Comprehensive Survey of Long Lake (Saxeville)
Waushara County, Wisconsin

Prepared by:

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Summary

A thorough study of Long Lake, Waushara County, Wisconsin was conducted between in 2008. The primary goals of this project have been 1) to gather baseline information on the physical, chemical and biological aspects of Long Lake and the surrounding watershed, 2) to identify and prioritize management concerns including water quality and possible introduction of exotic species, and 3) to provide information needed to make informed decisions regarding the future management of the waters both ecologically and sociologically.

Project elements focused primarily on the aquatic plant community of Long Lake, water quality parameters, and an assessment of the lake's watershed. This project was funded in part by the Wisconsin DNR's Lake Planning grant program.

Results of this study include:

- The most abundant plant species encountered in Long Lake were muskgrass (*Chara* sp.), variable pondweed (*Potamogeton gramineus*) and bushy pondweed (*Najas flexilis*).

- No Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*) or zebra mussels (*Dreissena polymorpha*) were found in the lake during the timeframe of the study.

- Analysis of plant data indicated via the Simpson Diversity Index, the Coefficient of Conservatism and the Floristic Quality Index that Long Lake that the quality of Long Lake is above average in terms of the aquatic plant community.

- Long Lake has very good water quality and falls within the lower end of a classic mesotrophic lake.

- Dissolved oxygen measurements indicate high levels of oxygen throughout much of the lake during the entire study.

- Analysis found that the watershed of Long Lake is small (~450 acres) and predominantly forests.

- Modeling of land cover and water quality data indicated the water quality of Long Lake is better than expected and that the largest contributors of phosphorus include non-point sources within the watershed, precipitation, and septic systems.

Introduction

Long Lake is located in northern Waushara County, Wisconsin, near the village of Saxeville. The Long Lake Association is the principle management unit representing the interests of lakefront property owners. A second organization, the Friends of Long Lake serves as a financial arm of the Association. It is a non-profit organization that accepts tax deductible donations which are used help fund Association activities.

Lake Characteristics

Long Lake is a deep, clear lake of glacial origin surrounded by forested hills (**Figure 1**). The lake's 272 acres lie in an east-west axis comprised of two basins (**Figure 2**). The west basin has a maximum depth of 71 feet. The east basin has a maximum depth of 60 feet. The lake as a whole has an average depth of 22 feet and a volume of 5,984 acre-feet (approximately 2 billion gallons). The lake has no inlets or outlets, and is primarily fed by groundwater seepage. Hydraulic residence time has been calculated at 4.9 years. Long Lake experiences both thermal and oxygen stratification. In the past, mid-summer thermoclines were found beginning from 15 to 25 feet deep. Mid-summer oxyclines began at 25 to 35 feet, with anoxic conditions occurring below a depth of 40 to 45 feet.

Water quality indicators categorize Long Lake as early mesotrophic – a classification typical of natural lakes of this size found in Central Wisconsin. The good water quality, sandy shores and depth found in Long Lake make the lake very appealing for boaters and swimmers. Not-surprisingly, the lake is entirely surrounded by cottages and year-round homes. A well-maintained boat launch located on the south shore of the lake provides access to the public.

Management History

Aquatic plant community

As of 2008 no exotic aquatic plant species have been identified in Long Lake. In addition, the native aquatic plant community has not impeded recreational use of the lake. Consequently, to date, no aquatic plant management efforts (herbicide treatment, harvesting, etc.) have taken place on Long Lake.

Lake fishery

Lake assessment activities occurring in the last twenty years have included periodic fishery surveys conducted by the Wisconsin Department of Natural Resources (WDNR). Lake management activities have primarily involved periodic fish stocking to maintain a sport fishery. Since 1993 Long Lake has been used by the WDNR as a rearing facility for spotted musky (*Esox masquinongy*) brood stock.

In 2004, the Long Lake Association retained Aquatic Biologists, Inc. to conduct aquatic plant surveys of the lake. Specific project objectives were to assess the native aquatic plant communities, determine if any exotic aquatic plant species were present, develop

contingency plans for dealing with exotic species invasion, and research management options for lake habitat improvement.

Water quality

Water quality data have routinely been collected on Long Lake since 1976 although in 1987 data collection became more routine and consistent. Analysis since 1987 has primarily included measurements of nutrients, chlorophyll, and water clarity. Data sources have included spring and fall turnover sampling coordinated by the Water and Environmental Analysis Laboratory at UW – Stevens Point, Self Help monitoring by lake volunteers and sampling by the Wisconsin DNR as part of ongoing research into water quality trends in Wisconsin lakes.

Additional research

A comprehensive lake survey commissioned by the Long Lake Association was conducted by R.A. Smith and Associates, Inc. in 1993 and 1994. This study assessed lake water quality, aquatic plants, hydrology, and nutrient inputs. In 2004, Aquatic Biologists, Inc. conducted a survey of aquatic plants in Long Lake, producing results that included recommendations for management and improvement of the lake.

The current study of Long Lake was conducted with the following goals 1) to gather baseline information on the physical, chemical and biological aspects of Long Lake and the surrounding watershed, 2) to identify and prioritize management concerns, and 3) to provide information needed to make informed decisions regarding the future management of the waters both ecologically and sociologically.

Zebra mussels

The following information was provided by Jim Schiek, board member of the Long Lake Association regarding the history of zebra mussels (*Dreissena polymorpha*) in the lake.

History of Zebra Mussels, Long Lake, Saxeville, WI

In August of 2002, two zebra mussel shells were found on the north shore of Long Lake by a teenager who was snorkeling in about 4-5 feet of water. The shells were taken to the DNR office in Wautoma where Scott Provost identified them as zebra mussel shells. Also earlier that summer, Mary Gansberg of the DNR had taken water samples which were sent to the state lab for analysis. The results confirmed the existence of free swimming zebra mussel larvae (veligers).

The following spring (2003), with the help of several volunteers, eight (8) artificial substrate monitoring samplers were placed at strategic locations around each basin. The samplers were a piece of 4" PVC pipe cut in half, 24" in length. They were hung under either a dock or raft preferably in a shady location. Two additional DNR zebra mussel sampling stations were added to the program in 2004 and 2005.

At our annual meeting in July of 2003, Mary Gansberg of the DNR did an informal presentation to teach the lake association membership how to identify zebra mussels. She displayed samples of zebra Mussel shells at various stages of growth. This provided approximately 50-75 property owners an awareness of what to look for when inspecting docks, rafts, piers and monitoring stations.

At the end of each season, Labor Day weekend, there's a group of property owners that go around the lake assisting each other with the removal of the piers, rafts and boat lifts. In fact, in 2005 Dick Sachs of the DNR joined us and assisted with the inspection process. Not a single sighting of zebra mussels was reported as a result of this activity.

In 2004, Chad Cason completed an aquatic plant survey to determine if any exotic plant species (Eurasian water-milfoil, curly-leaf pondweed, and purple loosestrife) were present in Long Lake. No exotic species were found. Chad did note that they were not necessarily looking for zebra mussels but that none were encountered.

Tom Catlin, a long time lake resident, also reported that amateur divers inspected fish cribs and did not find any Zebra mussels.

The purpose of the monitoring was to determine if there is in-lake reproduction of Zebra mussels occurring and/or to monitor the growth and location of adult colonies within Long Lake. In Jan 2006 we submitted the results to Dick Sachs of the DNR and requested that Long Lake be de-listed. The request was granted and Long Lake was placed on the DNR watch list.

The old monitoring samplers were retired in 2008 but will be replaced with six (6) new, official DNR zebra mussel sampling stations this summer.

By Jim Schiek, April 13, 2009

The following page contains a letter by Dick Sachs, Wisconsin DNR regarding the delisting of Long Lake from the list of waterbodies within the State which contain zebra mussels.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary
Ronald W. Kazmierczak, Regional Director

Northeast Region Headquarters
2984 Shawano Ave., P.O. Box 10448
Green Bay, Wisconsin 54307-0448
Telephone 920-662-5100
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February 2, 2006

James Schiek
Long Lake Association
PO Box 9
Saxeville, WI 54976

Subject: Zebra Mussel De-Listing

Dear Mr. Schiek:

The department has received and reviewed the zebra mussel monitoring information recently submitted by the Long Lake Association, for the purpose of addressing the lake association's request to consider the removal of Long Lake from the List of Zebra Mussel Infested Water Bodies. Along with the information provided by the lake association, data collected through the department's zebra mussel monitoring activities were also reviewed. Together, these data sets exhibit:

- Two consecutive years of veliger (larval zebra mussel) monitoring without a positive result.
- Three consecutive years of sampler deployment in the lake without finding any zebra mussels.
- Three consecutive years of monitoring in-lake substrates (piers, boats, etc.) without finding any zebra mussels.

These findings meet the department's criteria for de-listing, and therefore it is our decision to remove Long Lake from the List of Zebra Mussel Infested Water Bodies.

Long Lake will be put on the Zebra Mussel Watch List with other water bodies where zebra mussels have been detected, but have not established sustaining populations. The department considers the water bodies on this list as priorities for zebra mussel monitoring, thus the department will continue to monitor Long Lake for veligers. Accordingly, the lake association should also continue its zebra mussel monitoring efforts, specifically the deployment of the substrate samplers (half-pipe and plate samplers) and the inspection of docks, boats, etc. by residents.

In conjunction with this decision to de-list Long Lake, we will be replacing the yellow *Aquatic Invasive Species Advisory* sign at the Long Lake boat landing with a *Help Prevent the Spread* sign. It's our understanding that the lake association feels that such action will enhance its efforts to prevent the introduction of aquatic invasive species (AIS) to Long Lake. In that spirit of prevention, we encourage the lake association's ongoing efforts and pledge our support and willingness to work in partnership with you to keep Long Lake AIS-free!

Sincerely,

Richard Sachs
Aquatic Invasive Species Coordinator, Northeast Region

Cc: Ron Martin, Scott Provost, Steve Galarneau

Figure 1. Area surrounding Long Lake in Waushara County, Wisconsin.

