MEMORANDUM REPORT NO. 173

AN AQUATIC PLANT MANAGEMENT PLAN FOR PINE AND BEAVER LAKES

WAUKESHA COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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WAUKESHA COUNTY, WISCONSIN

Prepared by the

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An initial plant inventory for Pine Lake was published as SEWRPC Memorandum Report No. 124, *An Aquatic Plant Inventory for Pine Lake, Waukesha County, Wisconsin*. This inventory updates the Pine Lake information presented in that report and also includes an initial inventory for Beaver Lake.

October 2008

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Chapter I

INTRODUCTION

Pine Lake, located in the Village of Chenequa, Waukesha County, Wisconsin, is a valuable natural resource offering a variety of recreational and related opportunities to the resident community and its visitors. The Lake is located within U.S. Public Land Survey Township 7 North, Range 18 East, Section 5, and U.S. Public Land Survey Township 8 North, Range 18 East, Sections 21, 28, 29, 32 and 33, in the Town of Merton and Village of Chenequa in Waukesha County. Beaver Lake is located immediately east and upgradient of Pine Lake, within U.S. Public Land Survey Township 8 North, Range 18 East, Sections 21, 27, and 28, in the Town of Merton in Waukesha County. The lakes, while exhibiting distinctly different and individual hydrographical characteristics, offer a variety of water-based recreational opportunities and are the focus of the lake-oriented communities surrounding them. In both cases, however, the recreational and aesthetic values of the Lakes are perceived to be adversely affected by excessive aquatic plant growth within portions of the Lakes. Consequently, seeking to improve the usability and to prevent the deterioration of its natural assets and recreational potential, the Village of Chenequa, in partnership with the Town of Merton and Friends of Beaver Lake, Inc., have undertaken annual programs of lake and aquatic plant management within this combined basin, which forms a major tributary lake and stream system to the Oconomowoc River Basin of the Rock River drainage system.

Pine Lake has been the subject of an aquatic plant inventory prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) during 1998.[1] The current report refines that aquatic plant inventory included therein, by reporting on the aquatic plant communities in both Pine and Beaver Lakes during 2005. This report includes relevant tributary area and waterbody data, and provides recommendations for management of aquatic plants within Pine and Beaver Lakes.

BACKGROUND

Specifically, this report represents part of the ongoing commitment of the Village of Chenequa and the Town of Merton, to sound planning with respect to the Lakes. The report sets forth inventories of the aquatic plant communities present within Pine and Beaver Lakes. Those inventories were prepared by SEWRPC in cooperation with the Village of Chenequa, and include the results of field surveys conducted by the Commission staff during August 2005. The aquatic plant surveys were conducted by Commission staff using the modified Jesson and

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[1] *SEWRPC Memorandum Report No. 124,* An Aquatic Plant Inventory for Pine Lake, Waukesha County, Wisconsin, *December 1998.*

Lound[2] transect methodology employed by the Wisconsin Department of Natural Resources (WDNR). The planning program was funded, in part, under a Chapter NR 190 Lake Management Planning Grant administered by the WDNR and awarded to the Village of Chenequa.

As noted above, this report is intended to refine the previously-compiled aquatic plant inventory for Pine Lake. Unlike the latter inventory, this plan also presents aquatic plant management recommendations for Pine Lake, and includes the upstream Beaver Lake within the inventory and analysis. The scope of this report is limited to a consideration of the aquatic plant communities present within Pine and Beaver Lakes, the documentation of historic changes in the plant communities based upon existing data and information, and refinement of those management measures which can be effective in the control of undesirable aquatic plant growth. Recommendations are made with respect to the Village of Chenequa, and relevant local lake-oriented organizations and municipalities, currently conducting operations relating to aquatic plant and in-lake management in Pine and Beaver Lakes.

Of particular note, since the compilation of the previous aquatic plant inventory for Pine Lake, the Beaver Lake community has formed the Friends of Beaver Lake, Inc., a Chapter 181 not-for-profit corporation, as the focal entity charged with the collection and dissemination of information relevant to Beaver Lake to the riparian community resident around Beaver Lake within the Town of Merton and Village of Chenequa. The Friends of Beaver Lake, Inc., are a qualified lake association as set forth in Chapter NR 190 of the *Wisconsin Administrative Code*.

Pine Lake has adequate public recreational boating access as set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. Beaver Lake currently is served by a WDNR-owned carry-in recreational boating access site that does not meet the minimum standards for public recreational boating access as set forth in Chapter NR 1. Additional recreational boating access to Beaver Lake is provided by the Beaver Lake Yacht Club; however, this access is restricted to the Club's members and there is presently no private provider agreement in place that would satisfy the minimum standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*.

AQUATIC PLANT MANAGEMENT PROGRAM GOALS AND OBJECTIVES

The lake use goals and objectives for Pine Lake and Beaver Lake were developed in consultation with the Village of Chenequa and other local lake-oriented organizations and municipalities. The agreed goals and objectives are to:

1. Protect and maintain public health, and promote public comfort, convenience, necessity and welfare, in concert with the natural resource, through the environmentally sound management of native vegetation, fishes and wildlife populations in and around Pine and Beaver Lakes;

2. Effectively control the quantity and density of aquatic plant growths in portions of the Pine Lake and Beaver Lake basins to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the resource value of the waterbodies;

3. Effectively maintain the water quality of Pine Lake and Beaver Lake to better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the resource value of the waterbodies and,

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[2]*R. Jesson and R. Lound, Minnesota Department of Conservation Game Investigational Report No. 6,* An Evaluation of a Survey Technique for Submerged Aquatic Plants, *1962.*

4. Promote a quality, water-based experience for residents and visitors to Pine and Beaver Lakes consistent with the policies and objectives of the WDNR as set forth in the regional water quality management plan.[3]

This inventory and the aquatic plant management plan elements conform to the requirements and standards set forth in the relevant *Wisconsin Administrative Codes.*[4] Implementation of the recommended actions set forth herein should continue to serve as an important step in achieving the stated lake use objectives over time.

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[3] *SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000*, June 1979, as amended; see also SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

[4]*This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual removal and Mechanical Control Regulations."*

Chapter II

INVENTORY FINDINGS

INTRODUCTION

Pine Lake is located in the Village of Chenequa, and Beaver Lake is located in the Town of Merton and Village of Chenequa, both in Waukesha County, as shown on Map 1. As set forth in the initial aquatic plant inventory,[1] Pine Lake is a natural lake comprised of a single deep basin. The Lake is a drained lake, depending principally on: precipitation falling directly on the Lake's surface, runoff from its tributary drainage area, and groundwater flowing into the Lake from inside and outside the immediate surface tributary area, for its sources of water. Additional inflow in provided to Pine Lake from the upgradient Beaver Lake through an unnamed intermittent stream located along the eastern shoreline of Pine Lake. Water flows out of Pine Lake from the northernmost portion of the Lake via an unnamed stream to Cornell Lake, and ultimately to North Lake and the Oconomowoc River. Beaver Lake also is a drained lake, with intermittent outflows to Pine Lake through an unnamed stream draining the westernmost extreme of the Lake.

The levels of both Lakes are maintained through natural inflows and outflows without the aid of artificial impoundments or other structures. It should be noted, however, that the intermittent stream draining Beaver Lake to Pine Lake is almost wholly enclosed within a drainage culvert, conveying the out flowing waters under the intervening roadway and residential properties.

WATERBODY CHARACTERISTICS

Pine Lake is a 703-acre waterbody, the hydrographical characteristics of which are set forth in Table 1. As aforementioned, Pine Lake is a drained lake, comprised of a single deep basin. Pine Lake has a maximum depth of approximately 85 feet, a mean depth of about 38 feet, and a volume of about 27,000 acre-feet. The general orientation of Pine Lake is north-south. The bathymetry of the Lake is shown on Map 2.

Beaver Lake is a 316-acre waterbody. The hydrographical characteristics of Beaver Lake also is set forth in Table 1. Beaver Lake is a drained lake, with two distinct basins. Beaver Lake has a maximum depth of about 49 feet, a mean depth of about 15 feet, and a volume of approximately 4,740 acre-feet. The general orientation of Beaver Lake is northwest-southeast. The bathymetry of Beaver Lake also is shown on Map 3.

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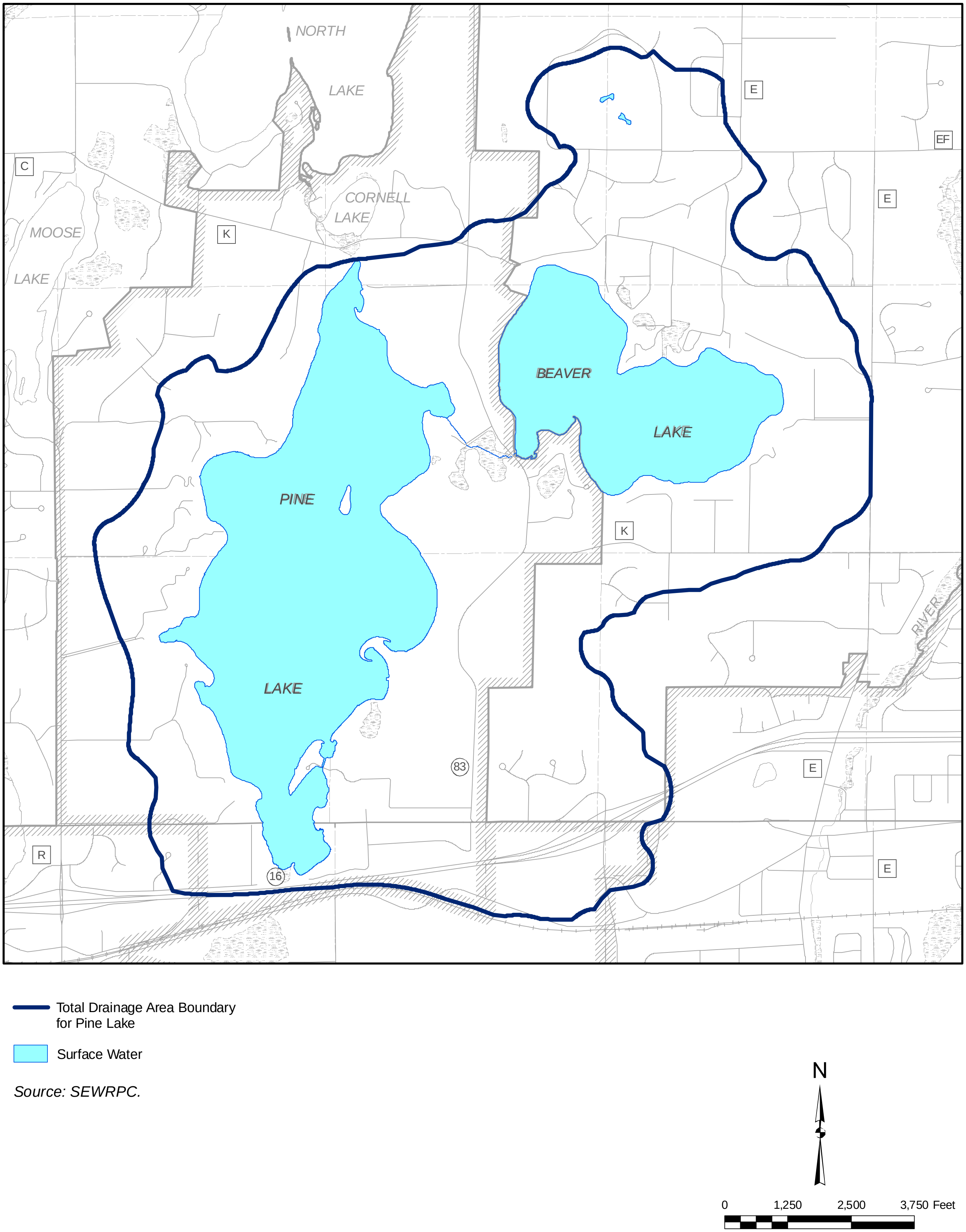
[1] *SEWRPC Memorandum Report No. 124*, An Aquatic Plant Inventory for Pine Lake, Waukesha County, Wisconsin, *December 1998.*

Map 1

LOCATION OF PINE AND BEAVER LAKES



Source: SEWRPC.

Table 1

HYDROLOGY AND MORPHOMETRY OF PINE AND BEAVER LAKES: 2007

Parameter	Pine Lake	Beaver Lake
Size		
Surface Area of Lake	703 acres	316 acres
Direct Tributary Area	2,250 acres	1,445 acres
Total Tributary Area	3,695 acres[a]	1,445 acres
Lake Volume	27,000 acre-feet	4,740 acre-feet
Residence Time[b]	5.2 years	2.6 years
Shape		
Length of Lake	2.3 miles	1.1 miles
Width of Lake	0.6 mile	0.5 mile
Length of Shoreline	6.7 miles	3.7 miles
Shoreline Development Factor[c]	1.8	1.5
General Lake Orientation	N-S	NW-SE
Depth		
Mean Depth	38 feet	15 feet
Maximum Depth	85 feet	49 feet

[a]*The total tributary area of Pine Lake was reported as 3,690 acres in the initial Southeastern Wisconsin Regional Planning Commission Memorandum Report No. 124,* An Aquatic Plant Inventory for Pine Lake, Waukesha County, Wisconsin, *December 1998. Since that time, advances in cartographical techniques have led to a refinement of tributary area boundaries and a more precise measurement of tributary area.*

[b]*Residence time is estimated as the time period required for a volume of water equivalent to the volume of the lake to enter the lake during years of normal precipitation.*

[c]*Shoreline development factor is the ratio of the shoreline length to the circumference of a circular lake of the same area.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Lake bottom sediment types in the nearshore areas of Pine Lake, based on Wisconsin Conservation Department—now the Wisconsin Department of Natural Resources (WDNR)—data, consist of mostly gravel.[2] Beaver Lake was noted to have a largely sand and marl substrate.[3] Observations by Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff, during the 2005 aquatic plant survey, confirmed these substrate compositions, but noted soft sediment types being found predominantly in the shallow water areas at the northern and southern extremes of Pine Lake and in the embayment located to the southwest. Similar observations on the substrate composition of Beaver Lake confirmed the presence of gravel in the nearshore areas, with some soft sediments in the embayment located along the southern shore of the Lake, adjacent to the current location of the public access site. A further area of softer substrate was observed in the northwestern corner of Beaver Lake.

TRIBUTARY AREA AND LAND USE CHARACTERISTICS

Pine and Beaver Lakes are situated in the north central portion of Waukesha County. The area directly tributary to Pine Lake, which drains directly to Pine Lake without passing through any upstream waterbody, is approximately 3.5 square miles in areal extent. The tributary area includes portions of: the Villages of Chenequa, Nashotah, and Hartland; the City of Delafield; and the Town of Merton, all in Waukesha County. As shown on Map 4, the total area tributary to Pine Lake is approximately 5.8 square miles in areal extent and includes Beaver Lake, which drains intermittently to Pine Lake from the east. The area directly tributary to Beaver Lake is about 2.3 square miles and includes portions of the Village of Chenequa and the Town of Merton, in Waukesha County.

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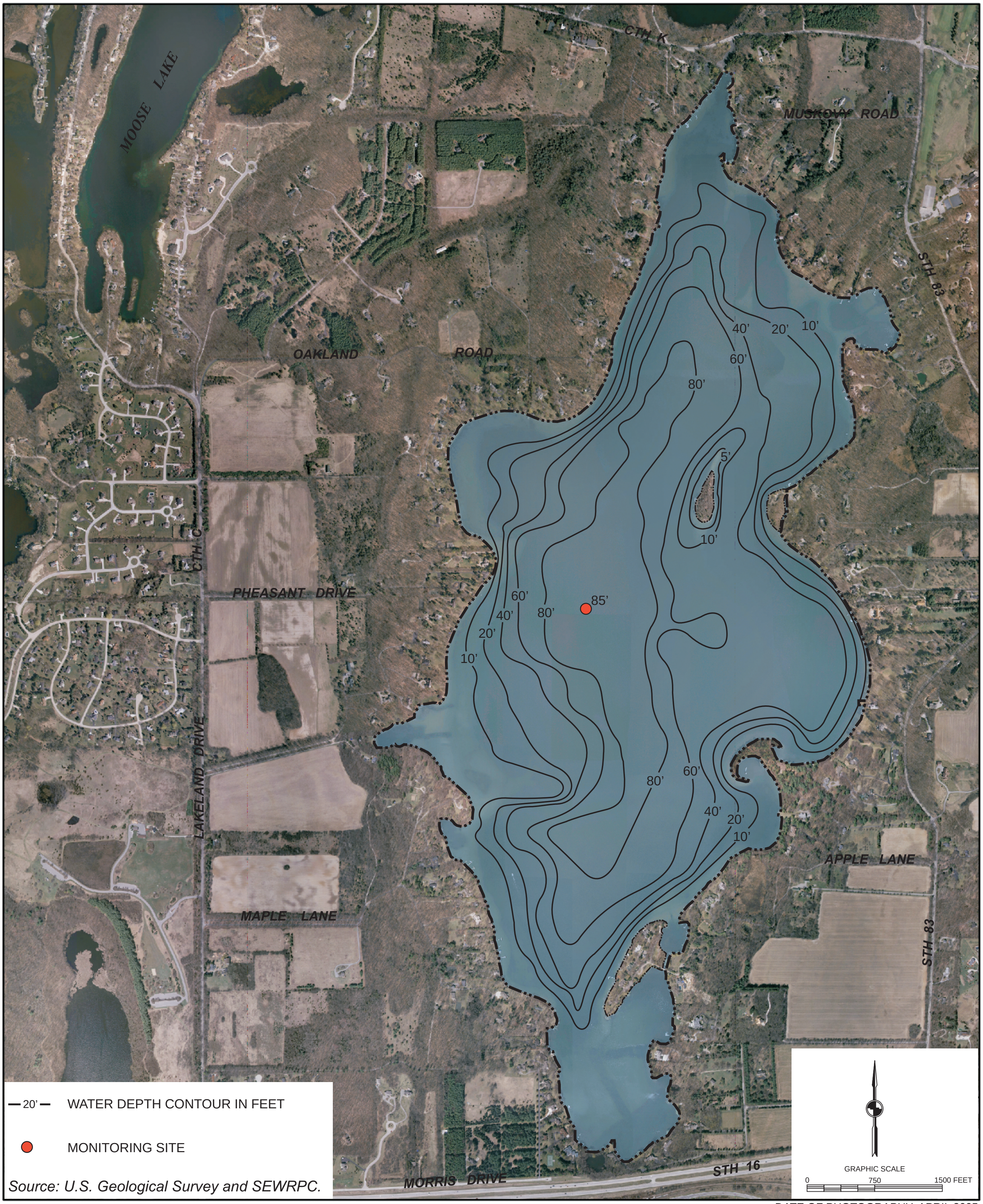
[2]*Wisconsin Conservation Department,* Surface Water Resources of Waukesha County*, 1963.*

[3]Ibid.

