involve the introduction of exotic (non-native) species to an ecosystem to outcompete or harvest over abundant individuals. Historically, management by exotics has had limited success and introduction of non-native organisms to a new environment presents a high amount of risk. One common biological control is described below:

1) Competitive Plant Species
The introduction of competitive plant species has had limited success. This strategy involves the use of exotic and/or native plants to displace nuisance species. However, using exotics is highly unpredictable. Numerous environmental factors make it difficult to determine where and how a species should grow.

Chemical Control

Chemical control is one of the more popular techniques for controlling nuisance aquatic vegetation. Chemicals are inexpensive and non-labor intensive means for treating selected areas, providing a vegetation control in hard to manage areas. Application rates and frequencies depend upon physical conditions (wave action, dilution, and water temperature). Manufacturers claim that chemicals degrade quickly after controlling target plants thereby preventing disruption of the food chain. However, studies on the toxicity, persistence, and bioaccumulation of chemicals is inconclusive. Until testing provides conclusive answers, potential negative short and long term affects will make further chemical usage questionable.

Mechanical Harvesting

Mechanical harvesting cuts nuisance aquatic vegetation below the water surface. The cut plants are removed from the lake and disposed. A harvester is typically constructed upon a low-draft barge with vertical and horizontal cutter bars. Vegetation is cut, harvested, and unloaded with a shore conveyor. The advantage of mechanical harvesting is that it provides immediate relief from nuisance aquatic vegetation. Specific areas such as boating lanes and channels can be opened for use. In addition, harvesting removes important plant growth nutrients in the form of plant tissue. Significantly reducing nutrient levels is difficult, but can occur if harvesting is continuously repeated. Root systems remain in place allowing plants to regenerate. Drawbacks to harvesting include the high initial investment in the machine, potential habitat loss for aquatic organisms (e.g., spawning and nursery areas), and possible damage to desirable species.

7.0 REFERENCES

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5) Jensen, R. and R. Lound, *An Evaluation of a Survey Technique for Submerged Aquatic Plants*, Minnesota Department of Conservation Game, Investigation Report Number 6.

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9) Winkelman, J., and R.C. Lathrop, *Aquatic Plants in Lake Monona: Their Status and Implications for Management,* Wisconsin Department of Natural Resources - Bureau of Research, Madison, Wisconsin, 1993.

10) Nichols, Stanley A. and James G. Vennie, *Attributes of Wisconsin Lake Plants*, Wisconsin Geological and Natural History Survey Information Circular 73, 1991.

434412088590700 LITTLE GREEN LAKE, AT CENTER, NEAR MARKESAN, WI

LOCATION--Lat 43°44'12", long 88°59'07", in SW 1/4 SW 1/4 sec.29, T.15 N., R.13 E., Green Lake County, Hydrologic Unit 04030201, 2 mi north of Markesan.

PERIOD OF RECORD.--February 1991 to current year.

REMARKS.--Lake sampled near center at a lake depth of about 28 ft. Lake ice-covered during Feburary sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, FEBRUARY 07 TO AUGUST 27, 1992
(Milligrams per liter unless otherwise indicated)

	Feb. 07		Apr. 22		June 15		July 30		Aug. 27	
Depth of sample (ft)	1.5	24	1.5	24	1.5	23	1.5	22	1.5	23
Lake stage (ft)	---		---		5.80		5.57		5.32	
Specific conductance (µS/cm)	327	361	328	328	278	325	315	354	287	345
pH (units)	8.8	7.6	8.0	8.5	9.1	7.7	8.7	7.5	8.6	7.5
Water temperature (°C)	4.5	4.5	9.0	9.0	21.5	15.5	22.5	19.5	21.5	20.0
Color (Pt-Co. scale)	---	---	10	15	---	---	---	---	---	---
Turbidity (NTU)	---	---	5.0	5.6	---	---	---	---	---	---
Secchi-depth (meters)	---		0.9		1.6		0.5		0.4	
Dissolved oxygen	17.5	1.0	13.0	12.9	7.5	1.0	9.2	0.1	6.5	0.8
Hardness, as CaCO3	---	---	150	150	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	28	28	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	20	20	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	6.6	6.6	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	4	4	---	---	---	---	---	---
Alkalinity, as CaCO3	---	---	140	140	---	---	---	---	---	---
Sulfate, dissolved (SO4)	---	---	5.0	5.0	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	14	14	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	0.1	0.1	---	---	---	---	---	---
Silica, dissolved (SiO2)	---	---	<0.2	<0.2	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	186	186	---	---	---	---	---	---
Nitrogen, NO2 + NO3, diss. (as N)	---	---	0.09	0.10	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	0.03	0.04	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.90	0.50	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.077	0.070	0.065	0.330	0.148	0.400	0.154	0.440
Phosphorus, ortho, dissolved (as P)	---	---	0.006	0.006	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<50	<50	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	<40	<40	---	---	---	---	---	---
Chlorophyll a, phytoplankton (µg/L)	---	---	37	---	15	---	96	---	140	---