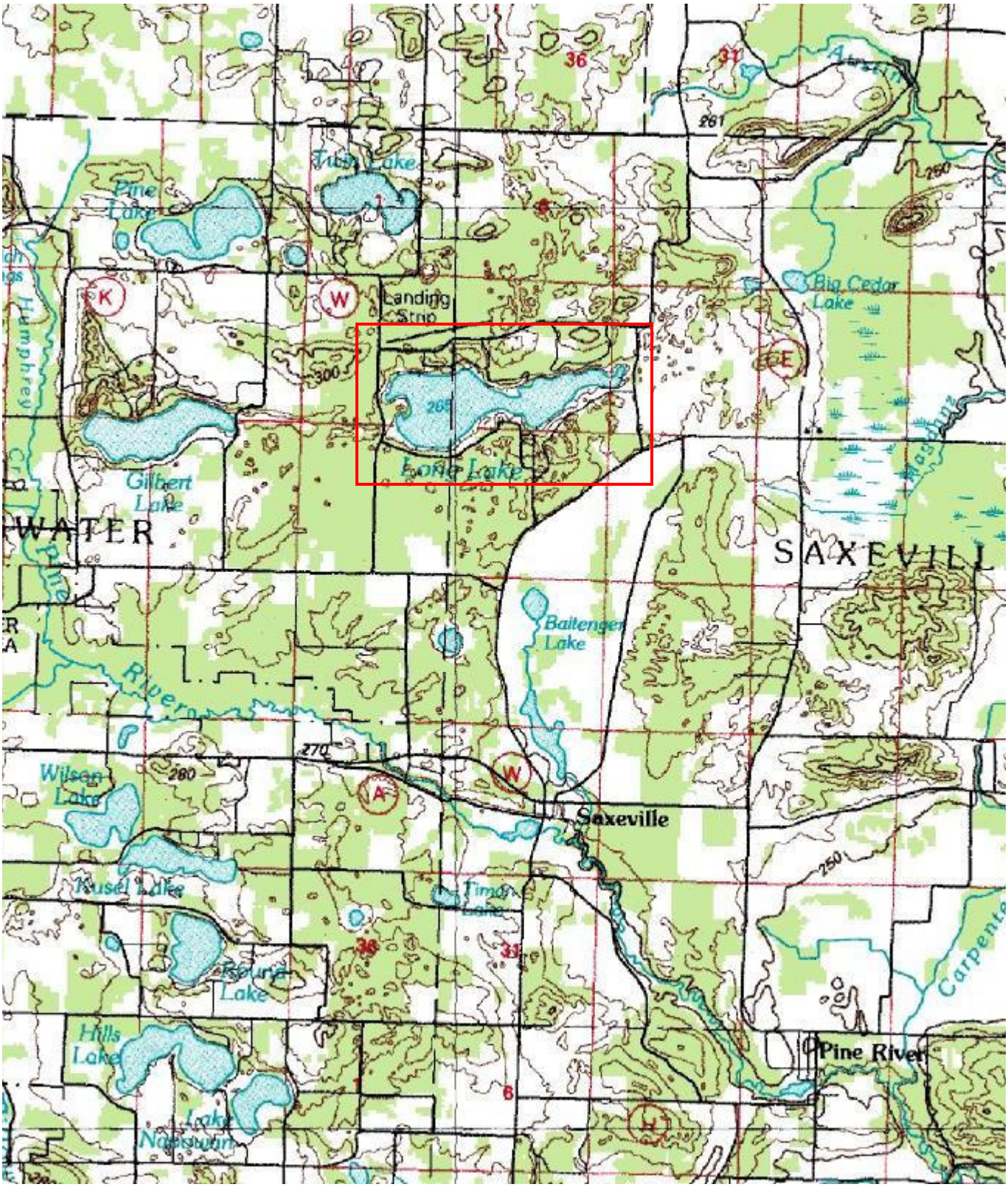
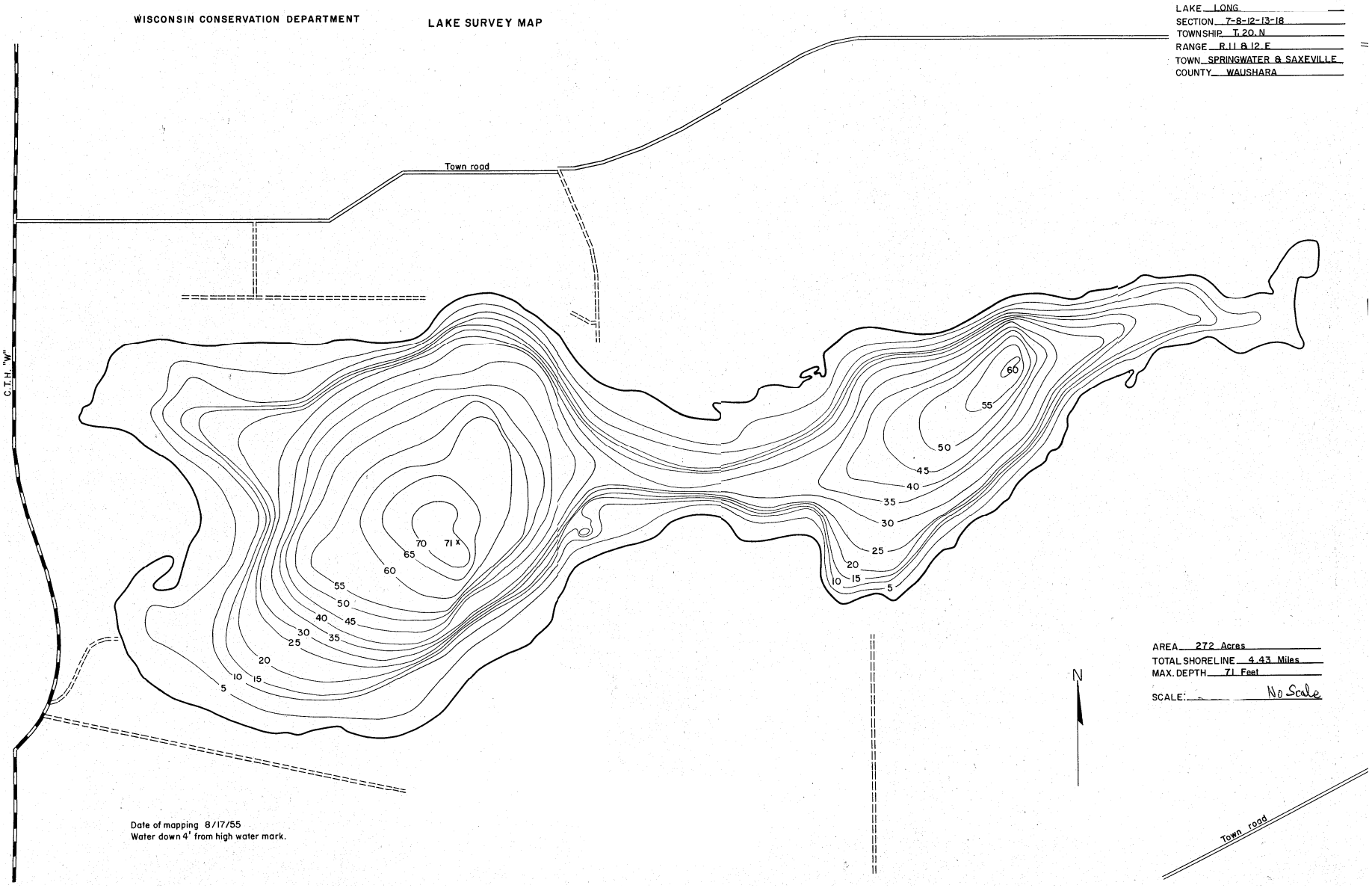


Figure 2. Long Lake in Waushara County, Wisconsin.



Methods

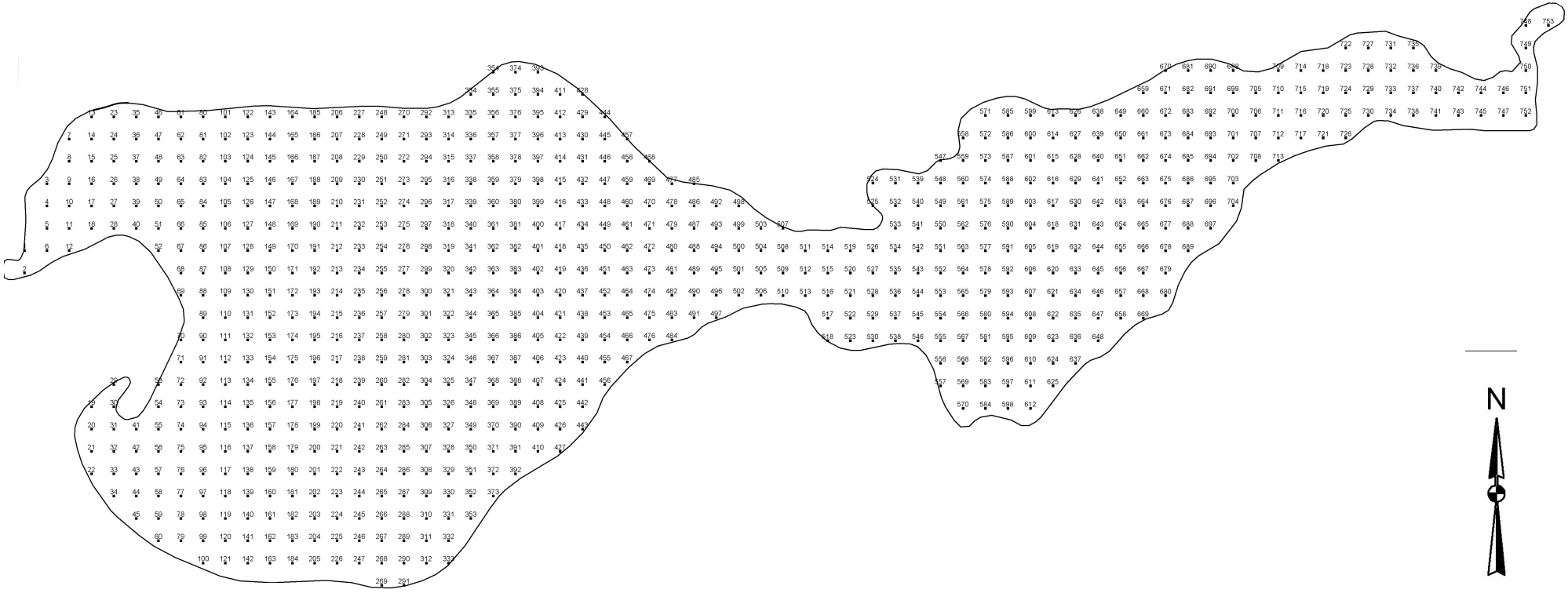
Submergent Aquatic Plant Survey

On August 28-29, 2008, a submergent aquatic plant survey was conducted. Within the past few years, DNR guidelines pertaining state-wide to the design and implementation of aquatic plant surveys have been established. These guidelines specifically require the use of a point-intercept method. Previous surveys in Long Lake have utilized a transect method. Under the guidance of Jennifer Hauxwell from the DNR, an approved plant survey map for Long Lake has been designed (**Figure 3**), in which a series of grid points were mapped across the lake. In total 753 points were mapped across the lake. At each location, aquatic plant samples were collected from a boat with a single rake tow. The rake used consisted of two short-toothed garden rake heads welded together and attached to a rope which was thrown from the boat. At each sample point, the rake was dragged along the bottom for approximately 2.5 feet to collect plants. All plant samples collected were identified to *genus* and *species* whenever possible, and the information was recorded. An abundance rating was given for exotic species collected using the criteria described in **Figure 4**. In addition to the plant data, depth and bottom substrate composition were recorded for each point intercept. Data collected has been be used to determine species composition, percent frequency and relative abundance. This data has also been used to develop distribution maps of the most abundant plant species.

Exotic Plant Distribution Mapping

On two occasions, surveys for exotic species namely Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), and Zebra mussels were conducted on Long Lake. These surveys utilized surface observations and rake tows to determine the possible extent and locations of these species. The point intercept locations identified in **Figure 3** were used as a guide for these surveys as well. The first survey was conducted on June 11, 2008. This survey was conducted earlier in the season to best identify curly-leaf pondweed, which dies back later in the summer, when water temperature rises. A second exotic species mapping effort was made at the time of the point-intercept survey on August 28-29, 2008.

Figure 3. Long Lake aquatic plant survey map.



N

WISCONSIN
DEPT. OF NATURAL RESOURCES

0 0.4 Kilometers

Long Lake
Waushara County
WBIC 191100
T20N R11E S12
254 acres / 102.9 ha
753 Sampling Points
37m between Points
Site1: Lat. 44.21680255
Long. -89.13725555
Created: 2007

Figure 4. Plant abundance rating criteria used in submergent aquatic plant surveys.

Rating	Coverage	Description
1		A few plants on rake head
2		Rake head is about ½ full Can easily see top of rake head
3		Overflowing Cannot see top of rake head

Water Quality Assessment

Each spring, water samples are collected by Long Lake volunteers and sent to UW-Stevens Point for analysis. In 2008, the assessment of water quality was expanded to include summer sampling. Sampling took place in July, August, and September. Analyses included:

- pH
- Conductivity
- Alkalinity
- Total phosphorus
- Nitrate + nitrite as N
- Chlorophyll *a*
- Dissolved oxygen profile
- Temperature profile
- Secchi depth

Because of the two distinct basins within Long Lake, samples were collected at the deep points within the east and the west basins of the lake on each of the sampling dates. For all sampling dates, dissolved oxygen, temperature and Secchi depth were analyzed in the field. For the remaining parameters, samples were sent to the State Lab of Hygiene for analysis of nutrients and chlorophyll.

Historic water quality data for Long Lake has been collected from a number of sources including the DNR's Surface Water Integrated Monitoring System (SWIMS) and the EPA's Storet site. All available data has been collected and used to assess the chemical characteristics of Long Lake.

Chlorophyll *a*, total phosphorus and Secchi depth data collected during the summer months was used to quantify the productivity of the lake (Trophic State Index).
Software available from the WDNR entitled Wisconsin Lake Modeling Suite (WiLMS) was used to predict the trophic state of Long Lake given its size, watershed area, mean depth and ecoregion. Comparisons were made between the predicted TSI values and those calculated from the phosphorus, chlorophyll and Secchi data collected in 2008.
In addition, this software was used to predict the spring overturn, growing season mean, and annual average total phosphorus concentration in Long Lake. Comparisons were made between the predicted phosphorus and TSI values and those calculated from the phosphorus, chlorophyll and Secchi data for the August sampling. The WiLMS program was also used to estimate the internal nutrient loading occurring in Long Lake by incorporating nutrient and dissolved oxygen data.

Watershed Assessment

Because much of what happens in the watershed surrounding a lake can impact the overall water quality and health of a lake, it is important to investigate and document aspects of the watershed which can have such an impact.

The boundary of the watershed of Long Lake was delineated by using topographic maps and aerial photos. Data obtained from the Wisconsin DNR's Bureau of Technology

Services was used to determine the land-use and vegetative cover types within the watershed. The percent cover for each of these categories has been determined and presented. Land use patterns, vegetative cover, potential nutrient loading sources, and environmentally sensitive areas were further assessed visually. Information from the Wisconsin DNR and Waushara County was used to assess conditions within the watershed and areas within the County outside the watershed.