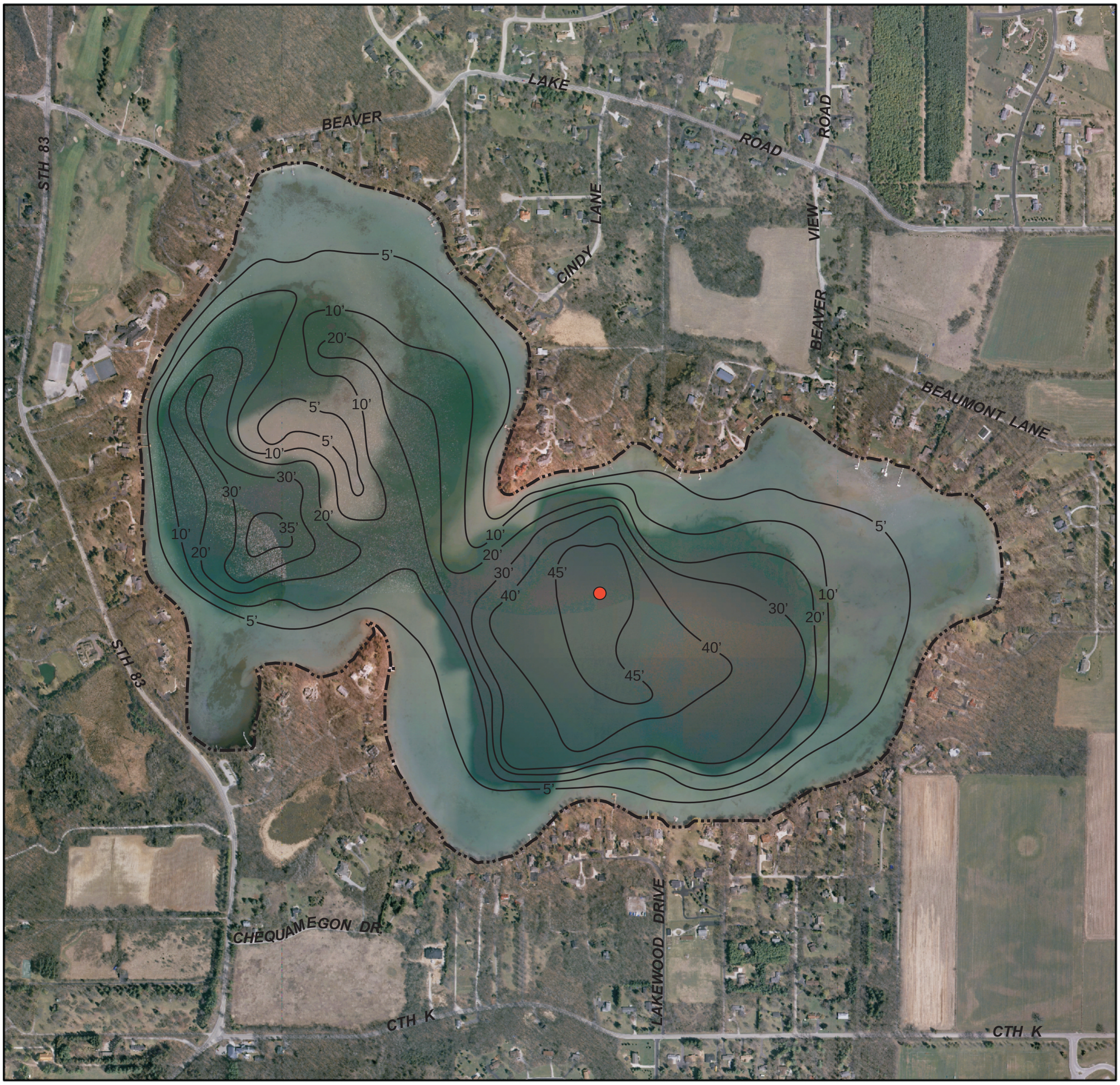
Map 2

BATHYMETRIC MAP OF PINE LAKE



Map 3

BATHYMETRIC MAP OF BEAVER LAKE

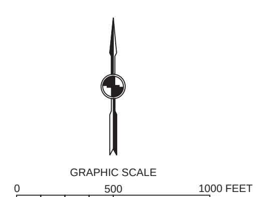


DATE OF PHOTOGRAPHY: APRIL 2005

— 20' — WATER DEPTH CONTOUR IN FEET

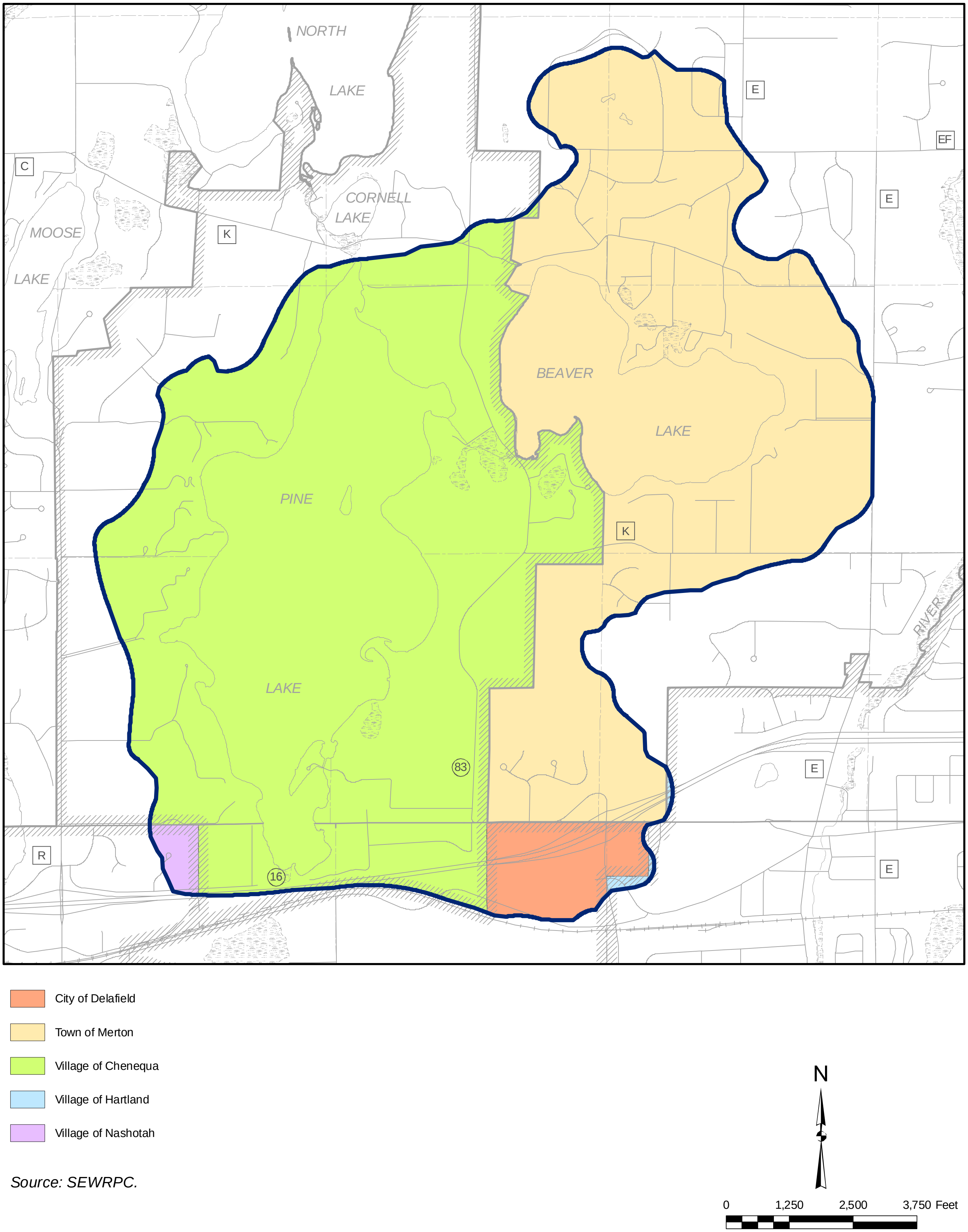
● MONITORING SITE

Source: U.S. Geological Survey and SEWRPC.



Map 4

CIVIL DIVISION BOUNDARIES IN THE AREA TRIBUTARY TO PINE AND BEAVER LAKES



Source: SEWRPC.

Table 2

POPULATION AND HOUSEHOLDS WITHIN THE TOTAL AREA TRIBUTARY TO PINE LAKE: 1963-2000

Year	Population	Households
1963	769	211
1970	1,424	381
1980	1,723	554
1990[a]	2,126	751
2000	2,244	835

[a]*In the initial SEWRPC study on Pine Lake, it was reported that in the Pine Lake total tributary area in 1990, the population was about 1,820 persons with about 690 housing units; these data differ from those in the above table as a result of a refinement of the Pine Lake tributary area boundaries through the use of more accurate topographical surveying techniques developed since the time of the earlier report.*

Source: U.S. Bureau of the Census and SEWRPC.

Population and Housing Units

Population and numbers of housing units within the total area tributary to Pine Lake for the period 1963 through 2000 have shown a steady increase, as shown in Table 2. The greatest increase in population occurred from 1963 to 1970 when the number of people increased by approximately 85 percent, from about 770 to 1,400 individuals. The numbers of housing units also increased during this period, from 211 to 381 units, an increase of over 80 percent. From 1970 to 1990, increases in population were fairly steady with an increase each decade of about 20 percent over the previous decade. From 1990 to 2000 the population increased by about 5 percent, from about 2,100 individuals to about 2,200 individuals, the smallest increase in any given 10-year period since 1963.

Land Uses

The land uses within the drainage areas tributary to Pine Lake and Beaver Lake are primarily urban, with low-density residential land uses being the dominant urban land use. The shorelines of both lakes are almost entirely developed for residential uses, although, due to the large sizes of the riparian lots, more of the shoreline exists in a natural state than that around the majority of lakes in the Region.

Map 5 shows existing land uses in the area tributary to Pine and Beaver Lakes as of 2000. Those uses are summarized in Table 3. Future changes in land use within the area tributary to the Lakes may include limited additional urban-density development, infilling of already platted lots, and possible redevelopment of existing properties. Under proposed buildout conditions, as shown on Map 6, urban land uses are expected to increase from about 32 percent of the land coverage in 2000, to about 43 percent of the land area in 2035. The remaining agricultural uses are anticipated to decrease from about 68 percent of the land coverage as of 2000, to about 57 percent of the land coverage under 2035 conditions. As shown on Map 6, these changes are forecast to occur mostly in the southwestern and southeastern corners of the tributary area, in that portion of the shorelands of Pine Lake along the eastern side of the Lake, and in the northeastern portion of the tributary area, east of Beaver Lake. These land use changes have the potential to modify the nature and delivery of nonpoint sourced contaminants to the Lakes, with concomitant impacts on the aquatic plant communities within the two waterbodies.

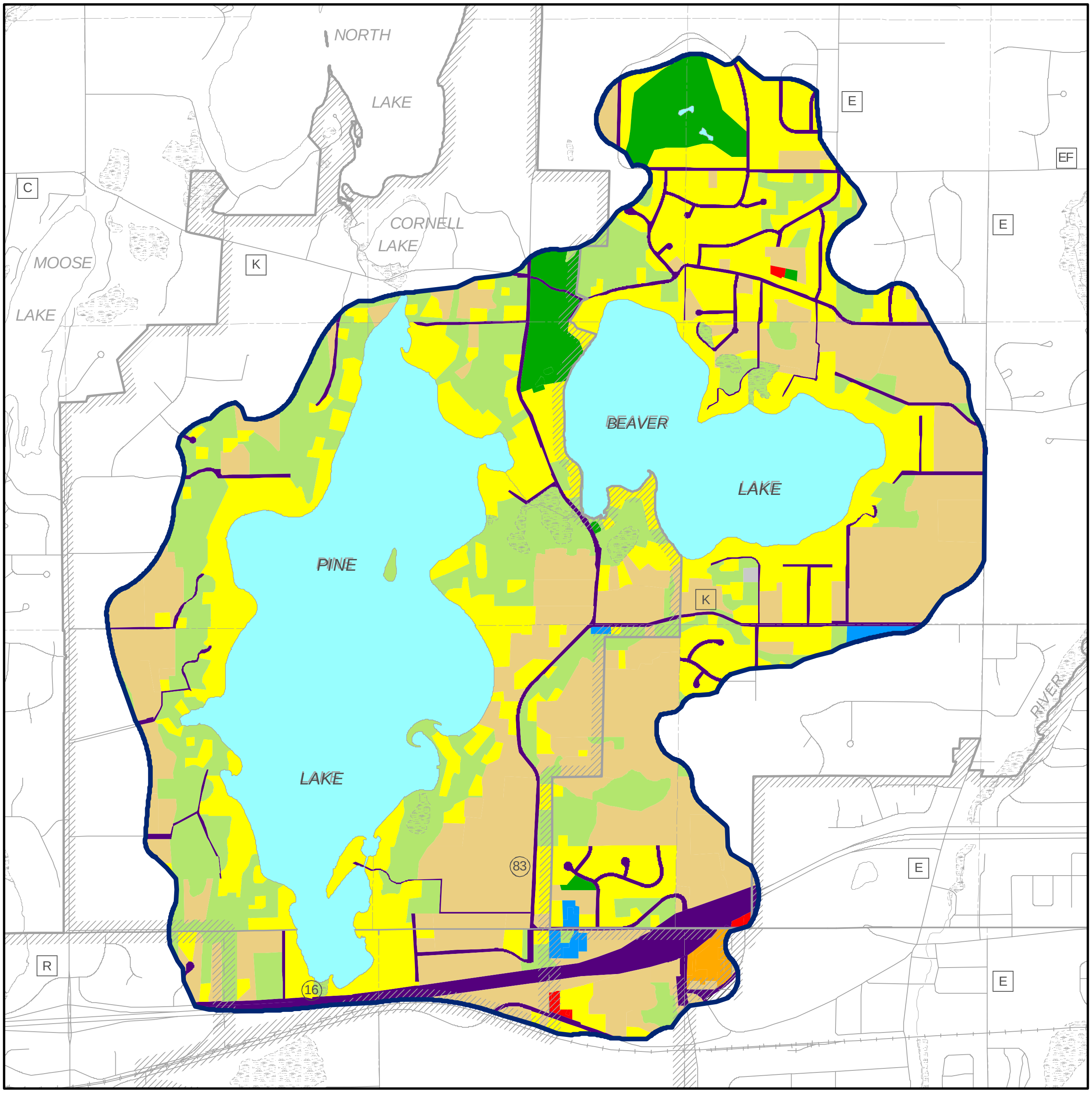
SHORELINE PROTECTION STRUCTURES

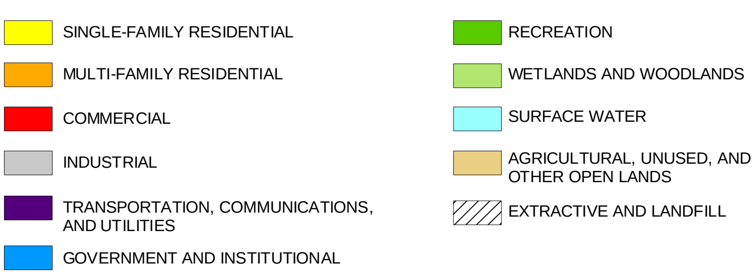
Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with lake access and use. Wind-wave erosion, ice movement, and motorized boat traffic wakes usually cause such erosion. A survey of the shoreline of Pine Lake, conducted by Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff during the initial study identified no obvious erosion-related problems during 1999. An estimated 75 percent of the shoreline of Pine Lake was in a natural state.

During the summer of 2005, similar observations by SEWRPC staff identified a substantial increase in the use of riprap as a shoreline protection measure on Pine Lake, with an estimated 75 percent of the shoreline currently protected by riprap, as shown on Map 7. During 2005, the shoreline of Beaver Lake was observed to be approximately equally maintained as natural shoreline and protected by riprap or similar structural shoreline protection structure, as shown on Map 8.

Map 5

EXISTING LAND USE IN THE AREA TRIBUTARY TO PINE AND BEAVER LAKES: 2000





Source: SEWRPC.