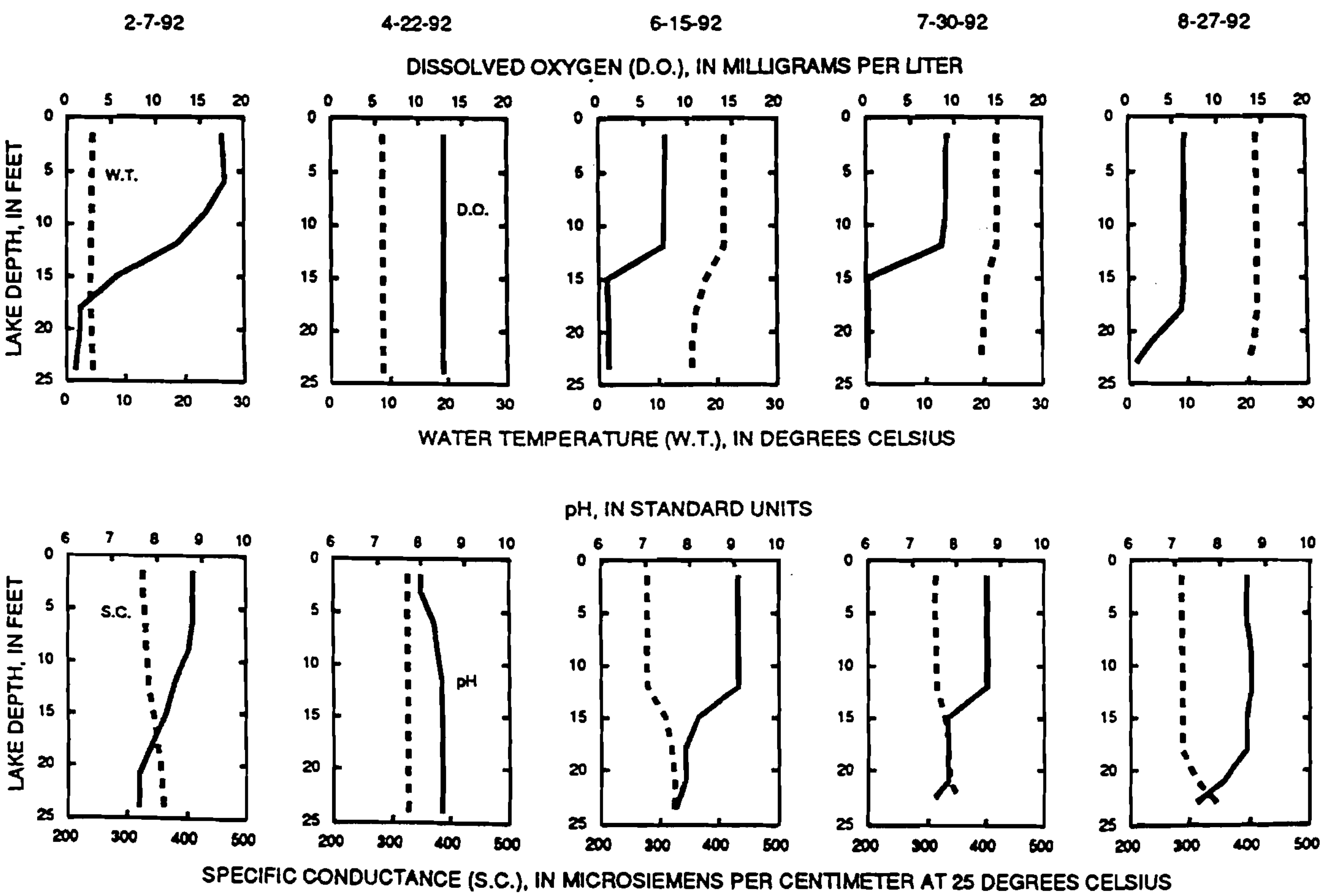

Figure 2. Lake water-quality data for Little Green Lake near Markesan, Wisconsin, 1992 water year