The WiLMS software was also used to estimate the external loading of runoff pollutants, namely phosphorus, into Long Lake. The software uses export coefficients for various land-use and cover types as well as precipitation, point sources and septic systems to represent phosphorus loading into the lake from external sources. This software also takes in account lake morphology, watershed drainage area and net precipitation.

The boundary of the watershed of Long Lake was delineated using topographic maps. ArcView GIS software was used to determine land- use patterns and vegetative cover. A ground survey of the watershed was conducted in an effort to identify potential nutrient loading sources and environmentally sensitive areas. The WiLMS software was used to estimate external and internal loading of phosphorus by assessing point and non-point sources of nutrients.

Data available from the Natural Resources Conservation Service (NRCS) was used to determine the soil types within the Long Lake watershed. This data includes percent cover for and the characteristics of each soil type.

Since a significant amount of nutrients and sediments can enter a lake from areas closest to the lake, it is important to also focus on the conditions nearest the lake and identify potential areas of concern. Possible areas of disturbance, high erosion, or generally poor riparian health were assessed. Suggestions for remediation or improvement of such areas have been included in this report.

Results

Aquatic Plant Community

Coordinates for the sampling points within the lake can be found in **Appendix A**.

Although 753 points were mapped across the Long Lake, vegetation was found at only 300 locations at the time of the survey. The remaining locations were predominantly too deep for aquatic plants to grow. Some locations (28 total) were either terrestrial or too shallow to navigate. A total of 19 aquatic plant species were found during the 2008 survey (**Table 1**). This is above the state-wide average of 13 species. Long Lake lies near the border of the Northern Central Hardwood Forests and Southeastern Wisconsin Till Plain regions of Wisconsin. The average number of species found in lakes in this region is 14 species (Nichols, 1999). The most abundant plant species encountered in Long Lake were muskgrass (*Chara* sp.), variable pondweed (*Potamogeton gramineus*) and bushy pondweed (*Najas flexilis*). Muskgrass was found at nearly 94% of the points sampled. Variable and bushy pondweeds were found at approximately 25% of these points. **Figures 5-7** show the distribution and density of these species across Long Lake at the time of the survey.

Percent frequency values reflect the relationship between the number of locations where a particular species was found versus the total number of locations sample. Relative frequency values reflect the abundance of a particular species in relation to all other species found.

In 2004 a similar submergent plant survey was conducted on Long Lake. This survey however, utilized a different survey methodology. This survey involved plotting a series of 23 transects approximately even distances around the lake shoreline. These transects extended at 90 degree angles from shore to a depth of twenty feet. Sampling plots were established along each transect at 2.5, 5, 10 and 20 foot depth contours. At each plot a 10-foot radius circle was estimated around the anchored boat. The circle was divided into four quarters, with each quarter representing a quadrant. Plants were collected in each quadrant with a rake. From each rake tow, all plants collected were identified to genus and species. Data was recorded separately for each quadrant. A total of 336 quadrants were sampled. The results of this survey are shown in **Table 2**. When compared to the results from 2008, as expected, many similarities exist. The most abundant species were found in each survey, albeit at different frequencies. Also, the 2008 survey identified more species than the 2004 survey. These differences are likely due to the methods used and the level of detail between the two surveys. Also, changes to the plant community of a lake are expected from year to year.

The raw data for the 2008 submergent aquatic plant survey can be found in **Appendix B**.

Figure 8 presents the relative abundance of submergent aquatic plant species found in Long Lake at the time of the 2008 survey.

Table 1. Results of the submergent aquatic plant survey conducted on Long Lake on August 28-29, 2008.

Species common name	scientific name	Percent Frequency	Relative Frequency
Muskgrass	*Chara* sp.	93.67	47.8
Variable pondweed	*Potamogeton gramineus*	25.33	12.9
Bushy pondweed	*Najas flexilis*	25.00	12.8
Wild celery	*Vallisneria americana*	11.33	5.8
Sago pondweed	*Stuckenia pectinata*	10.67	5.4
Northern water milfoil	*Myriophyllum sibiricum*	7.67	3.9
Illinois pondweed	*Potamogeton illinoensis*	5.67	2.9
Small pondweed	*Potamogeton pusillus*	3.67	1.9
Frie's pondweed	*Potamogeton friesii*	2.67	1.4
White water lily	*Nymphaea odorata*	2.33	1.2
White-stem pondweed	*Potamogeton praelongis*	1.67	0.9
Flat-stem pondweed	*Potamogeton zosteriformis*	1.67	0.9
Large-leaf pondweed	*Potamogeton amplifolius*	1.00	0.5
Floating-leaf pondweed	*Potamogeton natans*	1.00	0.5
Nitella	*Nitella* sp.	0.67	0.3
Clasping-leaf pondweed	*Potamogeton richardsonii*	0.67	0.3
Common bladderwort	*Utricularia vulgaris*	0.67	0.3
Common waterweed	*Elodea canadensis*	0.33	0.2
Robbins pondweed	*Potamogeton robbinsii*	0.33	0.2
Coontail	*Ceratophyllum demersum*	visual	--

Table 2. Results of the submergent aquatic plant survey conducted on Long Lake in 2004.

Species common name	scientific name	Percent Frequency	Relative Frequency
Muskgrass	*Chara* sp.	87.70	49.9
Variable pondweed	*Potamogeton gramineus*	19.90	11.3
Bushy pondweed	*Najas flexilis*	2.70	1.5
Wild celery	*Vallisneria americana*	8.70	5.0
Sago pondweed	*Stuckenia pectinata*	5.70	3.3
Northern water milfoil	*Myriophyllum sibiricum*	13.00	7.4
Illinois pondweed	*Potamogeton illinoensis*	24.40	13.9
Small pondweed	*Potamogeton pusillus*	--	--
Frie's pondweed	*Potamogeton friesii*	--	--
White water lily	*Nymphaea odorata*	0.30	0.2
White-stem pondweed	*Potamogeton praelongis*	1.20	0.7
Flat-stem pondweed	*Potamogeton zosteriformis*	3.90	2.2
Large-leaf pondweed	*Potamogeton amplifolius*	4.80	2.7
Floating-leaf pondweed	*Potamogeton natans*	3.00	1.7
Nitella	*Nitella* sp.	--	--
Clasping-leaf pondweed	*Potamogeton richardsonii*	--	--
Common bladderwort	*Utricularia vulgaris*	--	--
Common waterweed	*Elodea canadensis*	--	--
Robbins pondweed	*Potamogeton robbinsii*	--	--
Coontail	*Ceratophyllum demersum*	0.3	0.2

Figure 5. Distribution of muskgrass (*Chara* sp.) on August 28-29, 2008 in Long Lake, Waushara County, WI

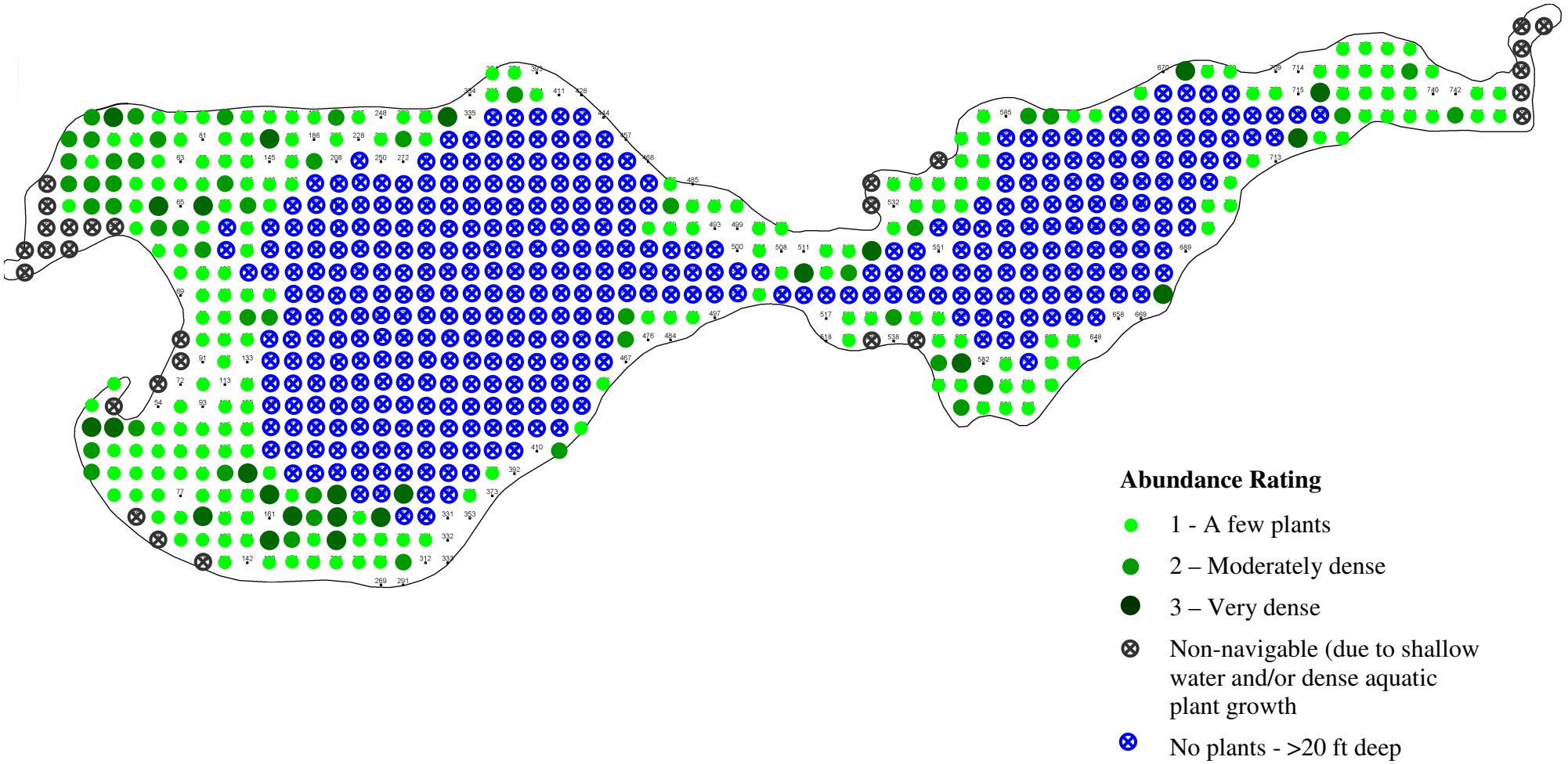


Figure 6. Distribution of variable pondweed (*Potamogeton gramineus*) on August 28-29, 2008 in Long Lake, Waushara County, WI

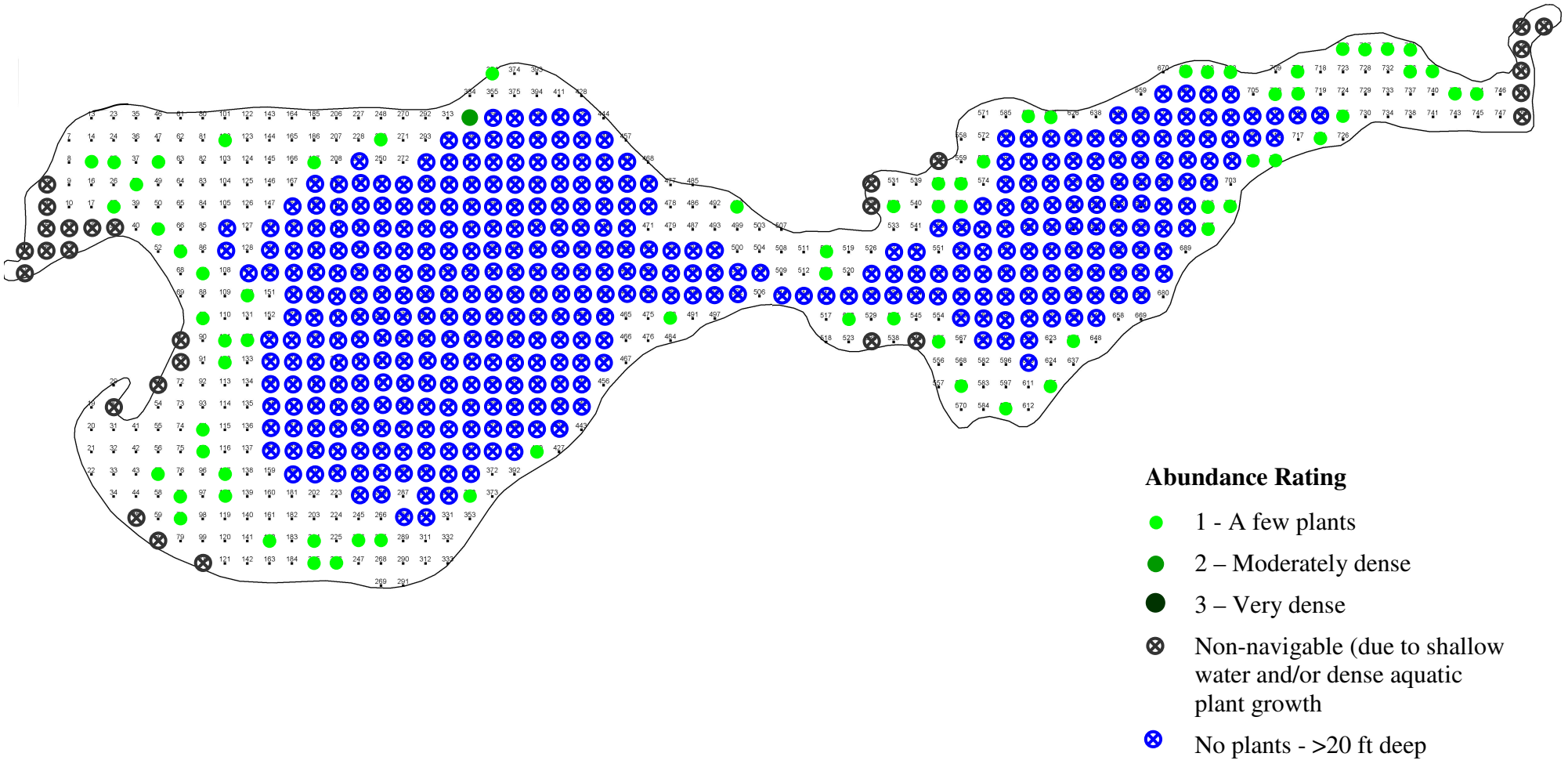


Figure 7. Distribution of bushy pondweed (*Najas flexilis*) on August 28-29, 2008 in Long Lake, Waushara County, WI