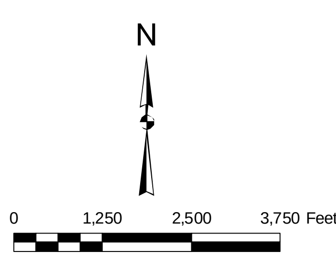


Table 3

EXISTING AND PLANNED LAND USE WITHIN THE TOTAL AREA TRIBUTARY TO PINE LAKE: 2000 AND 2035

Land Use Categories[a]	2000 Acres	2000 Percent of Tributary Area	2035 Acres	2035 Percent of Tributary Area
Urban				
Residential	847	22.9	1,064	28.8
Commercial	5	0.1	30	0.8
Industrial	2	0.1	2	0.1
Governmental and Institutional	15	0.4	89	2.4
Transportation, Communication, and Utilities	214	5.8	272	7.3
Recreational	104	2.8	119	3.2
Subtotal	1,187	32.1	1,576	42.6
Rural				
Agricultural and Other Open Lands	844	22.8	455	12.3
Wetlands	33	0.9	33	0.9
Woodlands	582	15.8	582	15.8
Surface Water	1,047	28.3	1,047	28.3
Extractive	2	0.1	2	0.1
Landfill	- -	- -	- -	- -
Subtotal	2,508	67.9	2,119	57.4
Total	3,695	100.0	3,695	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

WATER QUALITY

Water quality data on Pine Lake have been collected intermittently since 1972; data for the time period of 1972 through 1981 were reported in the initial study.[4] At that time, based on measurements of Secchi-disk water transparency, and chlorophyll-*a* and total phosphorus concentrations, the Lake was considered to have fair to good water quality. Additionally, it was reported that a dichotomy existed between the apparent nutrient status and the biotic response in the Lake; that total phosphorus data indicated the Lake to be a eutrophic waterbody, and that this status was not supported by chlorophyll-*a* and transparency measurements. The WDNR subsequently identified the cause of the observed dichotomy as arsenic interference with the analytical technique used to measure phosphorus concentrations in lake water,[5] and determined Pine Lake to be a mesotrophic waterbody, a status consistent with the chlorophyll-*a* and transparency measurements at that time.

For purposes of the current study, the U.S. Geological Survey (USGS) initiated a comprehensive water quality sampling program in the deep basin of Pine Lake during 2005,[6] the results of which for the 2005 and 2006

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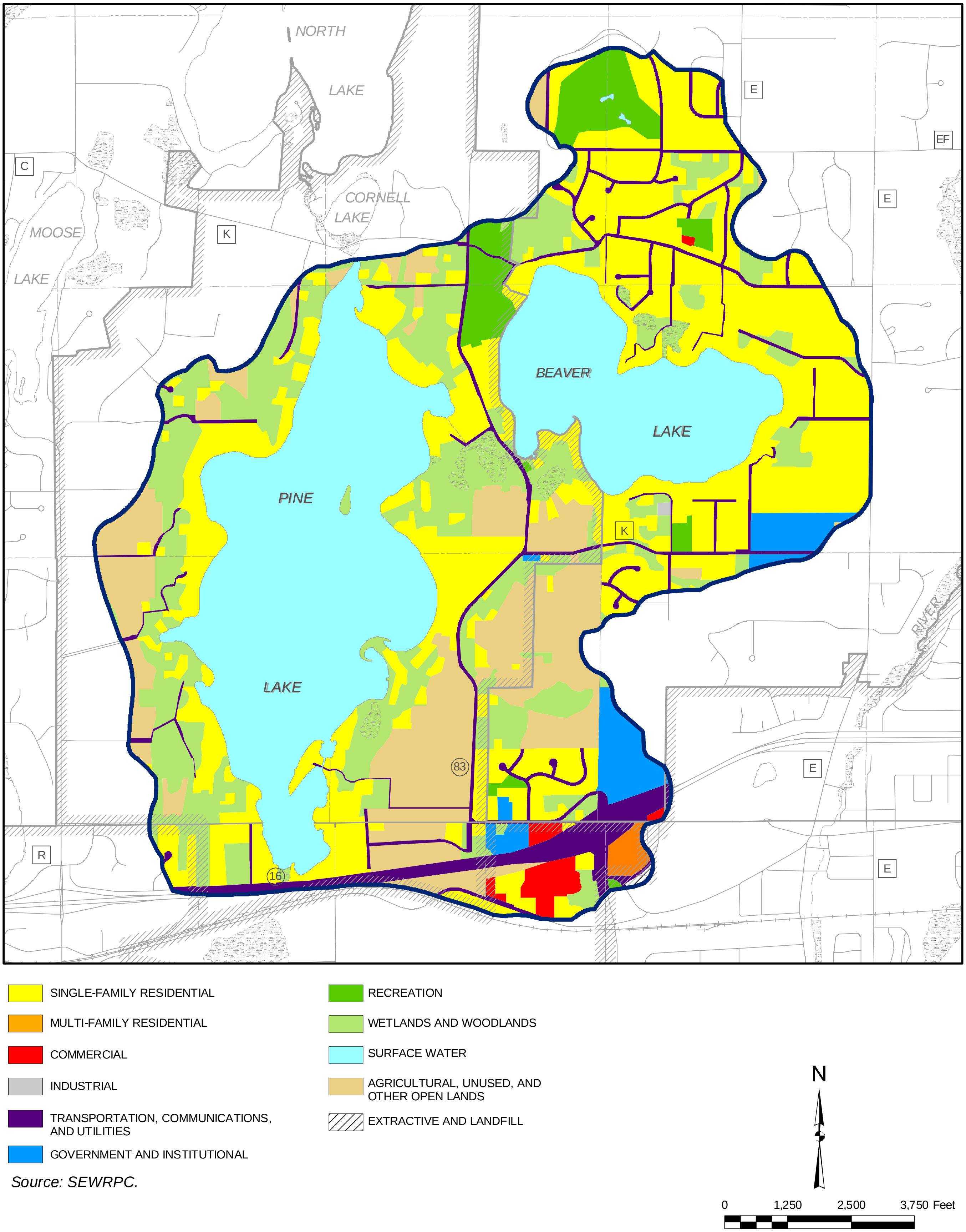
[4]*SEWRPC Memorandum Report No. 124,* op cit.

[5]*See Wisconsin Department of Natural Resources Publication No. PUBL-WR-194-86,* A Nonpoint Source Control Plan for the Oconomowoc River Priority Watershed Project, *March 1986; see also H.L. Golterman and R.S. Clymo,* Methods for Chemical Analysis of Fresh Waters, *International Biological Programme Handbook No. 8, Blackwell Scientific Publications, Edinburgh, 1971.*

[6]*U.S. Geological Survey Open-File Report No. 2006-1080,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2005, *2006; U.S. Geological Survey Open-File Report No. 2007-1173,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2006, *2007.*

Map 6

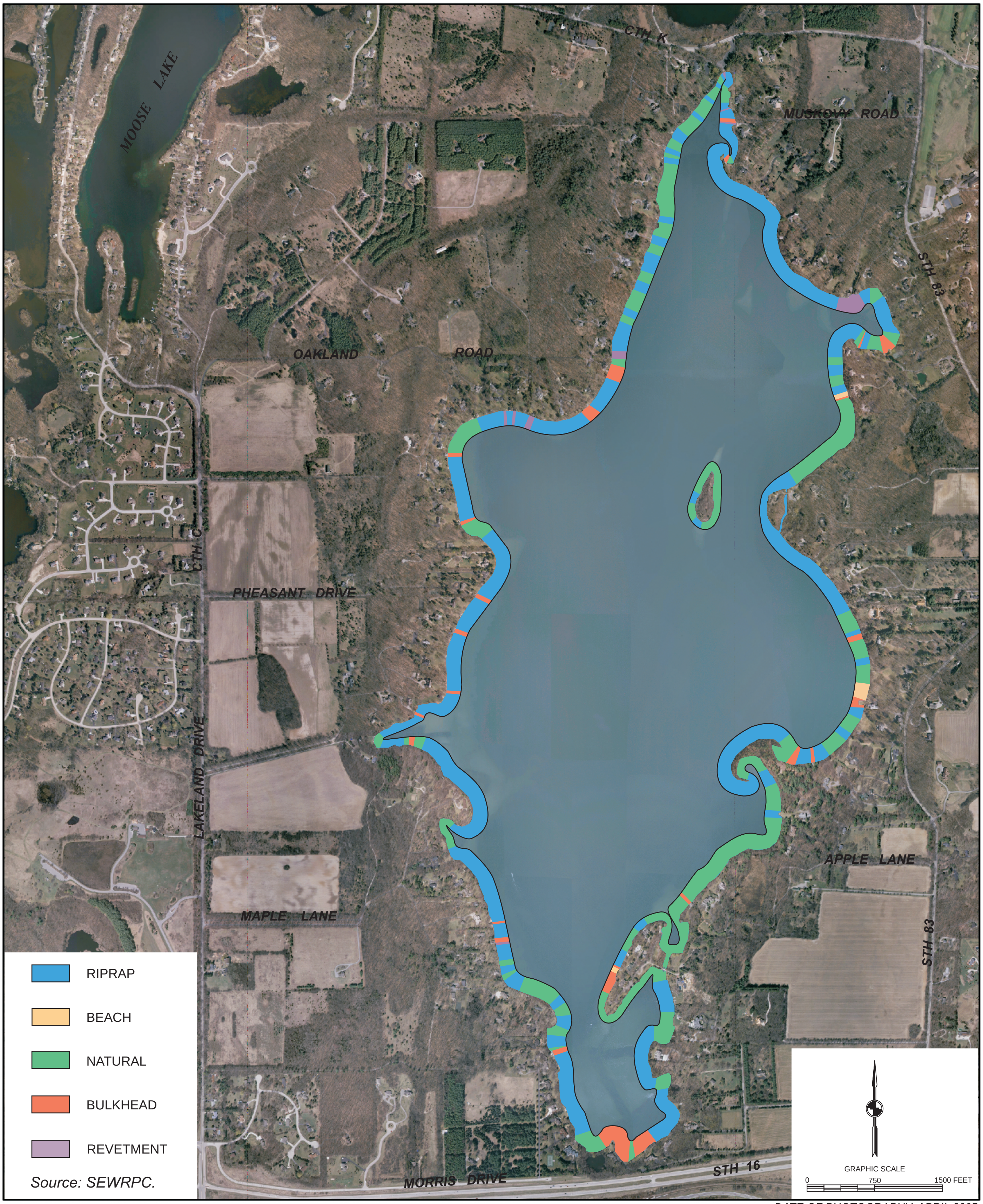
PLANNED LAND USE IN THE AREA TRIBUTARY TO PINE AND BEAVER LAKES: 2035



Source: SEWRPC.

Map 7

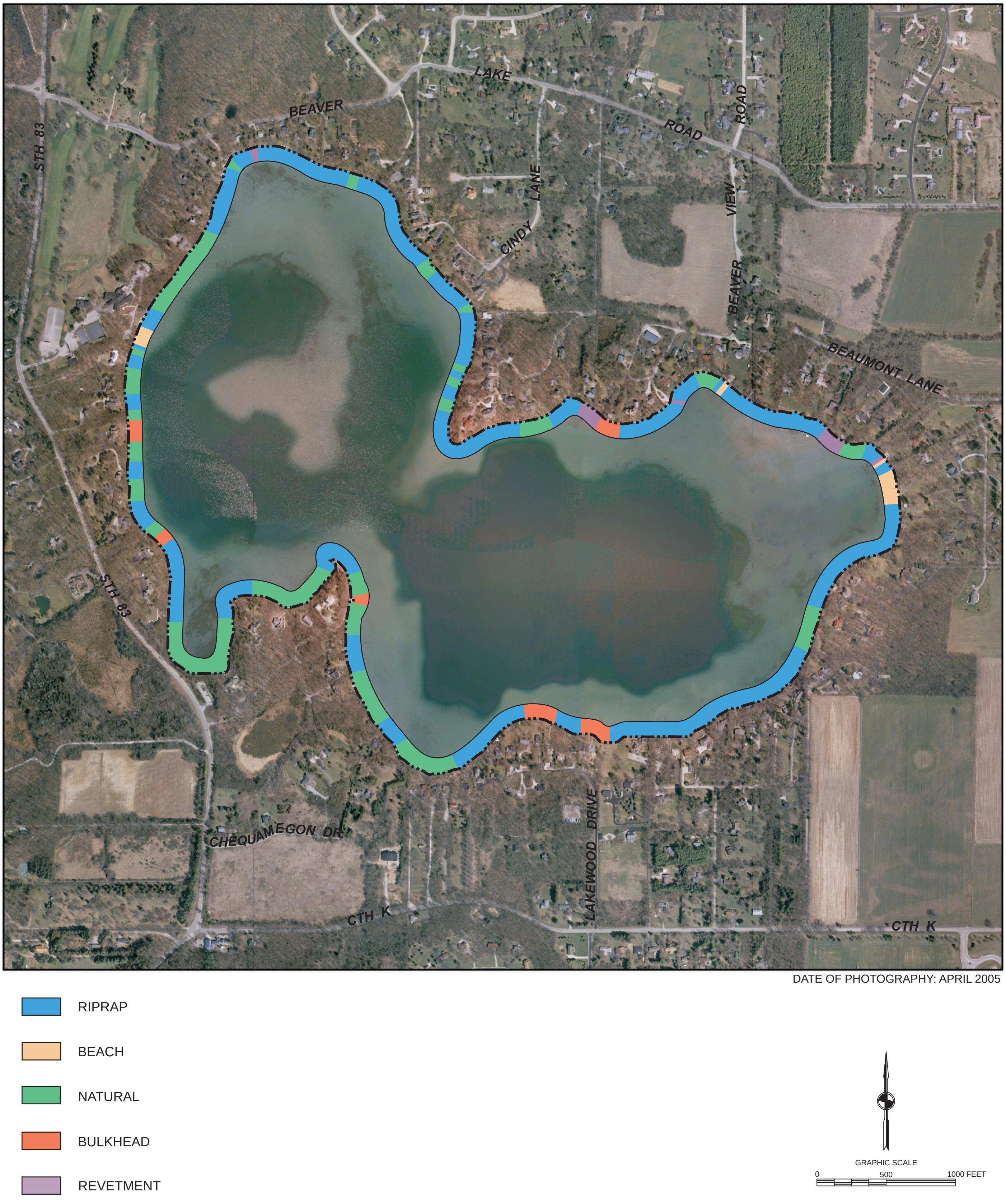
SHORELINE PROTECTION STRUCTURES ON PINE LAKE: 2008



DATE OF PHOTOGRAPHY: APRIL 2005

Map 8

SHORELINE PROTECTION STRUCTURES ON BEAVER LAKE: 2008



Source: SEWRPC.

hydrological years are shown in Table 4. These current data seem to indicate the continuing affects of arsenic interference on the deep-water measurements of total phosphorus. Nevertheless, there appears to be improvement in water quality since the initial study period. As shown in Figure 1, average total phosphorus measurements for the current 2005-2006 study period are within the range of values indicative of good water quality; measurements of water clarity and chlorophyll-*a* concentration also indicate very good water quality.

In Beaver Lake, water quality sampling was conducted from 1973 to 1975, under the auspices of the data collection program associated with the regional water quality management plan planning program.[7] At that time, total phosphorus concentrations and Secchi-disk transparency measurements indicated good to very good water quality. There have been few additional water quality data reported for Beaver Lake. Algal and water quality samples from the Lake were analyzed in 2007, as reported in Appendix A.

Water Clarity

Water clarity, reported as Secchi-disk transparency, is often used as an indication of water quality. Transparency can be affected by physical factors, such as water color and suspended particulates, and by various biologic factors, including seasonal variations in planktonic algal populations and the activities of fish and other organisms living in a lake. Both Pine and Beaver Lakes are listed by the WDNR as having established populations of zebra mussels, *Dreissena polymorpha*, a nonnative invasive species of shellfish with known negative impacts on native benthic invertebrate populations. Zebra mussels are having a varied impact on inland lakes in the Upper Midwest. They can disrupt the food chain by removing significant amounts of phytoplankton or algae which serve as food not only for themselves but also for larval and juvenile fish and many forms of zooplankton. Their filter feeding proclivities also can increase water clarity, leading to increased growths of rooted aquatic plants, including Eurasian water milfoil. Curiously, within the Southeastern Wisconsin Region, zebra mussels have been observed attaching themselves to the stalks of the Eurasian water milfoil plants, dragging these stems out of the zone of light penetration due to the weight of the zebra mussel shells, and interfering with the competitive strategy of the Eurasian water milfoil plants. This, in turn, has contributed to improved growths of native aquatic plants in some cases, and to the growths of filamentous algae too large to be ingested by the zebra mussels in others. These impacts will become more apparent, and should be monitored during subsequent aquatic plant surveys of Pine and Beaver Lakes. Regardless as to the seeming beneficial impacts of these animals, the overall effect is that, as zebra mussels and other invasive species spread to inland lakes and rivers, environmental, aesthetic, and economic costs to water users generally increase as ecosystem changes occur in the lakes and streams.