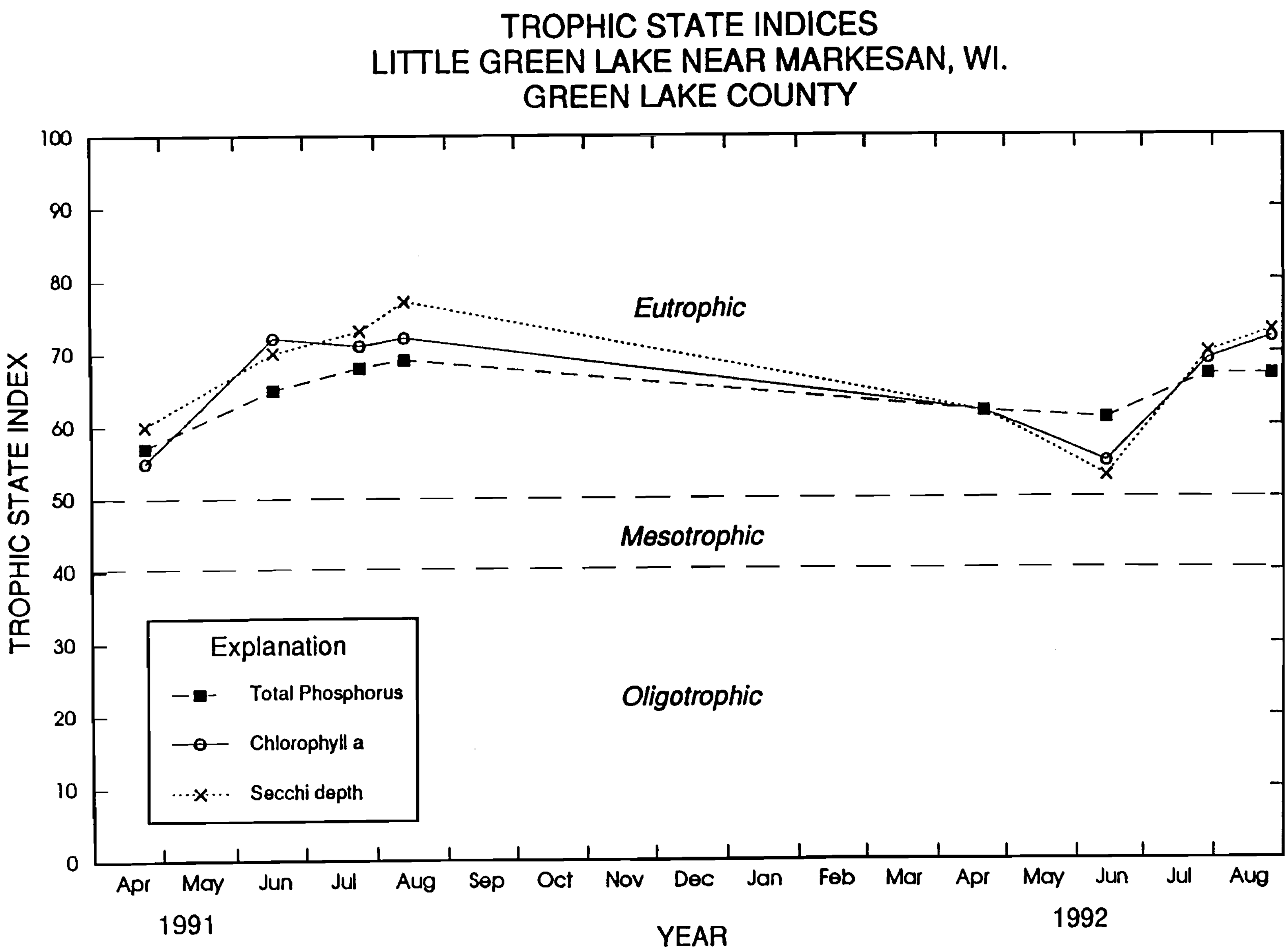

Figure 3. Trophic State Indices for Little Green Lake near Markesan, Wisconsin