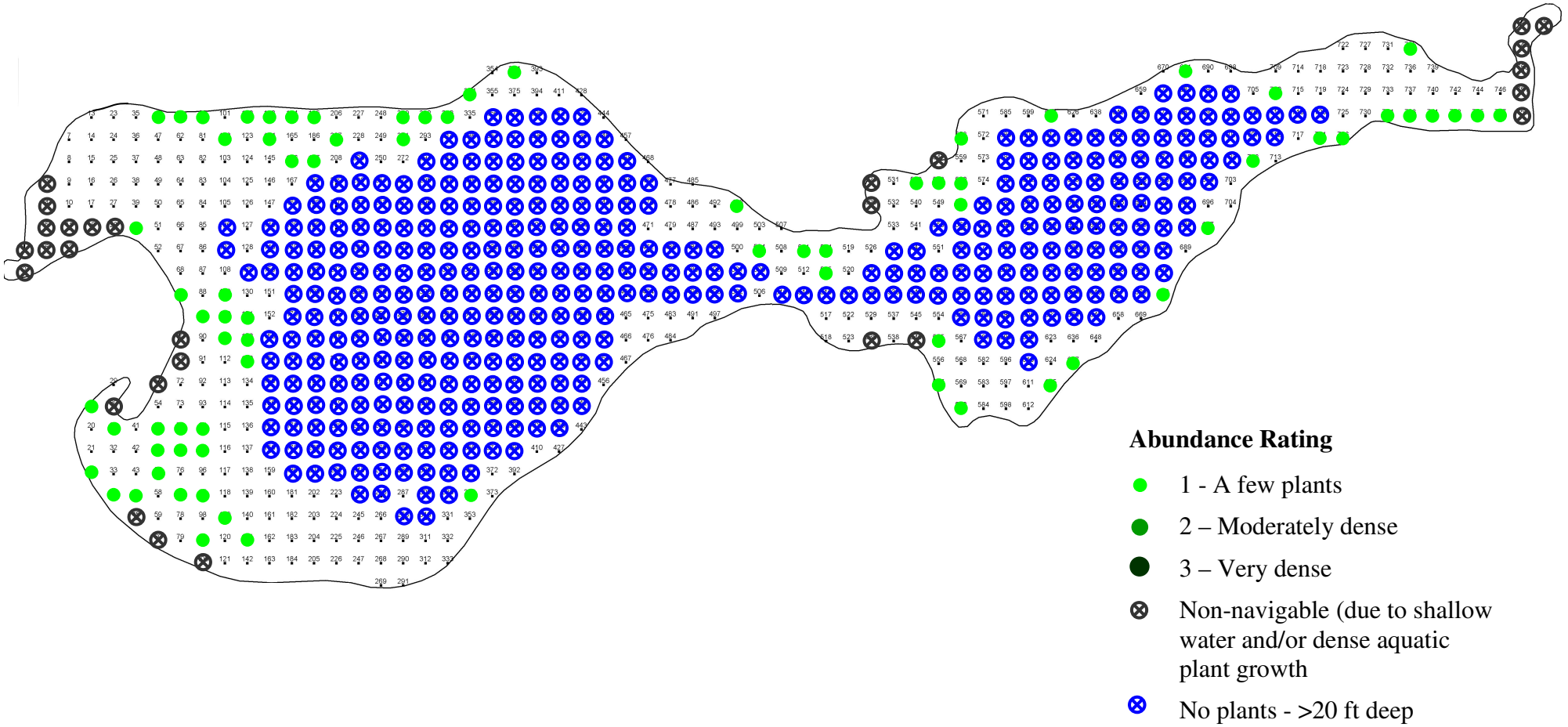
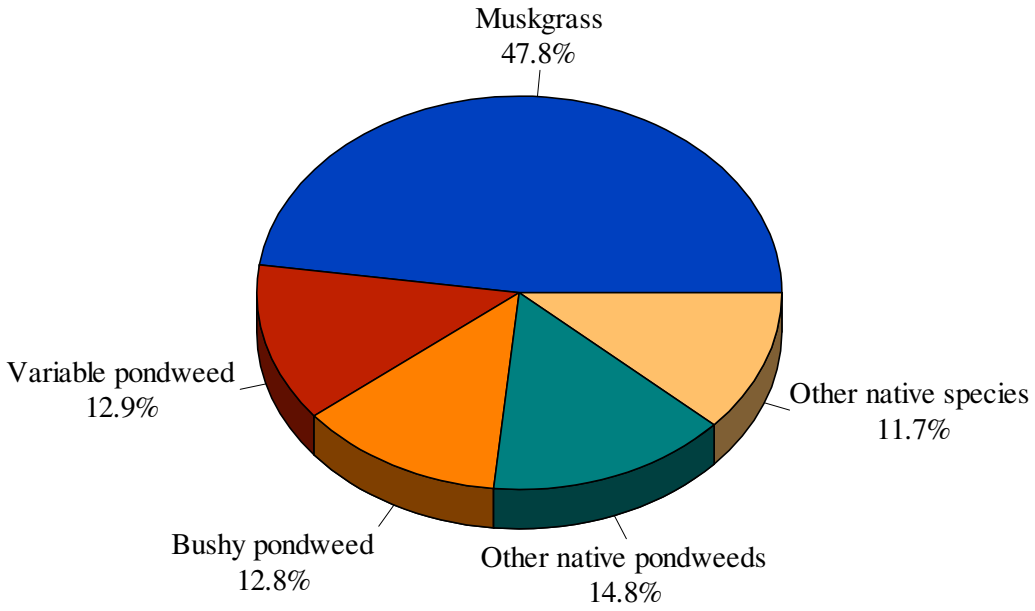


Figure 8. Submergent aquatic plant community composition for Long Lake, on August 28-29, 2008 in Long Lake, Waushara County, WI



Simpson Diversity Index

In order to estimate the diversity of the aquatic plant community, the Simpson Diversity Index takes in account both the number of species identified (richness) and the distribution or relative abundance of each species. As these parameters increase, so does the overall diversity. With the Simpson Diversity Index (D), 1 represents infinite diversity and 0, no diversity. That is, the bigger the value of D, the higher the diversity. The value of D calculated for Long Lake based on the 2008 data was 0.73.

Assessment of Floristic Quality

The plant data collect for Long Lake were used to assess the "floristic quality" of the lake. The method used assigns a value to each native plant species called a Coefficient of Conservatism. Coefficient values range from 0-10 and reflect a particular species' likelihood of occurring in a relatively undisturbed landscape. Species with low coefficient values, such as coontail, are likely to be found in a variety of habitat types and can tolerate high levels of human disturbance. On the other hand, species with higher coefficient values, such as wild rice, are much more likely to be restricted to high quality natural areas. By averaging the coefficient values available for the submergent and emergent species found in Long Lake, a lake-wide value of 6.26 was calculated (see **Table 3**). The average value for lakes in Wisconsin is 6.0 while the combined average for lakes in the Northern Central Hardwood Forests and Southeastern Wisconsin Till Plain regions of Wisconsin. is 5.6 (Nichols, 1999).

Table 3. Long Lake Floristic Quality Index (FQI) analysis table.

Species	Common Name	C
Chara spp.	Muskgrasses	7
Elodea canadensis	Common waterweed	3
Myriophyllum sibericum	Northern water-milfoil	7
Najas flexilis	Bushy pondweed	6
Nitella	Nitella	7
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton friesii	Frie's pondweed	8
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton natans	Floating-leaf	5
Potamogeton praelongis	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Robbins pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Stuckenia pectinata	Sogo pondweed	3
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
	N	19
	mean C	6.26
	FQI	27.3

By utilizing the Coefficients of Conservatism for the plant species of Long Lake, further assessment of floristic quality can be made. By multiplying the average coefficient values for Long Lake by the square root of the number of plant species found, a Floristic Quality Index (FQI) was calculated at 27.3 (see **Table 3**). In general, higher FQI values reflect higher lake quality. The average for Wisconsin lakes is 22.2. The average for lakes in the Northern Central Hardwood Forests and Southeastern Wisconsin Till Plain regions is 20.9 (Nichols, 1999). Both Coefficient of Conservatism and the Floristic Quality Index values suggest the quality of Long Lake specifically in terms of the plant community, is above average.

Aquatic plants serve an important purpose in the aquatic environment. They play an instrumental role in maintaining ecological balance in ponds, lakes, wetlands, rivers, and streams. Native aquatic plants have many values. They serve as important buffers against nutrient loading and toxic chemicals, act as filters that capture runoff-borne sediments, stabilize lakebed sediments, protect shorelines from erosion, and provide critical fish and wildlife habitat. Therefore, it is essential that the native aquatic plant community in Long Lake be protected. **Appendix C** provides a list of the more abundant native aquatic plant species that were found in Long Lake. Ecological values and a description are given for each species.

Exotic Plant Distribution Mapping

No exotic species were identified during either the June 11 or August 28 surveys of Long Lake. Of particular interest was the lack of exotic species during the extensive point-intercept plant survey in August. This survey was particularly useful in identifying exotic plant species such as Eurasian watermilfoil and curly-leaf pondweed. Also, because zebra mussels often attach themselves to aquatic plants, this survey was additionally useful in monitoring for his species as well.

Water Quality Analysis

Dissolved oxygen and temperature

Dissolved oxygen, temperature, and percent saturation data collected for the east and west basins of Long Lake in 2008 are presented in **Appendix D**. These data were used to develop the profile graphs shown in **Figures 9 and 10**. Dissolved oxygen data show that surface levels of dissolved oxygen remained high throughout the season. The threshold level of oxygen needed for fish such as bass, perch, and sunfish to survive and grow is 5 mg/L. Even at the warmest times of the year, sufficient levels of oxygen were present at the surface of the lake. However, during the summer months, oxygen levels were significantly lower in the deeper portions of the south basin. The depths at which oxygen levels dropped off, referred to as the oxycline, was at depths between 30 and 35 feet during the summer months. In many lakes of Wisconsin, this change in oxygen concentrations is seen. These conditions are referred to as lake stratification. Below the oxycline there was insufficient oxygen to support many fish species.

To better understand this data, it is important to first understand the relationship between dissolved oxygen and temperature. As a rule, colder water can hold more oxygen than warmer water. **Table 4** illustrates this point. By utilizing this relationship, the level (or percent) of saturation of oxygen can be determined at a given temperature. Saturation levels from sampling at Long Lake can also be found in **Appendix D**. A number of the readings taken throughout the year appear to exceed the oxygen solubility given in **Table 4**. For these data the dissolved oxygen levels were higher than solubility levels at the corresponding temperatures. As a result, the percent saturation levels recorded in the field were above 100%. This is referred to as supersaturation and is due to factors such as wind and wave action and biological processes. This also commonly occurs under warm sunny conditions. Percent saturation values of 80-120% are considered to be excellent and values less than 60% or over 125% are considered to be poor. With a few exceptions the saturation levels in the upper portions of Long Lake were indicative of excellent water quality.

Table 4. Oxygen solubility in water at different temperatures.