In addition to the direct measurements of water clarity in lakes using a Secchi-disk, transparency of many Wisconsin lakes has been measured using remote sensing technology. The Environmental Remote Sensing Center (ERSC), established in 1970 at the University of Wisconsin-Madison campus, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its volunteer Self-Help Monitoring Program, now titled the Citizen Lake Monitoring Network (CLMN) administered by the University of Wisconsin-Extension, was able to gather clarity measurements from about 800 of these lakes, or about 10 percent of Wisconsin's largest lakes. Based on an analysis of these two data sets, the satellite remote sensing technology utilized by ERSC was able to accurately estimate water clarity, providing some assurance that the data can be considered equally reliable for the remaining 90 percent of lakes. ERSC remote sensing estimated average water clarity to be 10.1 feet for Pine Lake and 17.7 feet for Beaver Lake, values indicative of very good water quality. The estimated transparency of Pine Lake compares well with the observed mean value for Secchi-disk transparency of 12.2 feet, in the range of 9.5 feet to 14.9 feet reported by the USGS for the 2005 and 2006 hydrological years, as summarized in Table 4.

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[7]*See SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume Two,* Alternative Plans, *February 1979.*

Table 4

SEASONAL WATER QUALITY CONDITIONS IN PINE LAKE: 2005-2006

Parameter[a]	Spring (April and June)		Summer (July and August)		Fall (October)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Physical Properties						
Alkalinity, as $CaCO_3$						
Range	147-148	- -	- -	- -	- -	- -
Mean	147.5	- -	- -	- -	- -	- -
Standard Deviation	0.7	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Hardness, as $CaCO_3$						
Range	180	- -	- -	- -	- -	- -
Mean	180	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	1	- -	- -	- -	- -	- -
Color (Pt-Co. scale)						
Range	5.0-20.0	- -	- -	- -	- -	- -
Mean	12.5	- -	- -	- -	- -	- -
Standard Deviation	10.6	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Dissolved Oxygen						
Range	9.8-12.6	2.0-11.7	8.2-8.7	0.0-0.2	9.0	0.0
Mean	11.2	6.2	8.5	0.08	9.0	0.0
Standard Deviation	1.5	4.5	0.2	0.09	0	0.0
Number of Samples	4	4	4	4	1	1
pH (units)						
Range	8.1-8.5	7.4-8.0	8.5-8.7	7.1-7.3	8.5	7.3
Mean	8.4	7.7	8.55	7.2	8.5	7.3
Standard Deviation	0.2	0.3	0.1	0.1	0	0
Number of Samples	4	4	4	4	1	1
Secchi Depth (meters)						
Range	2.2 - 5.1	- -	2.9-4.5	- -	4.7	- -
Mean	4.0	- -	3.7	- -	4.7	- -
Standard Deviation	1.3	- -	0.6	- -	0	- -
Number of Samples	4	- -	4	- -	1	- -
Specific Conductance (µS/cm)						
Range	396-418	399-440	384-396	423-466	383	435
Mean	403	420	388.3	442.5	383	435
Standard Deviation	9.9	16.9	5.3	18.5	0	0
Number of Samples	4	4	4	4	1	1
Temperature (°C)						
Range	5.9-22.9	3.8-5.3	24.0-26.9	5.3-5.3	- -	- -
Mean	11.6	4.8	25.5	5.3	- -	- -
Standard Deviation	9.8	0.9	2.1	0	- -	- -
Number of Samples	3	3	2	2	- -	- -
Turbidity (NTU)						
Range	2.9	- -	- -	- -	- -	- -
Mean	2.9	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	1	- -	- -	- -	- -	- -
Dissolved Solids						
Range	220-226	- -	- -	- -	- -	- -
Mean	223	- -	- -	- -	- -	- -
Standard Deviation	4.2	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Metals/Salts						
Dissolved Calcium						
Range	29.0-31.1	- -	- -	- -	- -	- -
Mean	30.1	- -	- -	- -	- -	- -
Standard Deviation	1.5	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Dissolved Chloride						
Range	27.8-27.9	- -	- -	- -	- -	- -
Mean	27.85	- -	- -	- -	- -	- -
Standard Deviation	0.07	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -

Table 4 (continued)

Parameter[a]	Spring (April and June)		Summer (July and August)		Fall (October)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Metals/Salts (continued)						
Dissolved Iron (µg/l)						
Range	<100-<100	- -	- -	- -	- -	- -
Mean	<100	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Dissolved Magnesium						
Range	24.3-25.7	- -	- -	- -	- -	- -
Mean	25.0	- -	- -	- -	- -	- -
Standard Deviation	0.9	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Dissolved Manganese (µg/l)						
Range	<0.5	- -	- -	- -	- -	- -
Mean	<0.5	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	1	- -	- -	- -	- -	- -
Dissolved Potassium						
Range	2.0-2.0	- -	- -	- -	- -	- -
Mean	2.0	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Dissolved Silica						
Range	0.4	- -	- -	- -	- -	- -
Mean	0.4	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	1	- -	- -	- -	- -	- -
Dissolved Sodium						
Range	12.5-13.0	- -	- -	- -	- -	- -
Mean	12.75	- -	- -	- -	- -	- -
Standard Deviation	0.4	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Dissolved Sulfate SO_4						
Range	20.6-21.1	- -	- -	- -	- -	- -
Mean	20.9	- -	- -	- -	- -	- -
Standard Deviation	0.4	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Nutrients						
Dissolved Nitrogen, Ammonia						
Range	- -	- -	- -	- -	- -	- -
Mean	- -	- -	- -	- -	- -	- -
Standard Deviation	- -	- -	- -	- -	- -	- -
Number of Samples	- -	- -	- -	- -	- -	- -
Dissolved Nitrogen, NO_2+NO_3						
Range	<0.19	- -	- -	- -	- -	- -
Mean	<0.19	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	1	- -	- -	- -	- -	- -
Total Nitrogen, Amm. + Organic						
Range	0.47-0.59	- -	- -	- -	- -	- -
Mean	0.53	- -	- -	- -	- -	- -
Standard Deviation	0.08	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -
Total Nitrogen						
Range	0.5	- -	- -	- -	- -	- -
Mean	0.5	- -	- -	- -	- -	- -
Standard Deviation	0	- -	- -	- -	- -	- -
Number of Samples	1	- -	- -	- -	- -	- -
Dissolved Orthophosphorus						
Range	0.008-0.011	- -	- -	- -	- -	- -
Mean	0.0095	- -	- -	- -	- -	- -
Standard Deviation	0.002	- -	- -	- -	- -	- -
Number of Samples	2	- -	- -	- -	- -	- -

Table 4 (continued)

Parameter[a]	Spring (April and June)		Summer (July and August)		Fall (October)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Nutrients (continued)						
Total Phosphorus						
Range	0.020-0.031	0.045-0.142	0.018-0.029	0.253-0.297	0.026	0.234
Mean	0.024	0.094	0.023	0.276	0.026	0.234
Standard Deviation	0.006	0.049	0.005	0.018	0	0
Number of Samples	4	3	4	4	1	1
Biological						
Chlorophyll-*a* (µg/l)						
Range	2.2-8.9	- -	2.29-3.06	- -	2.4	- -
Mean	4.6	- -	2.58	- -	2.4	- -
Standard Deviation	1.3	- -	0.42	- -	0	- -
Number of Samples	4	- -	3	- -	1	- -

[a]*Milligrams per liter unless otherwise indicated.*

[b]*Depth of sample approximately 1.5 feet.*

[c]*Depth of sample near bottom, approximately 85 feet.*

Source: U.S. Geological Survey and SEWRPC.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. As shown in Figure 2, dissolved oxygen levels were generally higher at the surface of Pine Lake, where there is an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels were lowest near the bottom of the Lake, where decomposer organisms and chemical oxidation processes utilized oxygen in the decay process. When any lake becomes stratified, that is, when a thermal or chemical gradient of sufficient intensity produces a barrier separating upper waters, called the epilimnion, from lower waters, known as the hypolimnion, the surface supply of oxygen to the hypolimnion is cut off. Eventually, if there is not enough dissolved oxygen to meet the demands from the bottom dwelling aquatic life and decaying organic materials, the dissolved oxygen levels in the bottom waters may be reduced to zero, a condition known as anoxia or anaerobiasis. As shown in Figure 2, Pine Lake thermally stratifies and also experiences hypolimnetic anoxia in late summer. While the data on dissolved oxygen concentrations in Beaver Lake from the 1970s are not sufficiently comprehensive to be able to determine whether or not that Lake experiences thermal stratification or hypolimnetic anoxia, the maximum depth of the Lake would suggest that such conditions are likely to occur.

Hypolimnetic anoxia is common in many of the lakes in southeastern Wisconsin during summer stratification. The depleted oxygen levels in the hypolimnion cause fish to move upward, nearer to the surface of the lakes, where higher dissolved oxygen concentrations exist. This migration, when combined with temperature, can select against some fish species that prefer the cooler water temperatures that generally prevail in the lower portions of the lakes. When there is insufficient oxygen at these depths, these fish are susceptible to summer-kills, or, alternatively, are driven into the warmer water portions of the lake where their condition and competitive success may be severely impaired. During the winter months, when ice cover limits the exchange of oxygen between the atmosphere and lake surface waters, similar conditions of oxygen depletion can occur and, in extreme cases, can lead to winter-kills of fishes.

In addition to these biological consequences, the lack of dissolved oxygen at depth can enhance the development of chemoclines, or chemical gradients, with an inverse relationship to the dissolved oxygen concentration. For example, the sediment-water exchange of elements such as phosphorus, iron, and manganese is increased under anaerobic conditions, resulting in higher hypolimnetic concentrations in these elements. Under anaerobic

Figure 1

PRIMARY WATER QUALITY INDICATORS FOR PINE AND BEAVER LAKES: SUMMERS 1974-2006

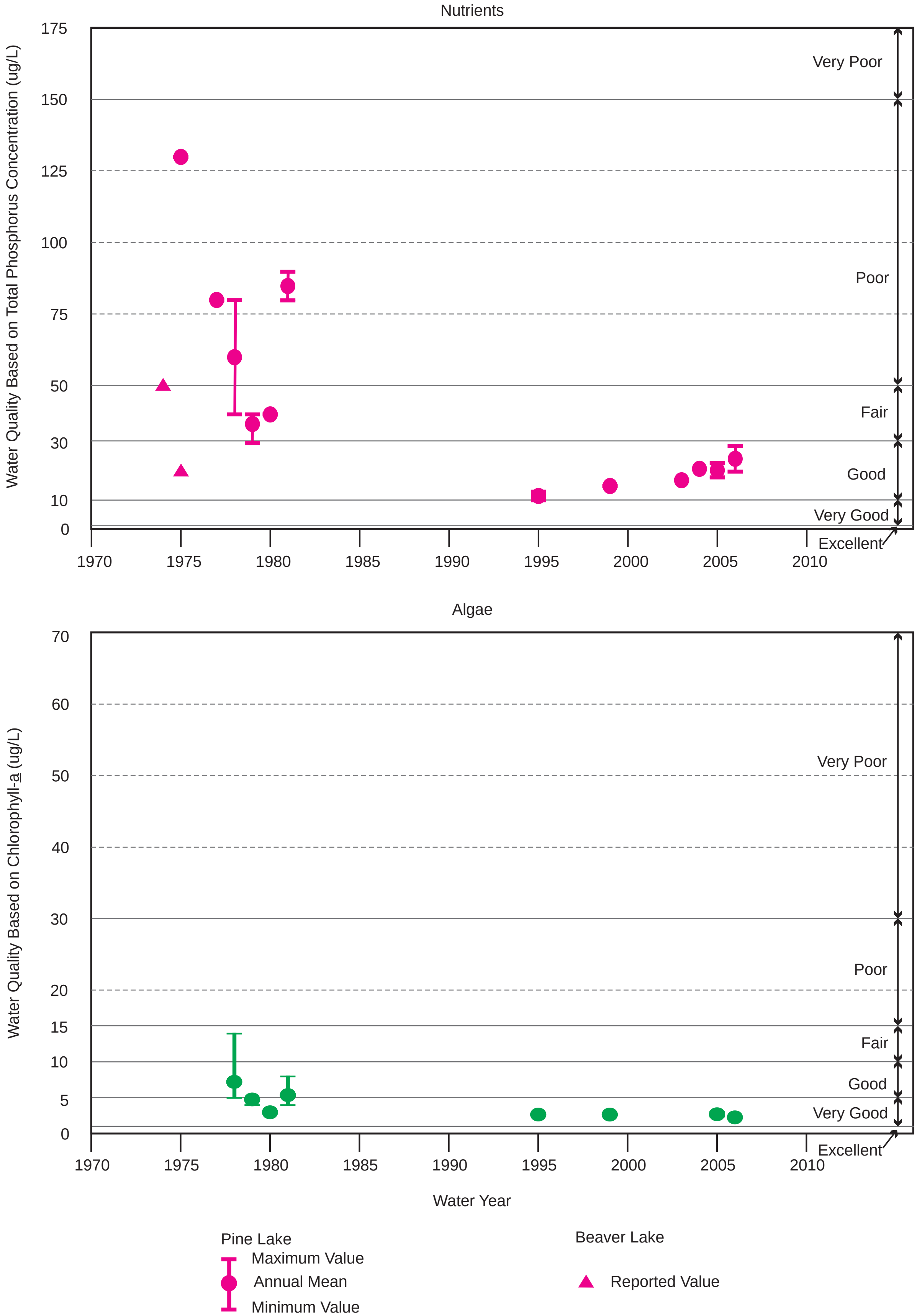
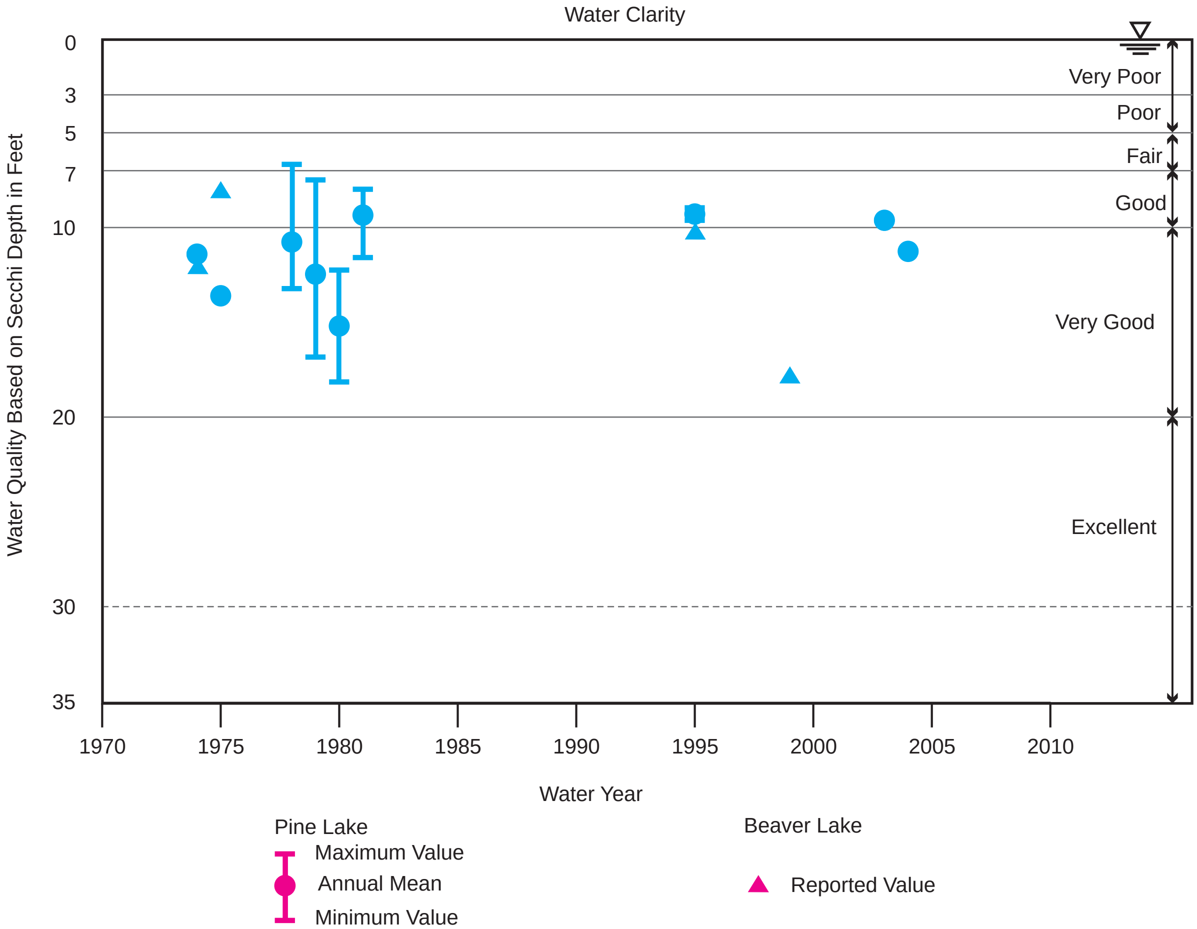


Figure 1 (continued)



Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

conditions, iron and manganese change oxidation states enabling the release of phosphorus from the iron and manganese complexes to which they are bound under aerobic conditions. This "internal loading" can affect water quality significantly if these nutrients and salts are mixed into the epilimnion, especially during early summer when these nutrients can become available for algal and rooted aquatic plant growth. The likely import of internal loading to the nutrient budget of Pine Lake is difficult to assess due to the aforementioned likely interference with phosphorus analyses from arsenic in the lake bottom sediments. However, measurements of total phosphorus concentrations in Beaver Lake during the 1970s did not seem to indicate the existence of internal loading in that Lake, and a similar lack of internal loading in Pine Lake can be surmised. Conductivity and pH data reported from Pine Lake by the USGS for the 2005 and 2006 water years, shown in Figure 3, would suggest that there is a release of certain elements to the hypolimnion of the Lake during the summer months but that such releases are not readily mixed into the surface waters of the Lake.[8]