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

Figure 9. Profiles of dissolved oxygen, temperature, and percent saturation from 2008 for the east basin of Long Lake, Waushara County, WI.

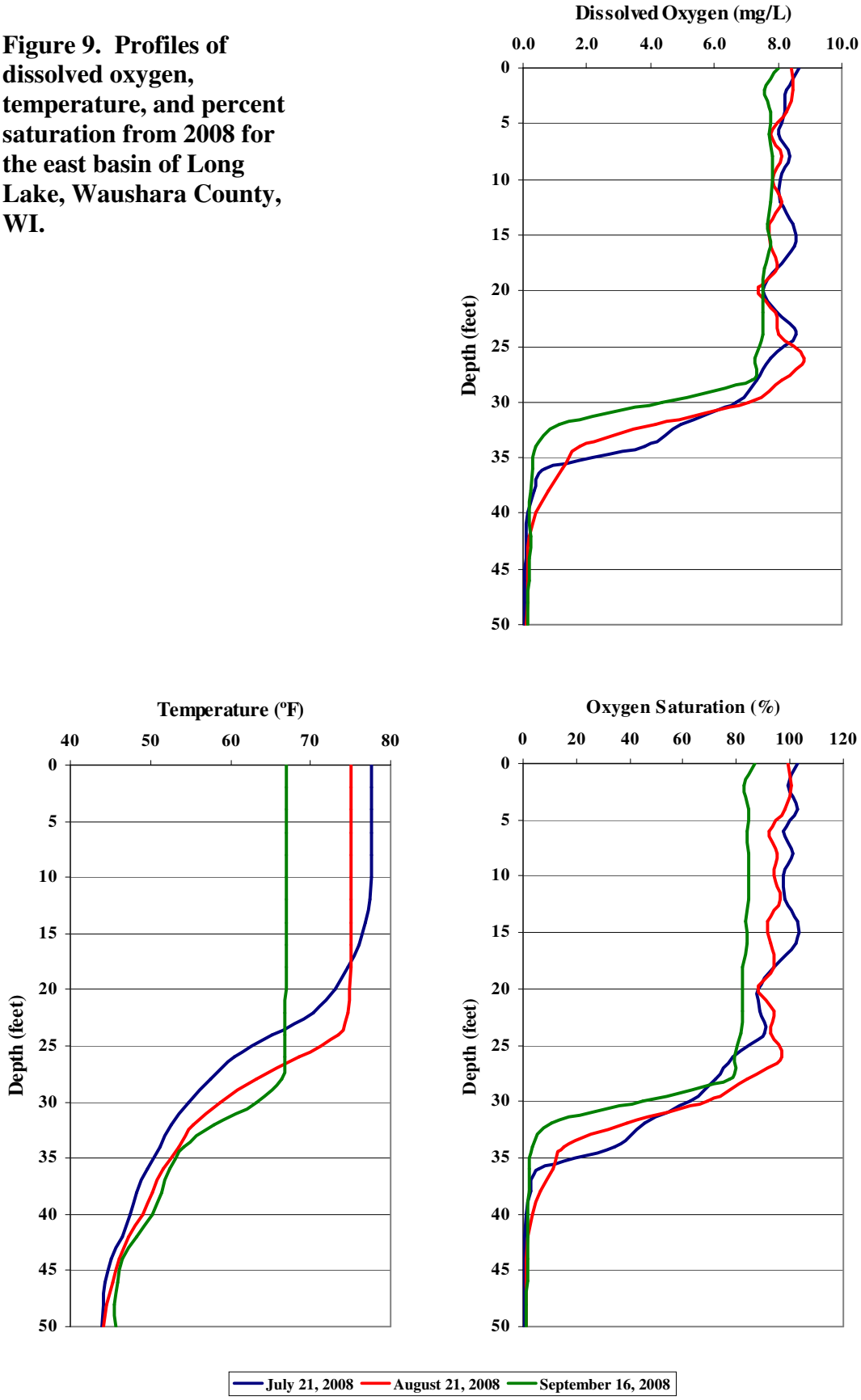
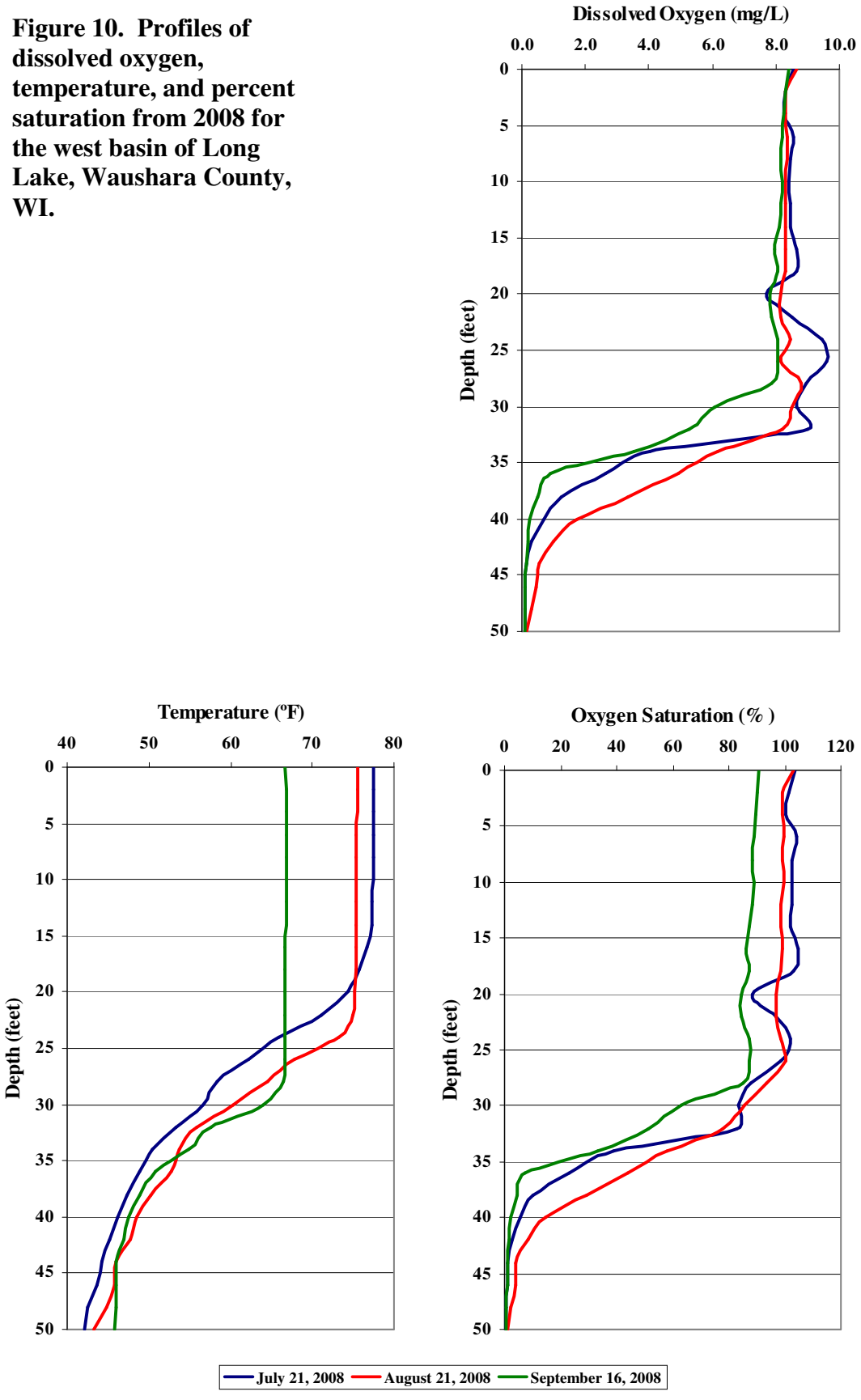


Figure 10. Profiles of dissolved oxygen, temperature, and percent saturation from 2008 for the west basin of Long Lake, Waushara County, WI.



Water Chemistry
Data available for multiple water chemistry parameters for Long Lake from 1976 to 2008 can be founding **Appendix D**. The results for parameters assessed in 2008 are discussed here.

pH
pH is a measure of a lake's acid level. It is the negative log of the hydrogen ion concentration in the water. Many factors influence pH including geology, productivity, pollution, etc. pH levels between 7 and 9.5 are not uncommon for hard water lakes in Wisconsin. pH data for Long Lake fall within this range and do not raise concern over water quality in the lake.

Conductivity
Conductivity is the measure of the inorganic compounds in a body of water as determined by how well an electrical current is carried through a water sample. Conductivity is dependant upon the concentration of inorganic compounds suspended in the water column. High conductivity values may indicate contamination from septic systems, fertilizers, animal wastes or road salts. As a result, conductivity can be used to determine if human activities are influencing water quality. The recommended value for conductivity in lake samples is below 300 μmhos/cm. The data from 2008 in both basin, were below 300 μmhos/cm.

Alkalinity
Alkalinity is a measure of the amount of carbonates, bicarbonates and hydroxide present in water. Alkalinity is predominantly determined by soil and bedrock characteristics. Lakes and ponds fed by groundwater from limestone aquifers tend to have high alkalinity. High alkalinity can also be a result of high algae and aquatic plant production. Low alkalinity (< 25 mg/L) waters are susceptible to acid rain. Alkalinity levels above 25 mg/L in Long Lake are indicative of a hard water system able to withstand acid rain conditions. These levels do not warrant concern.

Phosphorus
Total phosphorus is one of the most important water quality indicators. Because phosphorus is often the limiting factor in aquatic systems, phosphorus levels determine the amount of plant and algae growth in a lake. Phosphorus can come from external sources within the watershed (fertilizers, livestock, septic systems) or to a lesser extent, from groundwater. Phosphorus can also come from within the lake. Internal loading occurs when plants and chemical reactions release phosphorus from the lake sediments into the water column.

The average phosphorus concentration for natural lakes in Wisconsin is 0.025 mg/L (Shaw, et al, 2004). Values above 0.05 mg/L are indicative of poor water quality. With one exception in 1976, phosphorus levels have been consistently at or below 0.025 mg/L. Data in 2008 were all below 0.01 mg/L. These data indicate good water quality for Long Lake.

Chlorophyll
Chlorophyll is the pigment found in all green plants including algae that give them their green color. It is the site in plants where photosynthesis occurs. Chlorophyll absorbs sunlight to convert carbon dioxide and water to oxygen and sugars. Chlorophyll data is collected because this green pigment is found in algae and can be used to estimate how much phytoplankton (algae) there is in the lake. Generally speaking, the more nutrients there are in the water and the warmer the water, the higher the production of algae and consequently chlorophyll.

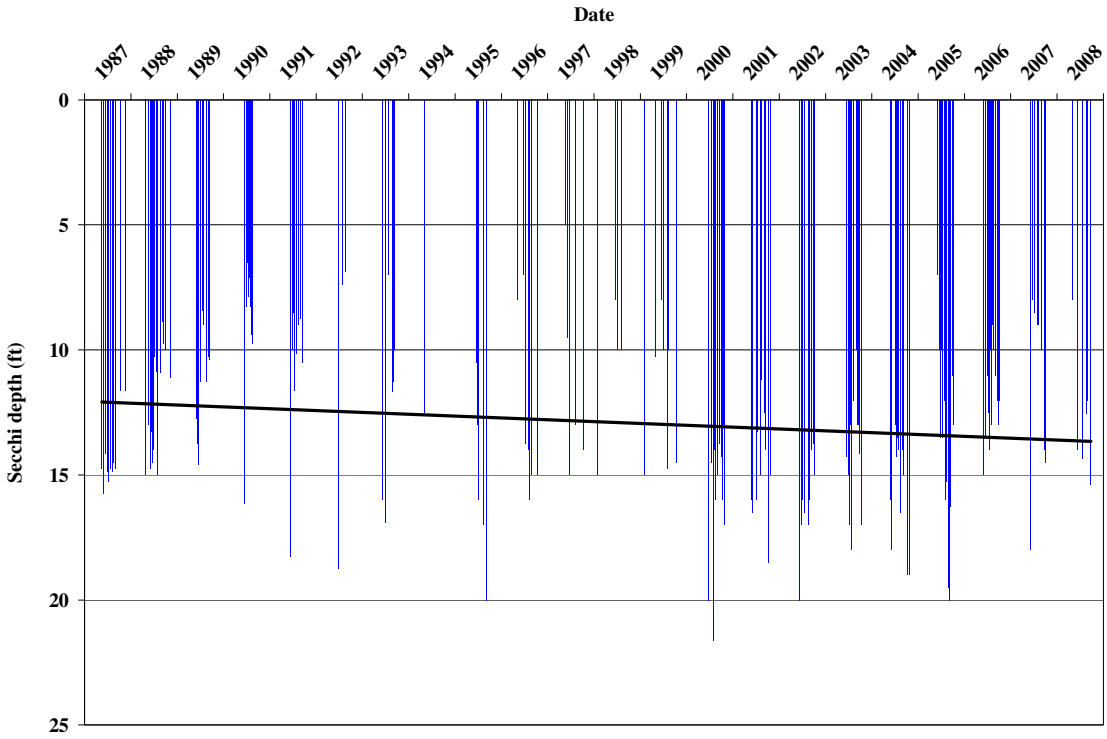
Chlorophyll concentrations below 10 ppb are most desirable for lakes. As with the phosphorus, the data collected for chlorophyll in the past 30 years were well below the level of concern. A majority of the chlorophyll were at or below 3.0 ppb.

Nitrogen
Excess nutrients (nitrates) entering groundwater in the watershed can be a significant threat to the overall water quality of Long Lake. Nitrogen is an important nutrient for plants and algae. It can enter lakes from groundwater, surface runoff (livestock manure and agricultural fertilizers) and precipitation. In addition, decomposing organic matter releases nitrogen.

Nitrogen can exist in a number of forms in aquatic systems. Samples collected from Long Lake in 2008 were tested for nitrates and nitrites. Nitrates and nitrites are inorganic forms of nitrogen which can be readily used by plants and algae. Water naturally contains less than 1 ppm of nitrogen. If the inorganic forms of nitrogen exceed 0.3 mg/l in spring, there is sufficient nitrogen to support summer algae blooms and negatively affect water quality. Nitrate and nitrite levels in Long Lake in 2008 were undetectable.

Secchi Transparency
Water clarity is often used as a quick and easy test for a lake's overall water quality, especially in relation to the amount of algae present. There is an inverse relationship between Secchi depth and the amount of suspended matter, including algae, in the water column. The less suspended matter, the deeper the Secchi disc is visible. Water clarity readings have been collected for over twenty years on Long Lake. These data can be found in **Appendix D**. **Figure 11** shows the Secchi depth data calculated for Long Lake since 1987. This figure also includes a black line showing the overall trend in water transparency over this timeframe. Secchi depths deeper than six feet are generally indicative of good water quality. Long Lake has consistently had transparencies greater than six feet over the past 20 years.

Figure 11. Water clarity data from 1988-1989, 1992-1994, and 2001 to present for Long Lake, Waushara County, Wisconsin.



Trophic State

There is a strong relationship between levels of phosphorus and chlorophyll and water clarity in lakes. As a response to rising levels of phosphorus, chlorophyll levels increase and transparency values often decrease. The effect of this is viewed as an increase in the productivity of a lake.

Lakes can be categorized by their productivity or trophic state. When productivity is discussed, it is normally a reflection of the amount of plant and animal biomass a lake produces or has the potential to produce. The most significant and often detrimental result is elevated levels of algae and nuisance aquatic plants. Lakes can be categorized into three trophic levels:

- oligotrophic - low productivity, high water quality
- mesotrophic - medium productivity and water quality
- eutrophic - high productivity, low water quality

These trophic levels form a spectrum of water quality conditions. Oligotrophic lakes are typically deep and clear with exposed rock bottoms and limited plant growth. Eutrophic lakes are often shallow and marsh-like, typically having heavy layers of organic silt and abundant plant growth. Mesotrophic lakes are typically deeper than eutrophic lakes with significant plant growth, and areas of exposed sand, gravel or cobble bottom substrates.

Lakes can naturally become more eutrophic with time, however the trophic state of a lake is more influenced by nutrient inputs than by time. When humans negatively influence the trophic state of a lake the process is called *cultural eutrophication*. A sudden influx of available nutrients may cause a rapid change in a lake's ecology. Opportunistic plants such as algae and nuisance plant species are able to out-compete other more desirable species of macrophytes. The resultant appearance is typical of poor water quality.

Total phosphorus, chlorophyll and Secchi depth are often used as indicators of the water quality and productivity (trophic state) in lakes. Values measured for these parameters can be used to calculate Trophic State Index (TSI) values (Carlson 1977). The formulas for calculating the TSI values for Secchi disk, chlorophyll, and total phosphorus are as follows:

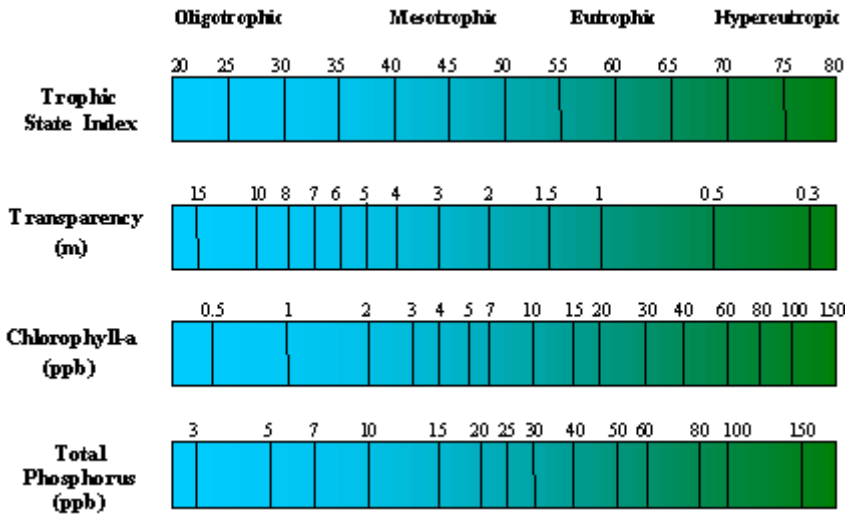
$$TSI = 60 - 14.41 \ln \text{Secchi disk (meters)}$$

$$TSI = 9.81 \ln \text{Chlorophyll } (\mu g/L) + 30.6$$

$$TSI = 14.42 \ln \text{Total phosphorus } (\mu g/L) + 4.15$$

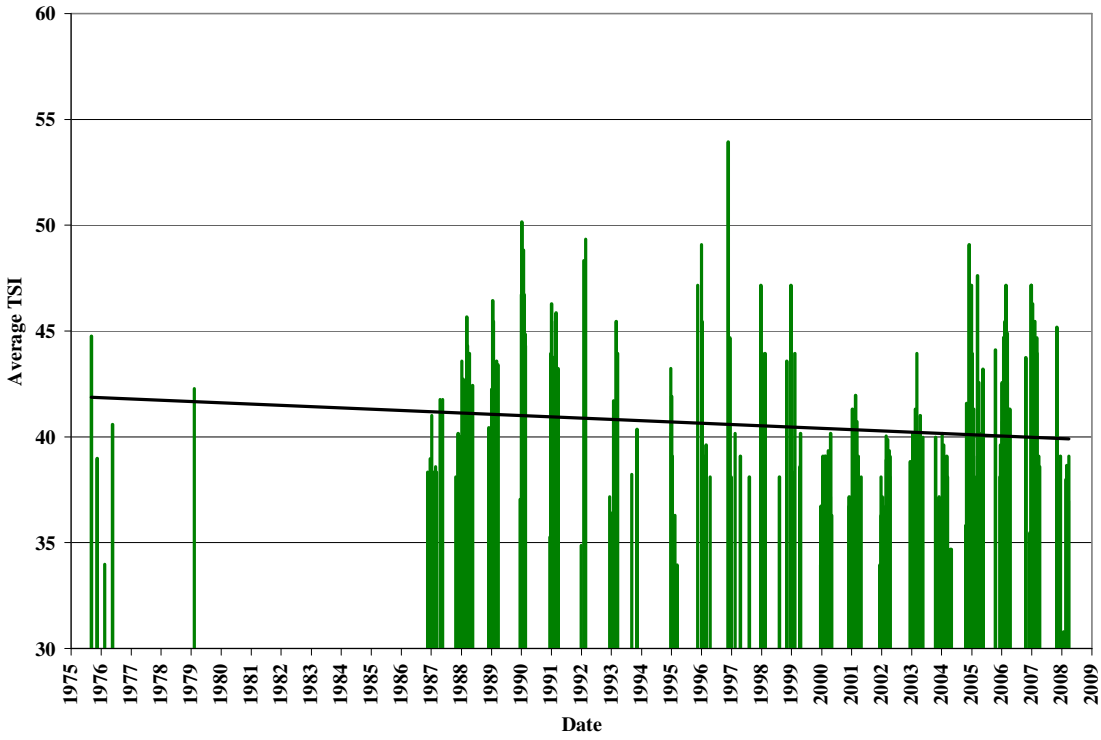
The higher the TSI calculated for a lake, the more eutrophic it is (**Figure 12**).

Figure 12. Relationship between trophic state in lakes and parameters including Secchi transparency, chlorophyll, and total phosphorus.



Classic eutrophic lakes have TSI values starting around 50. **Figure 13** shows the average TSI values dating back to 1976. In some cases the value of only one parameter was available. Other times the line on the graph represents the averaging of multiple parameters and in some cases the two basins. The TSI values fell below 50 nearly every time. In addition, the average TSI value since 1976 is 40.7. The average TSI value since 2000 is 39.7. This graph also has a black line indicating the overall trend in TSI values since 1976. The TSI data show that Long Lake falls within the lower end of a classic mesotrophic lake.

Figure 13. Average Trophic State Index values from 1976-2008 for Long Lake, Waushara County, WI.



Software available from the WDNR entitled Wisconsin Lake Modeling Suite (WiLMS) was used to predict the trophic state of Long Lake given its size, watershed area, mean depth and ecoregion. Comparisons were made between the predicted TSI values and those calculated from the phosphorus, chlorophyll and Secchi data for the July, August and September sampling events. In each category, the observed or measured values for these parameters were found to be lower than those predicted by the WiLMS software. In other words, water quality of Long Lake is greater than expected and above the average value for the North Central Hardwood Forests Ecoregion.

The WiLMS software was also used to estimate the internal and external loading of phosphorus into Long Lake. The software uses export coefficients for various land-use and cover types as well as precipitation, point sources and septic systems to represent phosphorus loading into the lake from external sources. This software also takes in account a number of other factors including lake morphology, watershed drainage area,

net precipitation, oxygen stratification, measured phosphorus concentrations during turnover and the growing season, and estimated area of anoxia. By inputting data for a number of these factors, the WiLMS software was able to predict the total annual phosphorus load into Long Lake. In total, the model estimated 1,433 kg (3,163 lbs) of phosphorus enter the lake annually from non point sources, aerial deposition, and septic systems. In addition, the annual internal loading of phosphorus was estimated at 109 kg (241 lbs). The internal loading value is low because only a small area of the lake becomes anoxic (areas greater than 30-35 feet) in the summer. It is under anoxic conditions that nutrients, namely phosphorus are released from the sediments in lakes.

Watershed Analysis

In August 2008, the watershed analysis was conducted. **Figures 14 and 15** show the delineation of the Long Lake watershed and the land use types present. The data for the land use map (**Figure 15**) was provided by the WDNR's Bureau of Technology Services.

The survey and resulting analysis found that the watershed of Long Lake is approximately 457.2 acres (0.71 mi^2). This is a small watershed relative to the size of the lake (272 acres). This is due to steep slopes around a majority of the lake; particularly along the south shore. In addition, areas just south of South Shore Drive and South Long Lake Road appeared to drain toward the lake. However, the elevated roads and lack of culverts cause rain water to be diverted away from the lake. This too limits the size of the watershed.

Information available online from the Wisconsin DNR indicates that areas within the Long Lake watershed have not been listed as environmentally sensitive areas.

Table 5 contains a breakdown of land use and cover types within the watershed of Long Lake. Not surprisingly, the watershed as a whole is dominated (over 90%) by coniferous and deciduous forests. In addition, 6.3% of the watershed is agricultural fields and 2.8% is wetland.

Table 5. Land use and cover types found within the watershed of Long Lake, Waushara County, Wisconsin.

Land Type	% cover	acres
Forest (deciduous)	69.6	318.2
Forest (coniferous)	21.3	97.4
Agriculture (general/row crops)	6.3	28.8
Wetland	2.8	12.8
		457.2

During the watershed assessment, no obvious signs of runoff or erosion were found. Lake residents noted that the area between Long Lake and Gilbert were once navigable by canoe. However these areas are now only small patches of wetlands. Property owners also indicated that in the past five years or more, the water level in Long Lake has been low. This is a sentiment shared by many lake residents in Wisconsin. The loss of navigability between the two lakes is certainly related to the low water levels. As is the fact that areas along the west end of the lake, which are now more wetland than lake were once navigable and the properties in this area once were waterfront lots.