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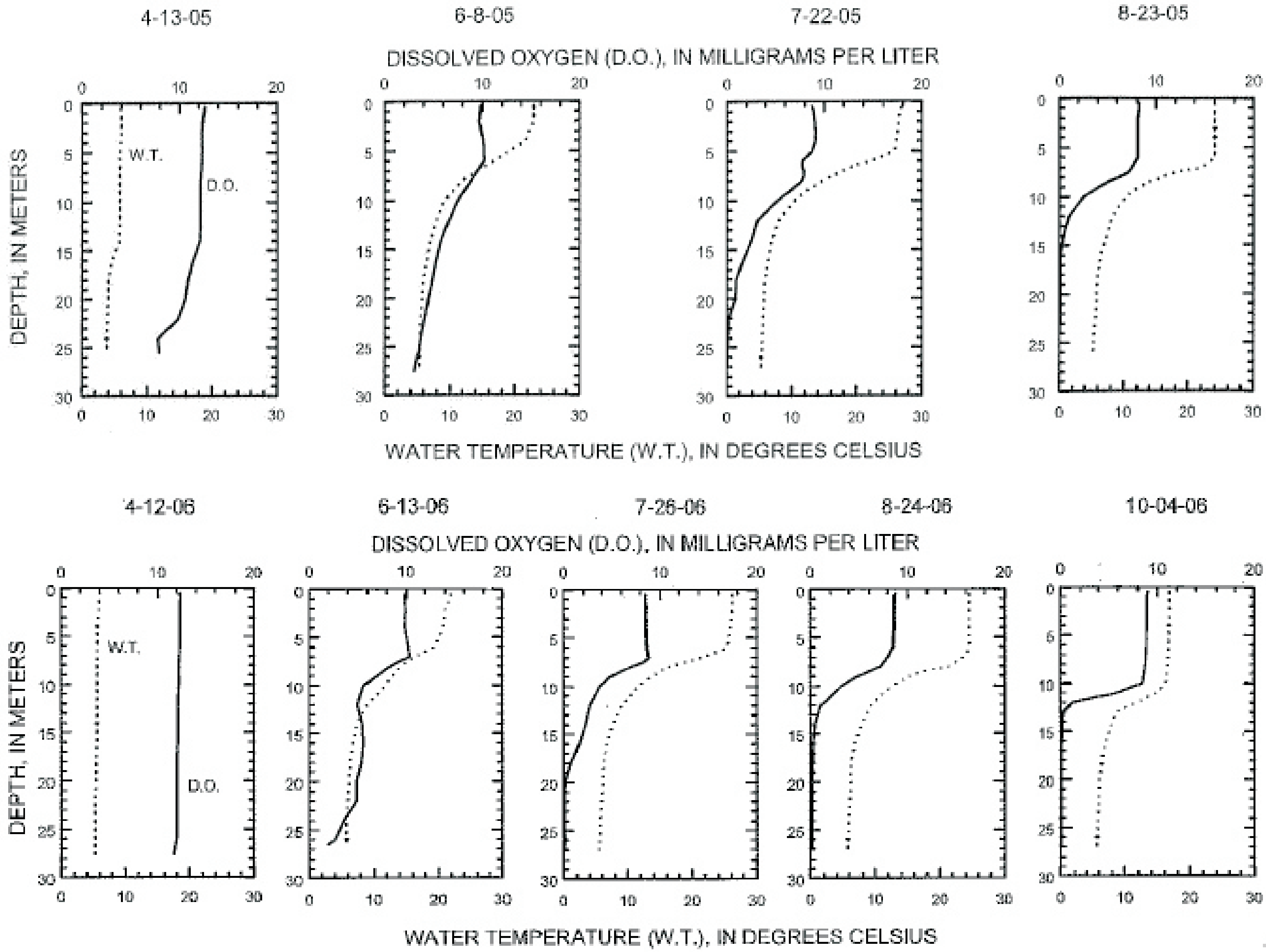
[8]*Werner Stumm and James J. Morgan,* Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, *Wiley-Interscience, New York, 1970; see also, for example, R.D. Robarts, P.J. Ashton, J.A. Thornton, H.J. Taussig, and L.M. Sephton, "Overturn in a hypertrophic, warm, monomictic impoundment (Hartbeespoort Dam, South Africa),"* Hydrobiologia, *Volume 97, 1982, pp. 209-224.*

Figure 2

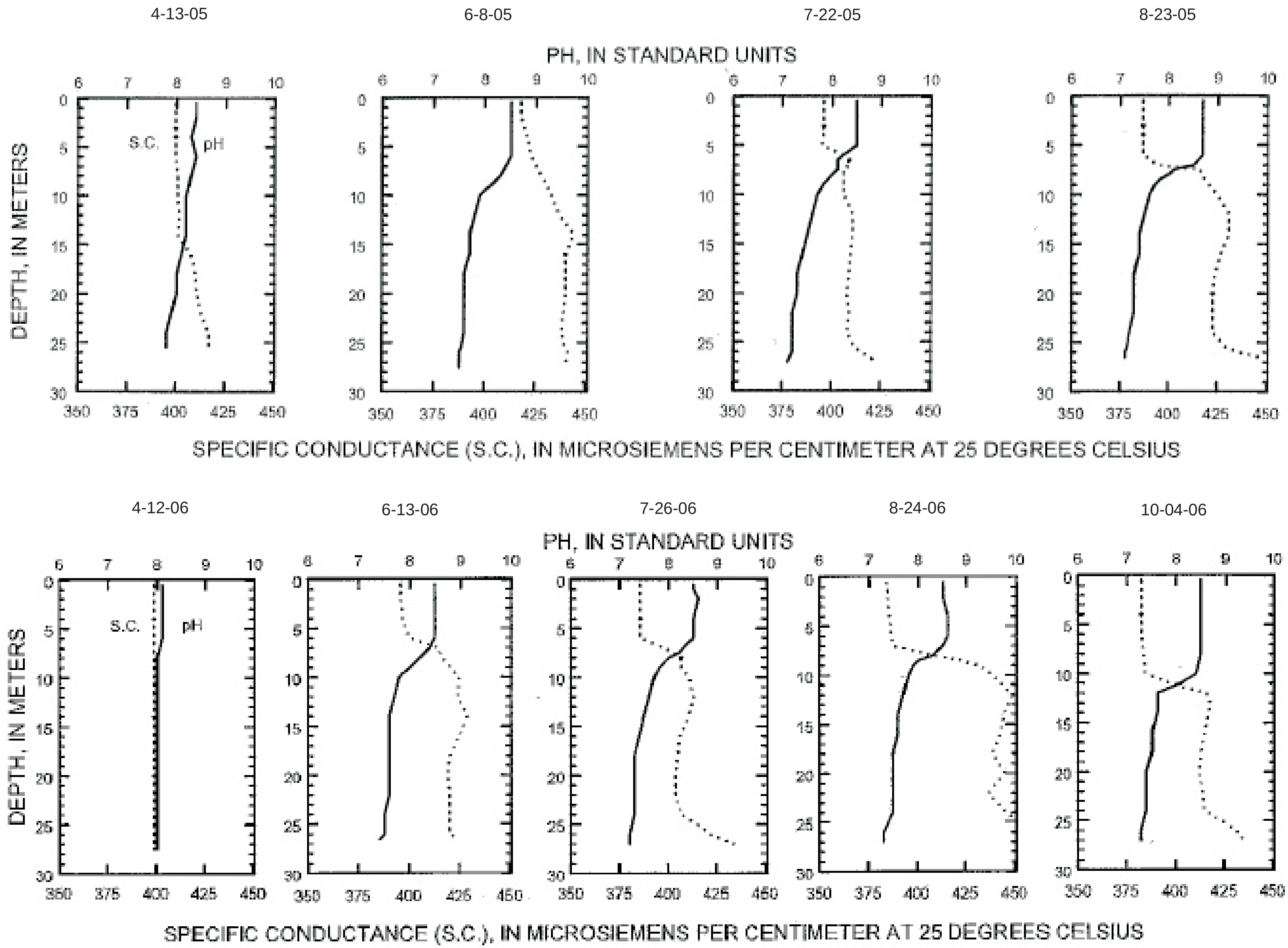
DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR PINE LAKE: 2005-2006



Source: U.S. Geological Survey and SEWRPC.

Figure 3

SPECIFIC CONDUCTANCE AND pH PROFILES FOR PINE LAKE: 2005-2006



Source: U.S. Geological Survey and SEWRPC.

POLLUTION LOADINGS AND SOURCES

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the area tributary to a lake. These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Pollutants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation. Pollutants transported across the land surface enter the lake as direct runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams enter a lake as surface water inflows. In drained lakes, like Pine and Beaver Lakes, precipitation falling directly onto the Lakes' surfaces, runoff from their direct tributary areas, and groundwater flowing into the Lakes from inside and outside of the immediate surface tributary areas, comprise the principal routes by which contaminants enter the waterbodies.[9] Currently, there are no significant point source discharges of pollutants to either Pine Lake or Beaver Lake, or to the surface waters tributary to the Lakes. For this reason, the discussion that follows is based upon nonpoint source pollutant loadings to the Lakes.

Nonpoint sources of water pollution include: urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such as runoff from agricultural lands and onsite sewage disposal systems.

In the previous report, phosphorus, sediment, and heavy metal budgets for Pine Lake were not computed. For the current study, nonpoint source phosphorus, suspended solids, and urban-derived metals inputs to Pine Lake and Beaver Lake were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.0) and unit area load-based models developed for use within the Southeastern Wisconsin Region. These estimated contaminant loads are summarized in Tables 5 through 8.

Phosphorus Loadings

The total nitrogen to total phosphorus ratios set forth in Table 4 indicate that phosphorus is the factor generally limiting aquatic plant growth in Pine Lake. Thus, excessive levels of phosphorus in the lake are likely to result in conditions that interfere with the desired use of the lake. Consequently, the magnitude and sources of the phosphorus loads to both Lakes are an issue of concern and potential area for the application of management practices that could limit undesirable aquatic plant growths.

During the current study, as shown in Table 5, existing year 2000 phosphorus loads to Pine and Beaver Lakes were identified and quantified using Commission land use inventory data. It was estimated that, under year 2000 conditions, the total phosphorus load to Pine Lake was 900 pounds. Of the annual total phosphorus load, it was estimated that 300 pounds per year, or about 35 percent, was contributed by runoff from urban lands; 410 pounds per year, or about 45 percent of the total loading, was contributed by runoff from rural lands; and 190 pounds, or about 20 percent, by direct precipitation onto the surface of the Lake.

Existing year 2000 phosphorus loads to Beaver Lake are shown in Table 6. In Beaver Lake, it was estimated that the total phosphorus load was 710 pounds. About 380 pounds per year, or about 55 percent, were contributed by runoff from urban lands; about 250 pounds per year, or about 35 percent of the total loading, was contributed by runoff from rural lands; and about 80 pounds, or about 10 percent, by direct precipitation onto the surface of the Lake.

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[9]*Sven-Olof Ryding and Walter Rast,* The Control of Eutrophication of Lakes and Reservoirs, *Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 1989; Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* The Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems*, Unesco Man and the Biosphere Series, Volume 23, Parthenon Press, Carnforth, 1999.*

Table 5

ESTIMATED EXTERNAL SOURCES OF PHOSPHORUS IN THE TOTAL AREA TRIBUTARY TO PINE LAKE: 2000 AND 2035

Source	2000		2035	
	Pounds	Percentage[a]	Pounds	Percentage[a]
Urban				
High-Density (commercial and industrial uses)	174.2	19.5	196.2	23.7
Medium-Density (multi-family and institutional uses)	6.6	0.7	13.2	1.6
Low-Density (single-family and suburban-density residential uses)	35.3	4.0	39.7	4.9
Onsite wastewater treatment facilities	79.5	8.9	79.5	9.6
Recreational Lands	2.2	0.2	2.2	0.2
Subtotal	297.8	33.3	330.8	40.0
Rural				
Mixed Agriculture	370.4	41.4	269.0	32.5
Wetlands	2.2	0.2	2.2	0.2
Woodlands	35.3	4.0	35.3	4.4
Water	187.4	20.9	187.4	22.7
Extractive and Landfill	2.2	0.2	2.2	0.2
Subtotal	597.5	66.7	496.1	60.0
Total	895.3	100.0	826.9	100.0

[a]*Percentages estimated from WILMS model results.*

Source: SEWRPC.

Table 6

ESTIMATED EXTERNAL SOURCES OF PHOSPHORUS IN THE TOTAL AREA TRIBUTARY TO BEAVER LAKE: 2000 AND 2035

Source	2000		2035	
	Pounds	Percentage[a]	Pounds	Percentage[a]
Urban				
High-Density (commercial and industrial uses)	114.7	16.1	172.0	27.6
Medium-Density (multi-family and institutional uses)	2.2	0.3	15.4	2.5
Low-Density (single-family and suburban-density residential uses)	39.7	5.5	55.1	8.9
Onsite wastewater treatment facilities	196.8	27.8	197.2	31.7
Recreational Lands	26.5	3.7	30.9	5.0
Subtotal	379.9	53.4	470.6	75.7
Rural				
Mixed Agriculture	233.7	32.9	55.1	8.9
Wetlands	2.2	0.3	2.2	0.3
Woodlands	11.0	1.6	11.0	1.7
Water	83.8	11.8	83.8	13.4
Subtotal	330.7	46.6	152.1	24.3
Total	710.6	100.0	622.7	100.0

[a]*Percentages estimated from WILMS model results.*

Source: SEWRPC.

Table 7

ESTIMATED CONTAMINANT LOADS FROM THE TOTAL AREA TRIBUTARY TO PINE LAKE: 2000 AND 2035

Land Use	2000					2035				
	Area (acres)	Sediment (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)	Area (acres)	Sediment (pounds	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Low-Density Residential	403	7,859	0.0	4.0	0.00	454	8,853	0.0	4.5	0.00
Commercial	4	3,136	0.9	6.0	0.04	29	22,736	6.4	43.2	0.29
Communications, Transportation, and Utilities	130	1,235	0.0	0.0	0.00	146	1,387	0.0	0.0	0.00
Governmental	9	4,599	0.6	7.2	0.00	54	27,594	3.8	43.2	0.00
Recreational	2	48	0.0	0.0	0.00	5	120	0.0	0.0	0.00
Water	722	135,736	- -	- -	- -	722	135,736	- -	- -	- -
Wetlands	18	66	- -	- -	- -	18	66	- -	- -	- -
Woodlands	435	1,609	- -	- -	- -	435	1,609	- -	- -	- -
Agricultural	518	233,100	- -	- -	- -	378	170,100	- -	- -	- -
Extractive and Landfill	2	900	- -	- -	- -	2	900	- -	- -	- -
Total	2,243	388,288	1.5	17.2	0.04	2,243	369,101	10.2	90.9	0.29

Source: SEWRPC.

Table 8

ESTIMATED CONTAMINANT LOADS FROM THE TOTAL AREA TRIBUTARY TO BEAVER LAKE: 2000 AND 2035

Land Use	2000					2035				
	Area (acres)	Sediment (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)	Area (acres)	Sediment (pounds	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Low-Density Residential	444	8,658	0.0	4.4	0.00	610	11,895	0.0	6.1	0.00
Commercial	1	784	0.2	1.5	0.01	1	784	0.2	1.5	0.01
Industrial	2	1,504	0.4	3.0	0.02	2	1,504	0.4	3.0	0.02
Communications, Transportation, and Utilities	84	798	0.0	0.0	0.00	126	1,197	0.0	0.0	0.00
Governmental	6	3,066	0.4	4.8	0.00	35	17,885	2.5	28.0	0.00
Recreational	102	2,448	0.0	0.0	0.00	114	2,736	0.0	0.0	0.00
Water	325	61,100	- -	- -	- -	325	61,100	- -	- -	- -
Wetlands	15	55	- -	- -	- -	15	55	- -	- -	- -
Woodlands	147	544	- -	- -	- -	147	544	- -	- -	- -
Agricultural	326	146,700	- -	- -	- -	77	34,650	- -	- -	- -
Total	1,452	225,657	1.0	13.7	0.03	1,452	132,350	3.1	38.6	0.03

Source: SEWRPC.

Under 2035 conditions, as set forth in the adopted regional land use and county development plans,[10] the annual total phosphorus loads to the Lakes is anticipated to diminish as agricultural activities within the areas tributary to the Lakes are replaced by urban residential land uses. The most likely annual total phosphorus load to Pine Lake under buildout conditions is estimated to be 830 pounds, as shown in Table 5 for year 2035 conditions. Of the total annual forecast phosphorus load, 330 pounds per year, or about 40 percent of the total loading, are estimated to be contributed by runoff from urban lands; 310 pounds per year, or about 35 percent, contributed by runoff from rural lands; and 190 pounds, or about 25 percent, by direct precipitation onto the surface of the Lake. Thus, it may be anticipated that the distribution of the sources of the phosphorus load to the Lake will change, with the amount of phosphorus being contributed from urban sources experiencing an increase from about 300 pounds of phosphorus per year in 2000 to about 330 pounds of phosphorus per year in 2035, or by about 10 percent of the total in year 2000. The amount of phosphorus from rural sources would decrease from about 410 pounds per year in 2000 to about 310 pounds per year in 2035, or by about 25 percent of the total in year 2000.