While much of the shore of Long Lake has a high concentration of homes, areas of significant erosion were not evident near shore either. Human activity can contribute to shoreline erosion. An increase in development translates to increases in the number of lawns, driveways and other hard surfaces which are known to contribute nutrients and

Figure 14. Watershed of Long Lake, Waushara County, Wisconsin.

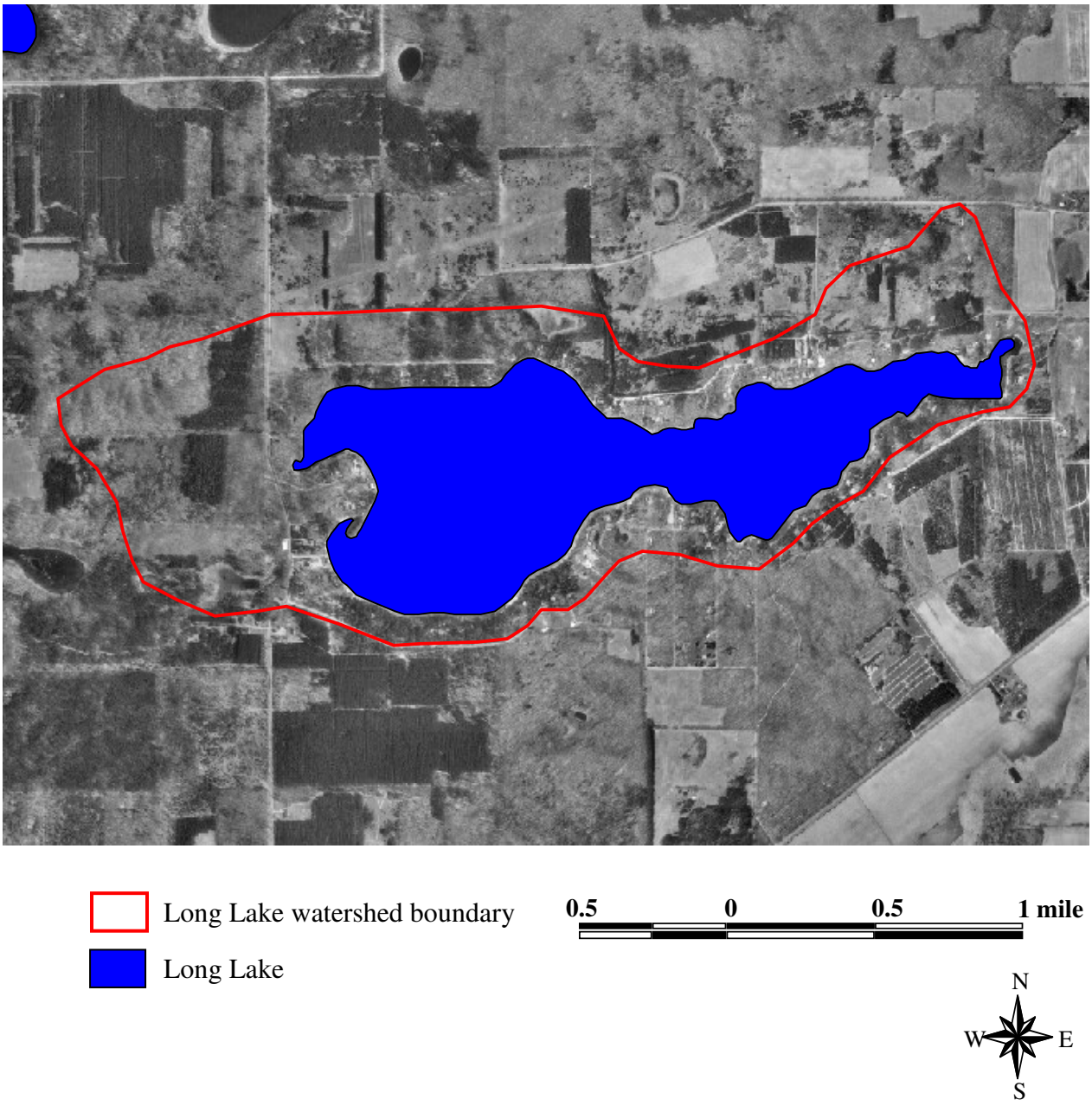
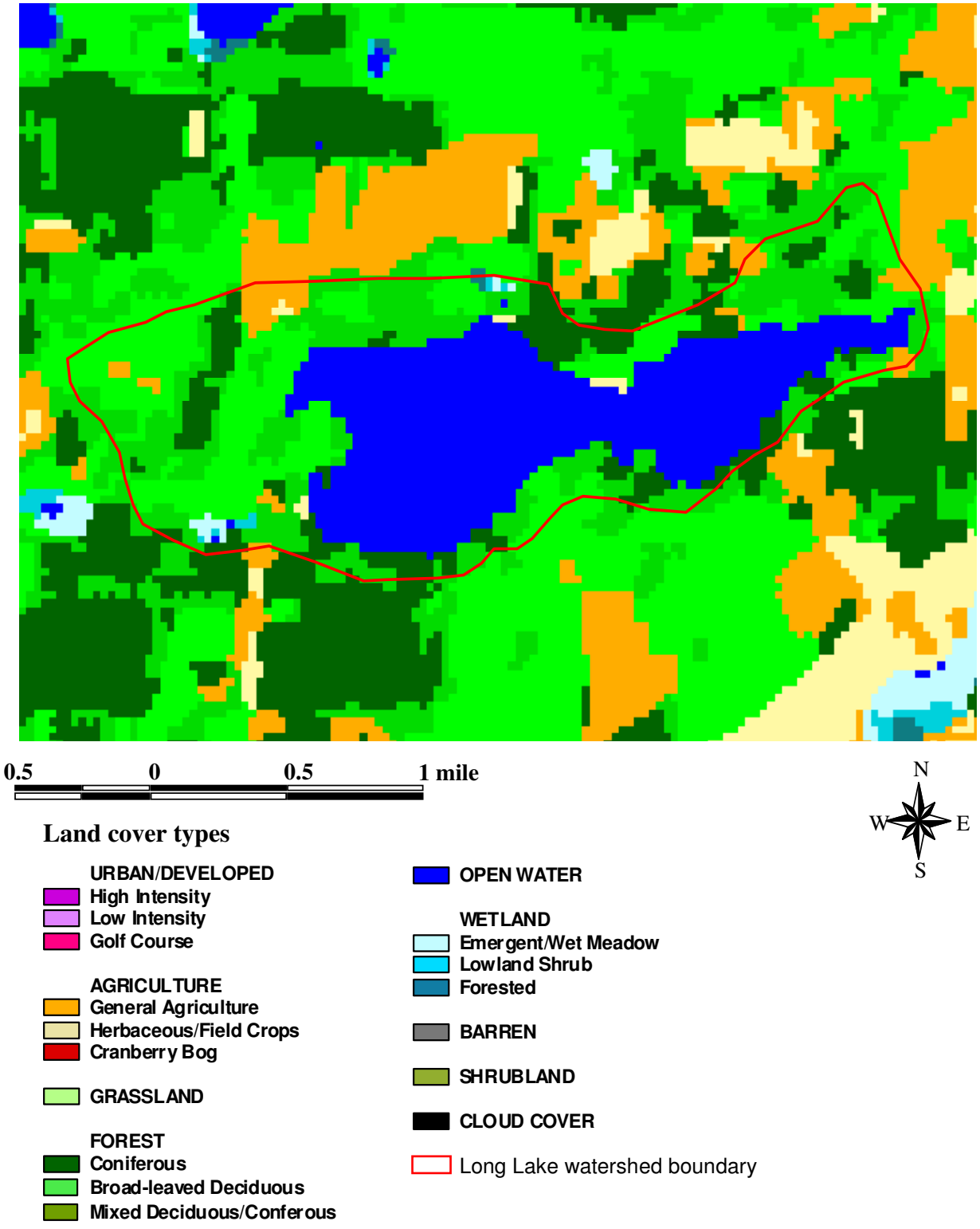


Figure 15. Land cover types and watershed delineation for Long Lake, Waushara County, Wisconsin.



sediments to a lake. Impacts from shoreline properties *can* have a negative impact on the water quality of a lake. This can be particularly significant for lakes like Long Lake with low agricultural cover and small watersheds.

Table 6 shows the percent of soil types within the watershed of Long Lake. A majority of the soils are well drained to excessively drained, and erodible. As a result, they are not prime farmland. This may account for the fact that only a small portion of the area surrounding Long Lake is actively farmed.

Table 6. Description of soil types within the watershed of Long Lake, Waushara County, WI

Soil type	Percent of Watershed	Description
Richford loamy sand, 12 to 20 percent slopes	24.00%	Somewhat excessively and well drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Highly erodible. Not prime farmland.
Plainfield sand, 12 to 30 percent slopes	19.64%	Excessively drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Highly erodible. Not prime farmland.
Plainfield sand, 6 to 12 percent slopes	14.76%	Excessively drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Potentially highly erodible. Not prime farmland.
Richford loamy sand, 6 to 12 percent slopes	12.94%	Somewhat excessively and well drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Potentially highly erodible. Not prime farmland.
Okee loamy sand, 6 to 12 percent slopes	10.10%	Somewhat excessively and well drained loamy soil. Moderate available water capacity. This soil is not hydric. The maximum allowable erosion rate is 4 tons/acre/year. Potentially highly erodible. Not prime farmland.
Richford loamy sand, 2 to 6 percent slopes	9.66%	Somewhat excessively and well drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Potentially highly erodible. Not prime farmland.
Okee loamy sand, 12 to 20 percent slopes	4.99%	Somewhat excessively and well drained loamy soil. Moderate available water capacity. This soil is not hydric. The maximum allowable erosion rate is 4 tons/acre/year. Highly erodible. Not prime farmland.
Plainfield sand, 2 to 6 percent slopes	2.96%	Excessively drained sandy soil. Low available water capacity. This soil is not hydric. The maximum allowable erosion rate is 5 tons/acre/year. Not highly erodible. Not prime farmland.
Houghton muck, 0 to 1 percent slopes	0.94%	Very poorly drained organic soil. Frequently ponded. Very high available water capacity. This soil is hydric. The maximum allowable erosion rate is 3 tons/acre/year. Not highly erodible. Not prime farmland.

In the Waushara County Land and Water Resource Management Plan completed in February 2006, conditions within the Pine River and Willow Creek Watersheds, where Long Lake lies, are discussed. "The west half of the watershed has minimal impacts from non-point source pollution. All of the Class I and II streams and rivers are designated as Exceptional Resources Waters except for the Willow Creek which is an Outstanding Resource Water."

"There are 43 named lakes and 18 unnamed lakes in this watershed. Many of the seepage lakes have no inlet or outlet and are groundwater fed. At some point there will be an excess of phosphorus that the lakes will not precipitate, thus causing algae blooms. Many of the larger lakes have been developed since the 1890's. At that time summer cottages were built anywhere they could be fit in. Due to relatively low land prices and taxes, extensive redevelopment has been occurring during the 1990's. Surface runoff from large houses (over 1200 sq. ft.), impermeable surfaces, lawns, and in some cases septic systems, have increased the potential of non-point pollutants reaching the lake."

The Waushara County Land and Water Resource Management Plan does not specifically address Long Lake in terms of watershed or water quality concerns. It does include recommendations or action objectives which pertain to riparian owners, shoreline conditions and exotic species management. These objectives are incorporated into the Conclusions and Discussions portion of this report.

Additional information available was obtained from Waushara County regarding the groundwater near Long Lake. The data indicate nitrate concentrations in the groundwater near the lake are far below the level of concern for drinking water. In addition, the area of the County near Long Lake is moderately susceptible to groundwater contamination when considering a number of factors. These include thedepth to bedrock, bedrock type, soil characteristics, surficial deposits, and the depth to the water table.

Long Lake Fishery

Wisconsin DNR data of fish stocking efforts in Long Lake date back to 1972. These data (**Appendix D**) show that a number of fish species have been stocked in the past 25 years. These include largemouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), smallmouth bass (*Micropterus dolomieui*), muskellunge (*Esox masquinongy*), white sucker (*Catostomas commersoni*), black crappie (*Pomoxsis nigromaculatus*), and yellow perch (*Perca flavescens*).

In addition, the following page displays a copy of a fishery summary written by the Wisconsin DNR. This summary contains boomshocking from 1990 to 2005 as well as information regarding the abundance and growth rates of a number of game fish species.

Additional information regarding the fishery of Long Lake and the habitat requirements of individual fish species can be found in the January 2005 report from Aquatic Biologist titled *A Survey of Aquatic Plants in Long Lake, Waushara County*.