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[10]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006; see also SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

Table 6 shows a similar pattern for Beaver Lake under 2035 conditions. Of the total annual forecast phosphorus load of about 620 pounds of phosphorus to the Lake, 470 pounds per year, or about 75 percent of the total load, are estimated to be contributed by runoff from urban lands; 70 pounds per year, or about 10 percent, by runoff from rural lands; and 80 pounds, or about 15 percent, by direct precipitation onto the surface of the Lake. Thus, similar to Pine Lake, the amount of phosphorus being contributed to Beaver Lake from urban sources maybe expected to increase during the planning period, with a concomitant decrease in rural sources.

Notwithstanding, the trend toward decreasing phosphorus loadings as rural lands are converted to urban uses may be offset by the increasing utilization of agro-chemicals in urban landscaping.[11] Studies within the Southeastern Wisconsin Region indicate that urban residential lands fertilized with a phosphorus-based fertilizer can contribute up to two-times more dissolved phosphorus to a lake than lawns fertilized with a phosphorus-free fertilizer or not fertilized at all.[12] For this reason, an increasing number of communities are adopting, *inter alia*, turf management ordinances to minimize phosphorus applications and loads from urban lands.[13]

Sediment Loadings

For the current study period, the estimated sediment loadings to Pine Lake for existing year 2000 are shown in Table 7. Under existing year 2000 conditions, a total annual sediment loading of 194 tons was estimated to be contributed to Pine Lake. Of the likely annual sediment load, it was estimated that eight tons, or about 5 percent, was contributed by urban lands; 118 tons per year, or about 60 percent of the total loading, was contributed by runoff from rural land (mostly agricultural); and 68 tons, or about 35 percent, contributed by atmospheric deposition onto the surface of the Lake and other waterbodies within the Lake's tributary area.

Existing year 2000 sediment loads for Beaver Lake are shown in Table 8. In Beaver Lake, it was estimated that 113 tons of sediment were contributed to the Lake under year 2000 land use conditions. Of this total load, about nine tons per year, or about 10 percent, were contributed by runoff from urban land; 73 tons per year, or about 65 percent of the total loading, was contributed by runoff from rural land; and about 31 tons, or about 25 percent, by direct precipitation onto the surface of the Lake.

Under 2035 conditions, as set forth in the adopted regional land use and county development plans, the annual sediment loads to the Lakes are anticipated to diminish. In Pine Lake, the most likely annual sediment load to the Lake under buildout conditions, as shown in Table 7, is estimated to be 185 tons. In addition, the distribution of the sources of the sediment load to the Lake also is expected to change, with an increased mass of sediment being contributed from urban lands, estimated to be 30 tons of sediment per year, and a decreased mass of sediment from rural lands, estimated to be 87 tons of sediment per year. An estimated 68 tons of sediment per year are expected to be contributed by direct precipitation onto the surface of the Lake. Thus, it is anticipated that the amount of sediment being contributed from urban sources will increase from about 5 percent of the total in 2000 to about 15 percent of the total in 2035, while the amount of sediment from rural sources will decrease from about 60 percent of the total in 2000 to about 45 percent of the total in 2035.

Table 8 shows sediment loads for Beaver Lake under 2035 conditions. Of the total annual forecast sediment load of 66 tons of sediment to Beaver Lake under 2035 conditions, about 18 tons per year, or 27.5 percent of the total loading, are estimated to be contributed by runoff from urban lands; 18 tons per year, or 27.5 percent, contributed

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[11]*U.S. Geological Survey Water-Resources Investigations Report No. 02-4130,* Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Lakeshore Lawns, Lauderdale Lakes, Wisconsin*, July 2002.*

[12]Ibid.

[13]*These regulations typically limit the application of those fertilizers containing phosphorus to those soil amendments containing no-phosphorus or low-phosphorus—less than 3 percent phosphorus and/or compost-based products—in urban areas; see also Wisconsin Department of Natural Resources Technical Standard No. 1100,* Turf Nutrient Management*, January 2006.*

by runoff from rural lands; and about 30 tons, or about 45 percent, by direct precipitation onto the surface of the Lake. Thus, as was the case with Pine Lake, the amount of sediment being contributed to Beaver Lake from urban sources will increase from about 10 percent of the total in 2000 to 27.5 percent of the total in 2035, while the amount of sediment from rural sources is expected to decrease from about 65 percent of the total in 2000 to about 27.5 percent of the total in 2035.

Urban Heavy Metals Loadings

Urbanization brings with it the increased use of metals and other materials that contribute pollutants to aquatic systems.[14] The majority of these metals become associated with sediment particles[15] and are likely to settle out of the water column rapidly, becoming encapsulated into the bottom sediments of the Lake.

Heavy metal loadings were not determined during the previous reporting period. For the current study, the estimated loadings of copper, zinc, and cadmium likely to be contributed to Pine Lake for existing year 2000 and forecast year 2035 are shown in Table 7. In 2000, 1.5 pounds of copper, 17 pounds of zinc, and less than one pound of cadmium were estimated to be contributed annually to Pine Lake from the surrounding urban lands. Under 2035 conditions, as set forth in the adopted regional land use and county development plans, the annual heavy metal loads to the Lake are expected to increase to about 10 pounds of copper, about 90 pounds of zinc, and about one-third of a pound of cadmium.

Heavy metal loadings to Beaver Lake for existing year 2000 and forecast year 2035 are shown in Table 8. Under year 2000 conditions, one pound of copper, 14 pounds of zinc, and less than one pound of cadmium were estimated to be contributed annually to Beaver Lake from urban lands. Under year 2035 conditions, the annual heavy metal loads to the Lake are expected to increase to 3.1 pounds of copper and 39 pounds of zinc. The cadmium load is expected to remain about the same.

Trophic Status

Lakes are commonly classified according to their degree of nutrient enrichment, or trophic status. The ability of lakes to support a variety of recreational activities and healthy fish and other aquatic life communities is often correlated to the degree of nutrient enrichment which has occurred. There are three terms generally used to describe the trophic status of a lake: oligotrophic, mesotrophic, and eutrophic.

Oligotrophic lakes are nutrient-poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain very productive fisheries. Oligotrophic lakes may provide excellent opportunities for swimming, boating, and waterskiing. Because of the naturally fertile soils and the intensive land use activities, there are relatively few oligotrophic lakes in southeastern Wisconsin.

Mesotrophic lakes are moderately fertile lakes which may support abundant aquatic plant growths and productive fisheries. However, nuisance growths of algae and macrophytes are usually not exhibited by mesotrophic lakes. These lakes may provide opportunities for all types of recreational activities, including boating, swimming, fishing, and waterskiing. Many lakes in southeastern Wisconsin are mesotrophic.[16]

Eutrophic lakes are nutrient-rich lakes. These lakes often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If the lakes are shallow, fish winterkills may be common. While portions of

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[14]*Jeffrey A. Thornton, et al.,* op. cit.

[15]*Werner Stumm and James J. Morgan,* op. cit.

[16]*R.A. Lillie, and J.W. Mason,* Limnological Characteristics of Wisconsin Lakes, *Wisconsin Department of Natural Resources Technical Bulletin No. 138, 1983. Also see SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries, albeit with a limited number of species. Extremely enriched lakes are frequently termed as "hypertrophic."

Several numeric "scales," based on one or more water quality indicators, have been developed to define the trophic condition of lakes. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applies. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[17] and the Carlson Trophic State Index (TSI),[18] with a variation known as the Wisconsin Trophic State Index value (WTSI).[19] The WTSI is a refinement of the Carlson TSI designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes, and has been adopted by the WDNR for use in lake management investigations.

Based upon data gathered by the aforementioned Environmental Remote Sensing Center (ERSC), Pine Lake had a Trophic State Index (TSI) value of 44, and Beaver Lake had a value of 36. A value between 40 and 50 is indicative of moderately enriched conditions. [20] These TSI values are consistent with the historically good to very good transparency conditions noted above, and indicate that Pine Lake should remain classified as a mesotrophic waterbody, while Beaver Lake may fit into an oligo-mesotrophic classification.

Carlson TSI data calculated by the USGS for Pine Lake during the current study indicate that Pine Lake should be considered a mesotrophic or oligo-meso trophic lake. TSI values based upon chlorophyll-*a* concentrations and Secchi-disk depths fluctuated between the mesotrophic and oligotrophic classifications, while the TSI values calculated from the total phosphorus concentrations fluctuated near the mesotrophic-eutrophic interface. WTSI values based on the water quality data for Pine Lake averaged about 42, which is consistent with the mesotrophic status reported by the ERSC and suggested by the Carlson TSI values presented above.

GROUNDWATER RESOURCES

Groundwater resources constitute a valuable element of the natural resource base related to Pine and Beaver Lakes. Groundwater in the vicinity of the Lakes moves within two distinct systems: a shallow water table system,[21] and a deep sandstone system.

The shallow water table system consists of glacial deposits and the dolomite bedrock nearest the surface. This shallow groundwater system interacts with the surface water system, contributing to the base flow of streams and

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[17]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition, *Washington, D.C., August 1990.*

[18]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography*, Vol. 22, No. 2, 1977.*

[19]*See R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes,"* Research and Management Findings*, Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93, May 1993.*

[20]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography*, Volume 22, No. 2, 1977, as refined by* R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes," *Research and Management Findings*, Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93, May 1993.

[21]*The water table is the upper limit of the portion of the ground which is fully saturated with water.*

maintenance of lake levels during low rainfall periods. The shallow sand and gravel aquifer,[22] consisting of water-bearing sand and gravel, extends to 100 to 200 feet in thickness in the vicinity of Pine and Beaver Lakes. Although the groundwater gradient in the surface aquifer is relatively flat in the vicinity of the Lakes, indicating limited horizontal movement, groundwater generally flows in a southwesterly direction, as shown on Map 9. The shallow sand and gravel aquifer also is significant in terms of sustaining the adjacent wetland systems.

The deep system includes all bedrock, mostly sandstone, directly above the crystalline Precambrian basement rocks. This system has limited interchange with the surfacial aquifers, and has significantly less influence on the surface water hydrology of the Beaver and Pine Lake flow system. This deep system, however, is frequently accessed as the principle source of water for municipal water supply systems in the Region.[23]

AQUATIC PLANTS: DISTRIBUTION AND MANAGEMENT AREAS

Phytoplankton

Phytoplankton, or algae are small, generally microscopic plants that are found in all lakes and streams. They occur in a wide variety of forms, as single cells or colonies, and can be either attached or free floating. Algae are primary producers that form one of the bases of the aquatic food chain. Through photosynthesis, they convert energy and nutrients to the compounds necessary to support life in the aquatic system. Oxygen, which is vital to higher forms of life in a lake or stream, is also produced in the photosynthetic process. Phytoplankton abundance varies seasonally with fluctuations in solar irradiance, turbulence due to prevailing winds, and nutrient availability. Phytoplankton abundance is usually reported in terms of the concentration of the green plant pigment, chlorophyll-*a*. Chlorophyll-*a* concentrations measured in Pine Lake by the USGS ranged from about 2.0 mg/m^3 and 8.0 mg/m^3 (= µg/l) during the 2005 and 2006 hydrological years. These values generally indicate fair to very good water quality, with concentrations of about 10 µg/l or more being the threshold above which algal populations are typically at densities that result in a green coloration of the water and severe enough to impair recreational activities such as swimming and skiing.

Green algae (Chlorophyta) are the most important source of food for zooplankton, or microscopic animals, in the lakes of Southeastern Wisconsin. Blue-green algae (Cyanophyta) are not ordinarily utilized by zooplankton or fish populations, and may become over-abundant and out of balance with the organisms that feed on them. Dramatic population increases, blooms, of blue-green algae may occur when excessive nutrient supplies are available, optimum sunlight and temperature conditions exist, and there is a lack of competition from other aquatic plant species and insufficient grazing by zooplankton. Algal blooms can cause noxious odors and unsightly conditions, while the decaying algae consume oxygen in the process of decomposition, periodically resulting in fish kills. Certain species of blue-green algae may form toxic varietals, which contribute to gastro-enteritis, skin irritations, and potential toxicity in animals and humans, as noted in Appendix A.

Samples of lake water for algological analysis were obtained from both Pine Lake and Beaver Lake in the vicinities of the public recreational boating access sites by Commission staff during late-July and during mid-August of 2007, when visible surface scums of algae were reported by lake residents. Additional samples from Beaver Lake were obtained by the Friends of Beaver Lake, Inc. These samples were sent to various laboratories for analysis of species composition and/or presence of algal toxins.

The July 2007 sample obtained from Pine Lake was found by Phycotech, Inc., to contain a variety of blue-green algae or cyanobacteria. The three species reported were identified as *Anabaena lemmermannii*, *Lyngbya birgei*, and *Microcystis aeruginosa*, with *Microcystis aeruginosa* being the most numerous alga. A similar sample obtained from Beaver Lake contained on *Microcystis aeruginosa*. Of these, *Microcystis aeruginosa* is a blue-green alga known to form potentially toxic varietals.

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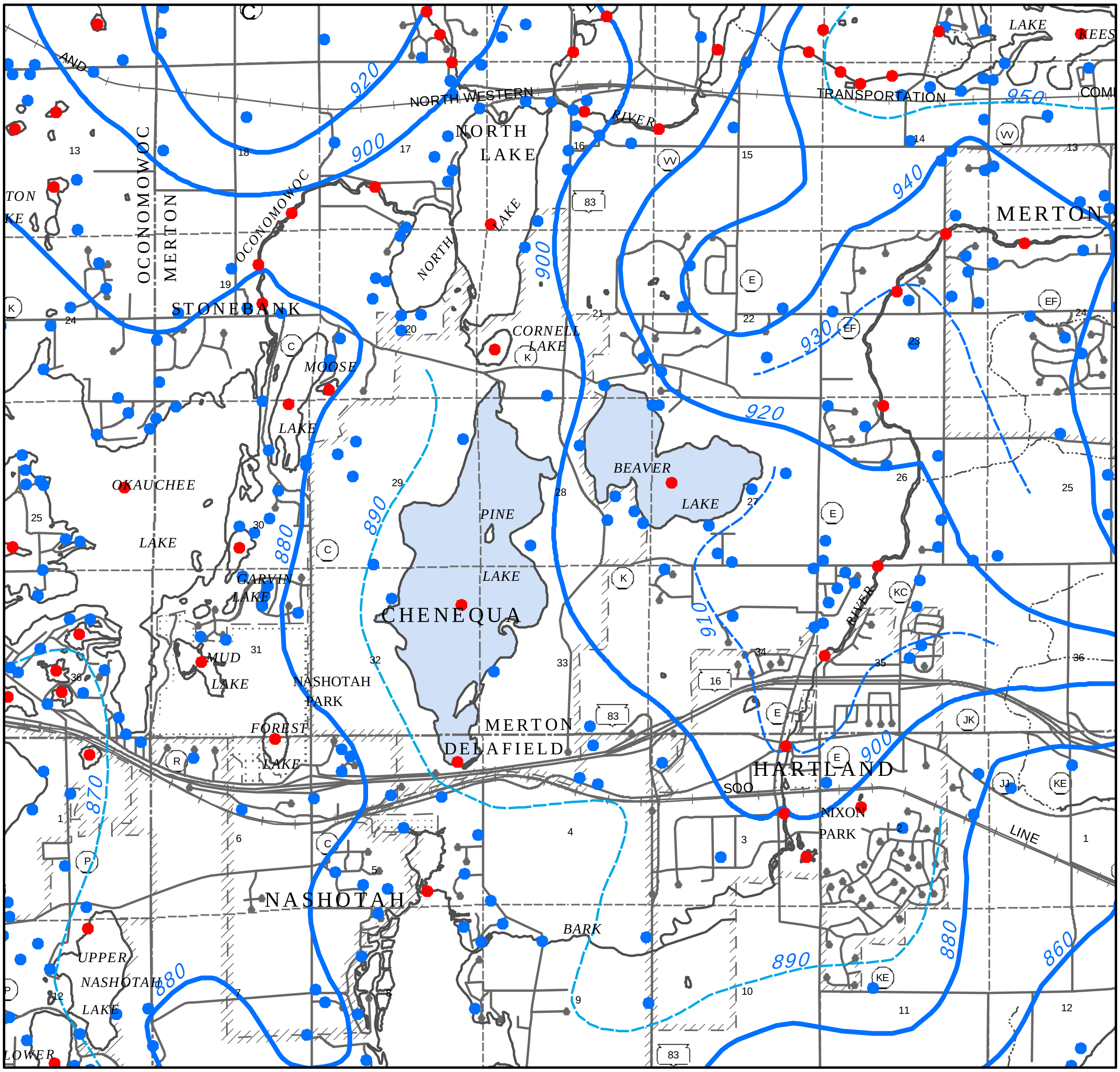
[22]*An aquifer is a water-bearing stratum of rock, sand, or gravel.*

[23]*See SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin, *June 2002.*

Map 9

DIRECTION OF GROUNDWATER FLOW IN THE PINE AND BEAVER LAKES AREA

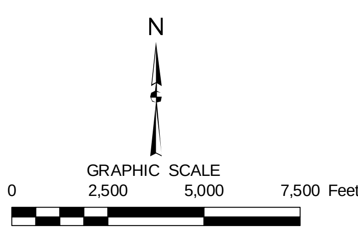


AVERAGE WATER-TABLE ELEVATION (FEET ABOVE MEAN SEA LEVEL)

SUPPLEMENTAL CONTOUR

SURFACE WATER POINT

WELL DATA POINT



Source: U.S. Geological Survey and SEWRPC.

The August 2007 samples, analyzed by the Wisconsin State Laboratory of Hygiene, also were reported to contain blue-green algae, specifically *Microcystis aeruginosa*. The numbers of cells reported, however, were below the guideline value of 20,000 cells per milliliter (ml) recommended by the World Health Organization (WHO) as having a probability for creating adverse health affects. Pine Lake had 1,100 cells/ml and Beaver Lake 3,800 cells/ml.

Further analysis of the August samples for the presence of algal toxins indicated that there were indeed toxins present. The enzyme-based test, known as an ELIZA test for algal toxicity, indicated that the level of toxin (microcystin) associated with the *Microcystis* colonies was below the WHO standard for the safe consumption of water. For reference, the WHO assumes the consumption of 2 liters (or about one-half gallon) of drinking water per day containing less than 1.0 micrograms of microcystin per liter (µg/l). The Pine Lake sample contained less than 0.10 µg /l and the Beaver Lake sample contained 0.38 µg /l.

Similar results were obtained from the samples obtained from Beaver Lake by the Friends of Beaver Lake, Inc.

Aquatic Macrophytes

Aquatic macrophytes play an important role in the ecology of Southeastern Wisconsin lakes. Macrophytes provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise could contribute to excessive algal growth. Many factors, including lake configuration, depth, water clarity, nutrient availability, bottom substrate composition, wave action, and the type and size of fish populations present, determine the distribution and abundance of aquatic macrophytes in a lake.

A survey and inventory of the aquatic plant communities in Pine Lake was conducted in June of 1996 as part of the initial SEWRPC study.[24] Prior to this, aquatic plant surveys had been conducted by the WDNR in 1978, 1980, and 1981. The aquatic plant surveys of Pine and Beaver Lakes were conducted using the modified Jesson and Lound transect method as adopted by the Wisconsin Department of Natural Resources. This methodology, when utilized in successive aquatic plant surveys, will allow the statistical evaluation of changes in the aquatic plant community within the Lake. [25] Concurrent with the 1996 survey, the Village of Chenequa commissioned a series of oblique aerial photographs of the Lake surface for the purpose of potentially monitoring the Lake's aquatic plant communities over time by comparing aerial photographs from year-to-year. Eurasian water milfoil, in particular, can be more visible than most other aquatic plants from an aerial viewpoint because of its tendency to form a spreading canopy on the surface of the Lake. The 1996 aerial photographs presented in the initial report showed areas of Eurasian water milfoil growth and, while it was concluded that such aerial surveys could provide a means of Eurasian water milfoil crop assessment in years when no on-lake surveys were conducted, it was suggested that on-lake aquatic plant surveys must continue to form the basis for aquatic plant management decisions.

A species list, compiled from the results of the Commission aquatic plant surveys in Pine and Beaver Lakes, is set forth in Table 9, along with comments on the ecological significance of each plant on the list. Representative illustrations of these aquatic plants can be found in Appendix B.

Pine Lake

At the time of the 1996 survey, aquatic plant communities were reported to be significantly more abundant and diverse than the plant communities reported by the WDNR in the earlier surveys. In the 1996 survey, 18 species of aquatic plants were recorded in the Lake basin. The dominant aquatic plant within the Lake was milfoil, *Myriophyllum* spp., with the most commonly occurring milfoil species, Eurasian water milfoil, *Myriophyllum*

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[24]*SEWRPC Memorandum Report No. 124*, op. cit.

[25]*Memo from Stan Nichols, to J. Bode, J. Leverence, S. Borman, S. Engel, D., Helsel, entitled "Analysis of Macrophyte Data for Ambient Lakes-Dutch Hollow and Redstone Lakes example," Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, February 4, 1994.*

Table 9

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN PINE AND BEAVER LAKES: 2005

Aquatic Plant Species Present	Native or Exotic	Ecological Significance
Ceratophyllum demersum (coontail)	Native	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	Native (high value)	Excellent producer of fish food, especially for young trout, bluegills, small and largemouth bass; stabilizes bottom sediments, and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (Elodea/Waterweed)	Native	Provides shelter and support for insects which are valuable as fish food
Myriophyllum sibiricum (northern water milfoil)	Native	Provides food for waterfowl, insect habitat and foraging opportunities for fish
Myriophyllum spicatum (Eurasian water milfoil)	Exotic	None known
Najas flexilis (bushy pondweed; slender naiad)	Native	One of the most important plants for waterfowl; stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Native	Important food source for ducks
Potamogeton amplifolius (large-leaf pondweed; bass weed; musky weed)	Native (high value)	A premier plant for providing fish habitat; offers shade, shelter and foraging for fish; valuable food for waterfowl; has been successfully transplanted
Potamogeton crispus (curly-leaf pondweed)	Exotic	Provides food, shelter and shade for some fish and food for wildfowl
Potamogeton foliosis (leafy pondweed)	Native	Provides food for geese and ducks; food for muskrat, beaver and deer; good surface area for insects and cover for juvenile fish
Potamogeton gramineus (variable pondweed)	Native	Provides habitat for fish and food for waterfowl, in addition to muskrat, beaver, deer, and moose
Potamogeton illnoensis (Illinois pondweed)	Native	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton natans (floating-leaf pondweed)	Native	Provides food for waterfowl, muskrat, beaver and deer; good fish habitat
Potamogeton pectinatus (sago pondweed)	Native	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton praelongus (white-stem pondweed)	Native (high value)	Good food provider for waterfowl, muskrat, and some fish species; valuable habitat for musky. Considered an indicator species for water quality due to its intolerance of turbid water conditions
Potamogeton pusillus (small pondweed)	Native	Important food source for a variety of ducks, in addition to providing food for some mammals. Food source and cover for fish
Potamogeton zosteriformis (flat-stem pondweed)	Native	Provides some food for ducks, fish, and invertebrates
Ranunculus longirostris (stiff water crowfoot)	Native	Provides food for trout, upland game birds, and wildfowl
Vallisneria americana (water celery/eelgrass)	Native	Provides good shade and shelter, supports insects, and is valuable fish food
Zosterella dubia (water stargrass)	Native	Provides food and shelter for fish, locally important food for waterfowl

Source: Wisconsin Lakes Partnership, Through the Looking Glass…A Field Guide to Aquatic Plants*, 1999, and SEWRPC.*

spicatum, being fairly widespread. The Lake also contained numerous species of pondweed, *Potamogeton* spp., which provide good fish and aquatic wildlife habitat and little interference with recreational use. It was noted that, while the southern portion of the Lake exhibited the greatest plant diversity in 1978, the northern portion of the Lake contained the more diverse plant communities during the 1996 survey. The Eurasian water milfoil communities had also undergone a change over time. What had previously been small, isolated monospecific stands of Eurasian water milfoil at the time of the earlier surveys in the 1970s and 1980s had expanded in size and

Table 10

AQUATIC PLANT SPECIES OBSERVED IN PINE LAKE: AUGUST 2005

Common Name	Scientific Name	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Bushy Pondweed	*Najas flexilis*	66	33.8	2.0	68.21
Coontail	*Ceratophyllum demersum*	46	23.6	1.4	32.31
Curly-Leaf Pondweed	*Potamogeton crispus*	15	7.7	2.1	15.90
Elodea	*Elodea canadensis*	14	7.2	1.9	13.33
Eurasian Water Milfoil	*Myriophyllum spicatum*	57	29.2	2.4	69.23
Flat-Stem Pondweed	*Potamogeton zosteriformis*	16	8.2	1.8	14.36
Floating-Leaf Pondweed	*Potamogeton natans*	17	8.7	1.9	16.41
Illinois Pondweed	*Potamogeton illinoensis*	32	16.4	1.9	30.77
Large-Leaf Pondweed	*Potamogeton amplifolius*	10	5.2	1.7	8.72
Leafy Pondweed	*Potamogeton foliosis*	41	21.0	1.8	37.44
Muskgrass	*Chara vulgaris*	129	66.1	2.8	183.10
Native Water Milfoil	*Myriophyllum spp.*	83	42.6	2.3	95.90
Sago Pondweed	*Potamogeton pectinatus*	68	34.9	2.4	82.10
Small Pondweed	*Potamogeton pusillus*	7	3.6	1.3	4.62
Spiny Naiad	*Najas marina*	61	31.3	2.2	69.23
Variable Pondweed	*Potamogeton gramineus*	12	6.2	2.4	14.87
Water Crowfoot	*Ranunculus longirostris*	11	5.6	1.3	7.18
Water Stargrass	*Zosterella dubia*	5	2.6	1.4	3.59
White-Stem Pondweed	*Potamogeton praelongus*	15	7.7	1.7	13.33

NOTE: Sampling occurred at 116 sites along 51 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

number and become more interspersed with the native plant species by the time of the 1996 survey. These changes were independently corroborated by observed changes in Eurasian water milfoil growth in Pine Lake reported by the aquatic plant management contractor employed by the Village of Chenequa between the mid-1970s to the mid-1990s.[26] Overall, the aquatic plant communities in Pine Lake reported during the 1996 survey appeared to be healthier and more robust than those observed during the earlier WDNR surveys.

During the current study period, Commission staff conducted an aquatic plant survey on Pine Lake in August of 2005, the results of which are shown in Table 10. The dominant species during the current study was muskgrass, *Chara vulgaris*, with native water milfoil, *Myriophyllum* spp., and Sago pondweed, *Potamogeton pectinatus*, also being present in significant numbers. Other major species present included Eurasian water milfoil, spiny naiad, *Najas marina*, and bushy pondweed, *Najas flexilis*.

Table 11 shows the frequency of occurrences of several major aquatic plant species present in the aquatic plant communities in Pine Lake in 1996 compared to the frequency of occurrence values for the same species during the current period. These data would seem to indicate a decrease in the Eurasian water milfoil population and a

[26]*Letter from Marine Biochemists, A Division of Applied Biochemists, Inc., Milwaukee, Wisconsin, to Village of Chenequa, dated May 14, 1996.*

Table 11

FREQUENCY OF OCCURRENCE OF MAJOR PLANT SPECIES IN PINE LAKE: 1996 AND 2005

Aquatic Plant Species Present	Frequency of Occurrence[a]	
	1996	2005
Bushy Pondweed (*Najas flexilis*)………………………	9.2	33.8
Coontail (*Ceratophyllum demersum*)	12.2	23.6
Curly-Leaf Pondweed (*Potamogeton crispus*)………...................	6.1	7.7
Eurasian Water Milfoil (*Myriophyllum spicatum*)	55.8	29.2
Flatstem Pondweed (*Potamogeton zosteriformes*)	7.6	8.2
Illinois Pondweed (*Potamogeton illinoensis*)..............................	6.9	16.4
Muskgrass (*Chara vulgaris*)	23.7	66.1
Native Water Milfoil (*Myriophyllum sibiricum*..............................	0.8	42.6
Sago Pondweed (*Potamogeton pectinatus*)…………	10.0	34.9

NOTE: Sampling occurred at 116 sites along 51 transects in 2005.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

Source: SEWRPC.

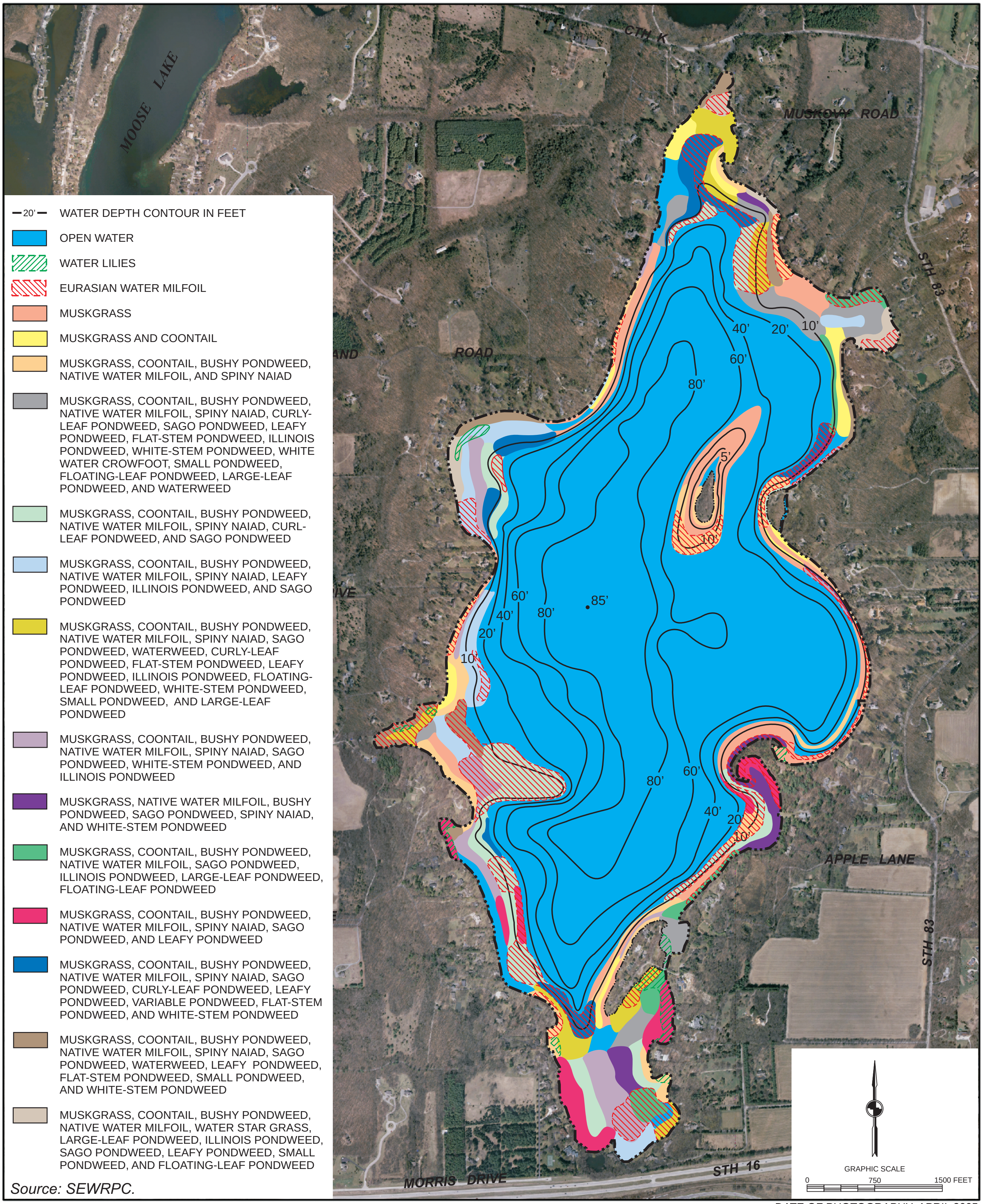
concomitant increase in the populations of native aquatic plants over this time period. In comparing the mean densities of the aquatic plant species observed in the initial report to those observed in 2005, the data show Eurasian water milfoil, elodea, native water milfoil, and bushy pondweed with about the same abundances in 2005 as in 1996, and coontail, muskgrass, water star grass, spiny naiad, large-leaf pondweed, curly-leaf pondweed, Illinois pondweed, floating-leaf pondweed, Sago pondweed, and flat-stem pondweed with increased abundances from 1996 to 2005. Eel grass, noted as scarce in 1996, was not observed during the 2005 survey.

The change in the Eurasian water milfoil population may reflect the results of aquatic management practices and/or may be a reflection of a periodicity the species naturally experiences. Such periodicity, especially in Eurasian water milfoil populations, has been observed elsewhere in Southeastern Wisconsin, and potentially reflects the influences of a combination of stressors. These stressors include biological factors, such as the activities of naturally occurring Eurasian water milfoil weevils, as well as climatic and limnological factors, such as insolation, water temperature, and lake circulation patterns.

The results of the 2005 aquatic plant survey are graphically depicted on Map 10. Several areas of Pine Lake showed significant diversity within the identified aquatic plant communities, being comprised of eleven or more different species. These highly diverse communities were most prevalent at the north end of the Lake, as well as in the shallower areas of the two larger bays along the western shoreline and in a few isolated shallow-water locations at the southern end of the Lake. By contrast, other areas of the Lake contained plant communities with very little diversity, communities with five or fewer species. Areas containing plant communities with low diversity included a portion of the shoreline in the northwest corner of the Lake, the shallow water shoreline area between the two large bays on the western shoreline of the Lake, the shallow shoreline stretch in the southeastern part of the Lake, and most of the eastern shoreline of the Lake, including the shallow water areas around the island. There were numerous areas of the Lake containing plant communities of moderate diversity, with between six and 10 species being observed. Such moderately diverse communities were found generally equally distributed around the Lake, with the largest areas at the southern end of the Lake, along the western shoreline of the Lake, and in the northeastern corner of the Lake. In general, aquatic plant communities of high diversity were found mostly at the northern end of the Lake, while moderately diverse communities were found mostly along the western shoreline and the southern end of the Lake, with the communities of lowest diversity being found in areas where the lake bottom was steeply sloped as along the eastern shoreline of the Lake and around the island.