Long Lake Summary

Boomshocking Catch Effort Comparisons (Number per Hour)

	Spring						Fall			
Lake	Long	Long	Long	Long	Long	Long	Long	Long	Long	Long
Date	04/25/2000	05/08/2000	04/23/2002	05/23/2002	04/20/2005	05/24/2005	10/15/1990	10/16/2002	10/18/2004	11/02/2005
Temp (F)	49	56	51	59	56	63	56	55	54	
Black Crappie	1	6	0	0				0		
Bluegill	191	444	580	594		512		794	474	731
Bluntnose Minnow	0		6					24		16
Bullhead spp.	1	2	0	10		2		0		
Cisco						1	16*	0		
Green Sunfish	0	0	4	0				0		
Largemouth Bass	64	184	122	80	67	75	26*	8	11	20
Northern Pike	8	4	2	6	3	17	21	2	7	19
Pumpkinseed	0	24	16	36		39		14		2
Rock Bass	49	64	104	78		108		62	84	153
Shiner spp.	0	0	2	0				2		
Smallmouth Bass	7	0	24	14	3	5	1	3	8	5
Walleye	20	0	12	0	15	6	4	2	2	6
White Sucker	31	32	38	18		88		0	24*	14
Yellow Perch	5	8	4	4		7		6	11	51

* many fish observed and were not captured
4/20/05 Gamefish only sampled.

Walleye Population Estimates

Lake	Long	Long	Long
Gear	Fyke	Fyke	Fyke
Date	1987	2002	2005
Number / Acre	1.1	0.9	1.2

Comments:

- **Cisco** During 1990 boomshocking survey approx. 49 cisco were captured and many more were observed. Past surveys using multiple gears (e.g. seine, fyke, and boomshock) captured numerous cisco. No cisco were captured in 2002 surveys. One captured in each 2004 and 2005 surveys. Numerous cisco were observed in deep water fall shocking run 2003 and 2004. Some late November anglers have reported splashing of spawning cisco in both 2003 and 2004.
- **White Sucker** fyke net catch has declined since the 1960s and 1970s surveys. In 2004 (1,385) and in 2005 (1,170) adult white suckers were stocked in Long Lake. Shocking run May 24, 2005 revealed good survival and spawning adults were abundant.
- **Bluegill** is dominant prey centrachid and appears to be in high abundance when compared to past surveys and other lakes with similar fisheries and physical characteristics. Growth rates are very slow with fish not reaching 6 inches until after 6 summers of growth.
- **Largemouth Bass** catch per effort decreased in the 2005 survey. In 2002 they had below average growth rates with fish not reaching 14 inches until after 7 complete summers of growth. Growth rates from 2005 survey were a mirror image of 2002 growth rates.
- **Walleye** population has remained relatively unchanged over the years holding fairly constant at ~ 1adult/acre. (Typical of walleye fisheries solely dependent on stocking). Some large fish were sampled spring of 2005 with 2 fish weighing over 13 pounds.
- **Spotted Musky** In 2004 fall shocking run, 2 adult musky were observed. In 2005 spring shocking runs, only 1 spotted musky was observed. No young of year or small spotted musky were sampled in our surveys. The hatchery removed 5 adult muskies in 2004 and 2 adults in 2005. Numerous reports of anglers targeting musky. Fall 2005 1 musky (41 inch) caught and removed.
- **Northern Pike** catch rates have increased slightly with fish from 11.5 - 35.4 inches being sampled. Only one fish sampled was legal (32 inch size limit). Most were in the 17-26 inch range. Growth rates of fish sampled in 2002 were below average. Growth rates were close to average in the 2005 survey. Because of lack of desirable shallow water spawning areas, the fish seem to be useing deeper water vegetation to spawn. Making them hard to sample.

Conclusions and Discussion

Aquatic Plant Management

Results of the aquatic plant survey conducted in 2008 reflect lake users comments that the aquatic plant community of Long Lake does not impact navigation or recreational use of the lake. In addition, survey results confirm that neither Eurasian watermilfoil nor curly-leaf pondweed currently infest the waters of Long Lake. There are about 25 lakes in Waushara County alone with Eurasian watermilfoil. This number increases when you include lakes with curly-leaf pondweed. Many of these lakes are a short distance from Long Lake. Due to the close proximity of these waters it is reasonable to assume that for the foreseeable future, Eurasian watermilfoil, in particular, will pose a risk of infesting the waters of Long Lake.

Exotic Species Contingency Plan

Because of the risk of infestation by exotic species, it is important that contingency plans be put in place to respond to the introduction of exotic species as quickly as possible. To this end, it would be wise to call upon the assistance of lake management consultants to annually survey Long Lake for exotic species. Lake residents should undertake an active monitoring program for the purpose of identifying and documenting possible exotics. This should be done through surveys similar to the one conducted on Long Lake in the spring 2008). However, by scheduling this type of survey in the spring and again in the late summer or early fall, the Association would be able to take advantage of the most opportune times to survey for curly-leaf pondweed and Eurasian watermilfoil, respectively.

The Long Lake Association has an active Clean Boats Clean Water (CBCW) program. The fact that there have been no exotics identified in Long Lake is a direct result of the efforts of the CBCW volunteers. Long Lake has the same level of public access and recreational use that many other area lakes have. Lake property owners should be highly encouraged to continue with the level of participation of recent years. It is the lake's best defense against introduction. If the level of volunteerism can be maintained, the spread of exotic species into Long Lake should be prevented or significantly delayed for the foreseeable future.

Education should play a big part in this program. All individuals willing to participate should be taught to identify exotic species. The Association should make it a priority to include such measures during all normally scheduled meetings whenever possible. In addition, special meetings should be considered to focus primarily on the identification of these species for riparian property owners and frequent lake users. The native plant, northern watermilfoil *(M. sibericum)*, grows in Long Lake. Because it superficially looks much like Eurasian watermilfoil, care should be taken to specifically learn to differentiate between the two species. In addition to Eurasian watermilfoil and curly-leaf pondweed, it would behoove members of the association to become familiar with the identification

of species such as purple loosestrife and zebra mussels. Each of these four species has been identified throughout Wisconsin and as was detailed prior, zebra mussels were at one time confirmed in Long Lake. **Appendix E** gives information regarding the identification and life history for these four species. Further information and education materials are available through the Wisconsin DNR and the local UW-Extension office.

If a lake user locates what he or she believes to be an exotic species, its location should be documented by recording GPS coordinates. In addition, a sample should be collected and taken to a member of the Association's Board or the coordinator of the monitoring program if one is appointed. Any suspicious material should be sent to the nearest Wisconsin DNR office for verification. If the identification is confirmed it will be important to initiate management measures as quickly as possible. The extent of an exotic species infestation often dictates which management option is most likely to result in successful control. As a result, **Appendix E** also contains information regarding management options for the four exotic species previously mentioned. As always, education should be a key component of any exotic species management effort.

Water Quality Management

Water quality is not a current problem for Long Lake. However it would be best for the Association to remain mindful and continue to keep the water quality of the lake a priority. It is recommended that the volunteer monitoring of the lake continue and be expanded. Currently spring and fall samples are collected for the ongoing study through UW - Stevens Point. This should continue. Also, summer monitoring of water quality should be expanded to not only include water clarity but also dissolved oxygen and temperature. The Association already owns a dissolved oxygen meter and Secchi disk. Therefore, it should not be difficult to expand the monitoring efforts. It is recommended oxygen and temperature be monitored monthly in April, July, August and September and water clarity be sampled either every month or every two weeks throughout the growing season (April through September)

Elevated nutrient inputs from human activities around Long Lake can adversely affect both water clarity and water quality. Although water quality in Long Lake is high, a number of practices can be carried out to ensure water quality is maintained. The most significant contributions of nutrients to Long Lake are from direct runoff from areas closest to the lake. The following are options for water quality enhancement which both the Association as a whole and individual lakefront property owners can undertake to maintain the water quality of Long Lake.

Nutrient management options

The first steps taken in managing nutrients in a lake should be to control external sources of nutrients. These can include: encouraging the use of phosphorus-free fertilizers; improving agricultural practices, reducing run-off, and restoring vegetation buffers around waterways.

Lawn care practices

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

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

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

Vegetative buffer zones

There are beneficial alternatives to the traditional mowed lawn. The best alternative is to leave the natural shoreline undisturbed. If clearing is necessary to access and view the lake, consider very selective removal of vegetation.

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

Shoreline vegetation serves as an important filter against nutrient

loading and trapping loose sediment. A buffer provides excellent fish and wildlife habitat, including nesting sites for birds, and spawning habitat for fish. Properly vegetated shorelines also play a key role in bank stabilization. A number of resources are available to assist property owners in creating beneficial buffer zones. These include descriptions of native beneficial plant species and where they can be found locally.

Shoreline plant restoration

Shoreline vegetation can benefit lake ecology tremendously. A properly vegetated shoreline provides habitat for a variety of birds, furbearers, amphibians, and reptiles. Much of the emergent vegetation in Long Lake appears to have been replaced by lakefront development. Benefits to lake water quality, fishery and wildlife could be achieved by restoring shoreline plants in Long Lake. Lakefront habitat improvement is often done on a property-by-property basis. In recent years many new techniques have been developed for restoring lakefronts. This type of work often incorporates many attractive flowering plants and adds a great deal of aesthetic appeal to lakefronts as well. Studies have also shown that providing complex habitats through shoreline features such as plants and erosion control devices can result in significant increases in fish species richness (Jennings et al., 1999).

Erosion control

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

Reduced impacts from boating

Boat traffic can cause an increase in suspended solids especially in shallow areas of lakes (Hill, 2004). Studies have shown that maximum increases in turbidity occur between 2 and 24 hours following boating activities. The full effects of heavy boating depend upon a number of factors including propeller size, boat speed, draft, and sediment characteristics (Asplund, 1996). Silty sediments tend to have the highest susceptibility to resuspension and the highest potential for the reintroduction of nutrients into the water column. Studies have also focused on algae (chlorophyll a) concentrations but found no significant changes following boating activity. This is due primarily to an indeterminate time lag which occurs between the release of nutrients and the subsequent increase in

algal growth. It has also been suggested that disturbances to the native plant communities due to watercraft use can accelerate the spread of opportunistic exotic plant species such as Eurasian watermilfoil and curly leaf pondweed (Asplund and Cook, 1997).

Wisconsin statutes require boaters to maintain no-wake speeds within 100 feet of shorelines, other boats, or fixed structures, including boat docks and swimming platforms. However, it is difficult to enforce such regulations and even slow boat traffic can have a negative impact on sediments and plant communities in shallow areas. This not only has a negative impact to the lake but can also damage boats. It is recommended that the Long Lake Association take the opportunity to educate members and lake users alike of the impacts boating can have on a lake.

Septic system maintenance

Septic systems are known to contribute nutrients to a lake. It is the responsibility of lakeshore property owners to ensure that septic systems are properly functioning. A failing septic system can contaminate both surface and ground water. Each home can contribute up to 2 lbs of phosphorus annually. If located in a groundwater discharge area, failing septic systems can be a particularly significant source of nutrient loading in a lake. Systems should be professionally inspected every 3 years, and pumped every 2-5 years depending on operating circumstances (EPA, 2002). Avoid flushing toxic chemicals and pharmaceuticals into the system. These can leach into the groundwater ad/or harm important bacteria that live in your tank and naturally break down wastes. Avoid planting trees, compacting soil, or directing additional surface runoff on top of the drain field.

Citizen Participation

In March 2009, hardcopies of the survey results from this study were provided to the Long Lake Association's board. Each board member was given the opportunity to review and provide feedback and questions regarding the study findings and clarifications were made to the report following that review. On March 28, 2009 the results of this study were presented to the Long Lake Association at a meeting held at the Saxeville Town Hall. This meeting was open to the public. A number of Association members as well as the members of the board were present. Results of the study were presented and a time was given for questions and answers. On May 23, 2009 Cason & Associates staff met with the Association board to discuss changes to the report. This meeting was followed by a brief presentation at the Clean Boats Clean Waters training session held at the Town Hall. Again an overview of the study and the results was given. On July 4, 2009, Jim Schiek and Larry Annen presented the findings of the study to the members of the Long Lake Association at their Annual Membership Meeting at the Saxeville Town Hall. A number of questions regarding the condition of the lake, results of the study and current lake management were answered and addressed. On July 18, 2009, Cason & Associates staff attended the Long Lake Association's annual Family Picnic. Although this was an informal setting, a number of questions regarding the condition of the lake and current management were addressed. Also, at the March 2009 Town of Saxeville Board Meeting, LLA board members reported on the study activity and again at a Town of Saxeville Land Use Planning Committee Meeting later in the summer. The discussions did not get into details but basic information was shared with non-lake residents as to the overall quality of Long Lake and the valuable asset this lake is to the community.

In addition to discussions at meetings, information regarding the results of this study has been included in Association newsletters. Also, hardcopies of the report have been made available to Association members. To date, all pertinent concerns have been addressed and the necessary changes were made to the report.

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