Map 10

AQUATIC PLANT COMMUNITY DISTRIBUTION IN PINE LAKE: 2005



DATE OF PHOTOGRAPHY: APRIL 2005

Table 12

AQUATIC PLANT SPECIES OBSERVED IN BEAVER LAKE: AUGUST 2005

Common Name	Scientific Name	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Bushy Pondweed	*Najas flexilis*	40	34.5	1.9	63.79
Eel Grass..............................	*Vallisneria americans*	3	2.6	2.7	6.90
Eurasian Water Milfoil	*Myriophyllum spicatum*	2	1.7	1.5	2.59
Illinois Pondweed	*Potamogeton illinoensis*	2	1.7	2.0	3.45
Muskgrass.............................	*Chara vulgaris*	102	87.9	3.3	289.70
Native Water Milfoil	*Myriophyllum spp.*	2	1.7	1.5	2.59
Sago Pondweed....................	*Potamogeton pectinatus*	32	27.6	2.5	68.97
Spiny Naiad...........................	*Najas marina*	19	16.4	1.7	27.59
Water Crowfoot	*Ranunculus longirostris*	2	1.7	1.5	2.59
White-Stem Pondweed	*Potamogeton praelongus*	27	23.3	1.4	33.62

NOTE: Sampling occurred at 116 sites along 32 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

Aerial photographs of Pine Lake taken in 2005 showed aquatic plant growth in many of the same areas as do the photographs reproduced in the initial report. Although areas of heavy plant growth were generally discernable from the 2005 photographs, it was difficult to ascertain their species compositions with any degree of certainty. Whereas it might be possible to use low altitude photographs of a few specific areas known to contain high densities of Eurasian water milfoil in order to determine the approximate degree of change from year to year in those particular areas, the use of aerial photography of the Lake in general to accurately identify and catalogue aquatic plant communities with regard to species composition and density is probably beyond the capabilities of this method of aquatic plant reconnaissance. It seems likely that on-lake surveys will continue to be the most accurate method for determining changes in plant communities in Pine Lake over time.

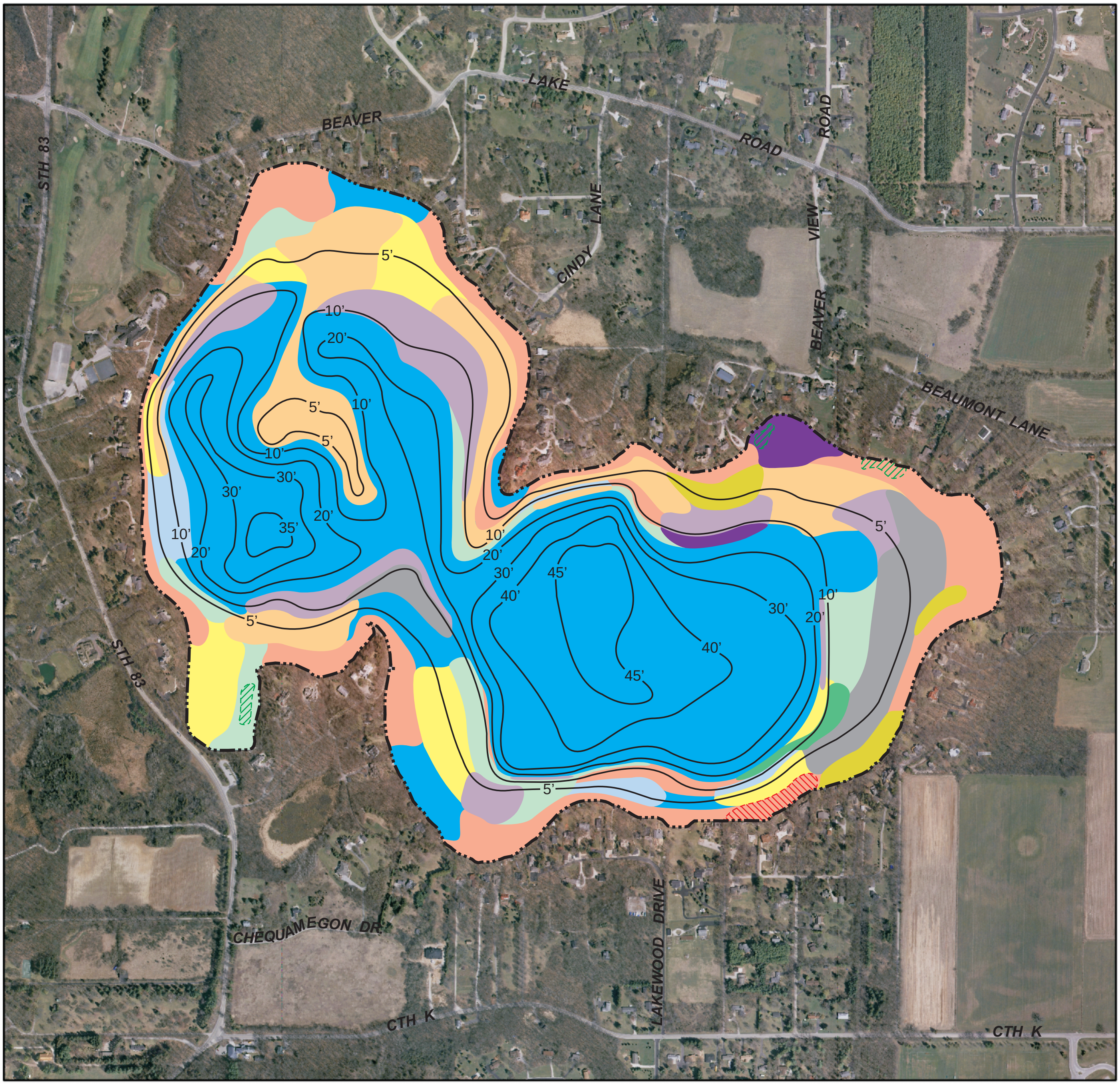
Beaver Lake

Commission staff also conducted an aquatic plant survey on Beaver Lake during 2005. The results of this survey are shown in Table 12 and depicted graphically on Map 11. The sparse aquatic plant population of Beaver Lake was dominated by muskgrass with bushy pondweed and Sago pondweed also being present in significant amounts. Muskgrass was found in all areas sampled that contained aquatic plants, with the majority of plant communities in Beaver Lake often being comprised of muskgrass alone or muskgrass together with only one or a few other species. By contrast, the majority of plant communities sampled in Pine Lake were comprised of eight to 10 species with several communities containing over a dozen species, as described above. White-stem pondweed was observed in several of the plant communities in Beaver Lake; large-leaf pondweed was not observed in Beaver Lake.

Of the nonnative invasive aquatic plant species, curly-leaf pondweed was not observed in Beaver Lake and Eurasian water milfoil was observed in only two locations, at one location on the northern shore of the eastern bay at a depth of about 11 feet, and at a location along the southern shore of the eastern bay, at a depth of about 1.5 feet.

Map 11

AQUATIC PLANT COMMUNITY DISTRIBUTION IN BEAVER LAKE: 2005



DATE OF PHOTOGRAPHY: APRIL 2005

20' WATER DEPTH CONTOUR IN FEET

OPEN WATER

WATER LILIES

EURASIAN WATER MILFOIL

MUSKGRASS

MUSKGRASS AND WHITE-STEM PONDWEED

MUSKGRASS AND BUSHY PONDWEED

MUSKGRASS, BUSHY PONDWEED, AND SAGO PONDWEED

MUSKGRASS, BUSHY PONDWEED, WHITE-STEM PONDWEED, AND SAGO PONDWEED

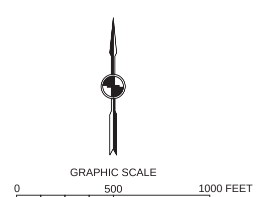
MUSKGRASS, BUSHY PONDWEED, SPINY NAIAD, AND SAGO PONDWEED

MUSKGRASS, BUSHY PONDWEED, SPINY NAIAD, WHITE-STEM PONDWEED, SAGO PONDWEED, AND WILD CELERY

MUSKGRASS, SPINY NAIAD, WATER BULLRUSH, AND WHITE WATER CROWFOOT

MUSKGRASS, BUSHY PONDWEED, SPINY NAIAD, WHITE-STEM PONDWEED, AND NATIVE WATER MILFOIL

MUSKGRASS AND ILLINOIS PONDWEED



Source: SEWRPC.

Aerial photographs taken of Beaver Lake during 2005, coincident with the on-lake survey conducted by Commission staff, yielded results similar to those reported from Pine Lake, although some areas of aquatic vegetation in the Lake were discernable from the air. As noted, the accurate identification of particular plant species from the aerial photographs was not possible and, in the case of Eurasian water milfoil, due to the extreme sparseness of this species in Beaver Lake, it was not possible to identify this species from the photographs even in areas where on-lake sampling had determined its presence.

Consequently, copies of the 2005 aerial photographs of Beaver, as well as Pine, Lakes are not included in the current report.

Aquatic Plant Species of Special Significance

During the 2005 aquatic plant surveys on Pine and Beaver Lakes, several species of significance were observed. Two of these species, Eurasian water milfoil and curly-leaf pondweed (*Potamogeton crispus*), are nonnative species and are considered detrimental to the ecological health of the Lakes.[27] Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one known to be exotic or nonnative. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can inhibit its explosive growth under suitable conditions. The plant exhibits this characteristic growth pattern in lakes with organic-rich sediments, or where the lake bottom has been disturbed. It frequently has been reported as a colonizing species following dredging unless its growth is anticipated and controlled. Eurasian water milfoil populations can displace native plant species and interfere with the aesthetic and recreational use of the waterbodies. This plant has been known to cause severe recreational use problems in lakes within the Southeastern Wisconsin Region.

Eurasian water milfoil reproduces by the rooting of plant fragments. Consequently, some recreational uses of lakes can result in the expansion of Eurasian water milfoil communities, especially when boat propellers fragment Eurasian water milfoil plants. These fragments, as well as fragments that occur for other reasons, such as wind-induced turbulence or fragmentation of the plant by fishes, are able to generate new root systems, allowing the plant to colonize new sites. The fragments also can cling to boats, trailers, motors, and/or bait buckets, and can stay alive for weeks contributing to the transfer of milfoil to other lakes. For this reason, it is very important to remove all vegetation from boats, trailers, and other equipment after removing them from the water and prior to launching in other waterbodies.

Curly-leaf pondweed is a plant that thrives in cool water and exhibits a peculiar split-season growth cycle that helps give it a competitive advantage over native plants. In late summer, the plant produces specialized over-wintering structures, or “turions.” In late summer, the main body of the plant dies off and drops to the bottom where the turions lie dormant until the cooler fall water temperatures trigger the turions to germinate. Over the winter, the turions produce winter foliage that thrives under the ice. In spring, when water temperatures begin to rise again, the plant has a head start on the growth of native plants and quickly grows to full size, producing flowers and fruit earlier than its native competitors. Because it can grow in more turbid waters than many native plants, protecting or improving water quality is an effective method of control of this species; clearer waters in a Lake can help native plants compete more effectively with curly-leaf pondweed.

There were several native plant species observed in the 2005 survey of the Lakes that are of exceptionally high ecological value: muskgrass, large-leaf pondweed (*Potamogeton amplifolius*), and white-stem pondweed (*Potamogeton praelongus*) were notable in this regard. Muskgrass, the dominant plant in the Lakes, is a favorite waterfowl food source and, as an effective bottom sediment stabilizer, benefits water quality. Its prevalence in the plant communities of the Lakes may be a significant contributing factor to the good water quality of the Lakes and, subsequently, in establishing water quality conditions that assist native plant species to successfully compete with curly-leaf pondweed, as described above. Large-leaf pondweed, also known as musky weed or bass weed,

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[27]*These two aquatic plant species are identified as nonnative invasive aquatic plant species in Chapter NR 109 of the* Wisconsin Administrative Code.

enjoys a reputation as a highly valuable provider of fish habitat. White-stem pondweed, because of its sensitivity to changes in water quality and intolerance of turbidity, is considered an excellent indicator species, as its disappearance from disturbed aquatic systems may be an indication of declining water quality in those systems. Conversely, its presence in a lake is usually an indicator of very good water quality. White-stem pondweed and large-leaf pondweed were observed in several of the more highly diverse plant communities found in Pine Lake.

Past and Present Aquatic Plant Management Practices

An aquatic plant management program has been carried out on Pine Lake in a documented manner since 1950, when records of aquatic plant management efforts were first maintained by the WDNR. In Wisconsin, the use of chemicals to control aquatic plants and algae has been regulated since 1941, even though records of aquatic herbicide applications have only been maintained by the WDNR since 1950. Prior to 1950, aquatic plant management interventions are likely, but were not recorded. Currently, all forms of aquatic plant management are subject to permitting by the WDNR pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

Aquatic plant management activities in Pine Lake can be categorized primarily as chemical control. Recorded chemical herbicide treatments that have been applied to Pine Lake are set forth in Table 13.

As shown in Table 13, between 1950 and 1967, a total of 129,877 pounds of sodium arsenite and 17,434 pounds of copper sulfate were applied to Pine Lake to control perceived nuisance growths of aquatic plants and algae. As noted in the initial report, of 167 lakes in Wisconsin receiving sodium arsenite treatments for aquatic plant control, Pine Lake received the fourth largest amount. In 1969, when it became apparent that arsenic, which presents potential health risks to both humans and aquatic life, was accumulating in the sediments of treated lakes, the use of sodium arsenite was discontinued in the State.

In contrast, copper compounds, including copper sulfate, AV-70, and Cutrine Plus, continue to be applied to Pine Lake. Copper is a nutrient required by plants in very low amounts, although, at higher concentrations, it is toxic to most species of planktonic and filamentous algae. Blue-green algae are especially susceptible to copper toxicity. Like arsenic, copper can accumulate in the bottom sediments, and excessive levels of copper have been found to be toxic to fish and benthic organisms. However, copper is typically not harmful to humans,[28] and this element continues to be used periodically as an algicide in Pine Lake.

Also as shown in Table 13, the aquatic herbicides diquat, endothall, and 2,4-D have been applied to Pine Lake in recent years to control aquatic macrophyte growth. Diquat and endothall are contact herbicides and kill plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (*Lemna* sp.), milfoil (*Myriophyllum* spp.), and waterweed (*Elodea* sp.). However, this herbicide is nonselective and will kill many other aquatic plants, such as pondweeds (*Potamogeton* spp.), bladderwort (*Utricularia* sp.), and naiads (*Najas* spp.). Endothall kills primarily pondweeds, but does not control such nuisance species as Eurasian water milfoil (*Myriophyllum spicatum)*; 2,4-D is a systemic herbicide that is absorbed by the leaves and translocated to other parts of the plant. It is considered to be more selective than the other herbicides listed above, and is generally used to control Eurasian water milfoil, although it also will kill more valuable species, such as water lilies (*Nymphaea* spp. and *Nuphar* spp.).

Chemical treatments applied to Beaver Lake are set forth in Table 14. Records of chemical applications applied to Beaver Lake indicate no use of sodium arsenite or copper sulfate.

[28]*A small number of humans are unable to excrete copper from their bodies, and, hence, are susceptible to copper toxicity. However, these cases are so rare as to not warrant discontinuation of the use of copper as an algicide: see J.A. Thornton and W. Rast, "The Use of Copper and Copper Compounds as Algicides," in H. Wayne Richardson,* Handbook of Copper Compounds and Applications*, Marcel Dekker, New York, 1997, pp. 123-142.*

Table 13

CHEMICAL CONTROL OF AQUATIC PLANTS IN PINE LAKE: 1950-2003

Year	Total Acres Treated	Algae Control			Macrophyte Control				
		Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine Plus (gallons)	Sodium Arsenite (pounds)	2, 4-D (gallons)	Diquat (gallons)	Glyphosate (gallons)	Endothall/ Aquathol (gallons)
1950	N/A	450.00	- -	- -	2,600	- -	- -	- -	- -
1951	N/A	800.00	- -	- -	3,920	- -	- -	- -	- -
1952	N/A	800.00	- -	- -	4,400	- -	- -	- -	- -
1953	N/A	1,500.00	- -	- -	3,360	- -	- -	- -	- -
1954	N/A	1,200.00	- -	- -	30,432	- -	- -	- -	- -
1955	N/A	400.00	- -	- -	7,240	- -	- -	- -	- -
1956	N/A	2,180.00	- -	- -	9,660	- -	- -	- -	- -
1957	N/A	2,050.00	- -	- -	10,980	- -	- -	- -	- -
1958	N/A	450.00	- -	- -	10,260	- -	- -	- -	- -
1959	N/A	800.00	- -	- -	9,600	- -	- -	- -	- -
1960	N/A	995.00	- -	- -	4,020	- -	- -	- -	- -
1961	N/A	1,175.00	- -	- -	4,032	- -	- -	- -	- -
1962	N/A	802.00	- -	- -	450	- -	- -	- -	- -
1963	N/A	850.00	- -	- -	3,570	30	- -	- -	13.0
1964	N/A	570.00	- -	- -	2,970	- -	- -	- -	- -
1965	N/A	330.00	- -	- -	2,475	- -	- -	- -	9.0
1966	N/A	1,057.00	- -	- -	1,908	- -	- -	- -	54.0
1967	N/A	1,025.00	- -	- -	18,000	- -	- -	- -	13.0
1968	N/A	- -	- -	- -	- -	580	40	- -	- -
1969	N/A	- -	- -	- -	- -	4	348	- -	55.0
1970	50.00	- -	- -	- -	- -	105 + 660 lbs	35	- -	25.0
1971	N/A	- -	- -	- -	- -	79		- -	270.0
1972	N/A	- -	- -	- -	- -	- -	10	- -	180.0
1973	N/A	- -	- -	- -	- -	- -	55	- -	223.0
1974	N/A	- -	- -	- -	- -	230	- -	- -	- -
1975	N/A	- -	- -	- -	- -	180	- -	- -	- -
1976	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1977	N/A	- -	- -	5	- -	185	- -	- -	50.0
1978	N/A	- -	- -	- -	- -	- -	- -	- -	850.0
1979	N/A	- -	- -	- -	- -	138	- -	- -	5.0
1980	N/A	- -	- -	- -	- -	161	- -	- -	4.0
1981	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1982	N/A	- -	- -	8	- -	167	- -	- -	2.0
1983	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1984	N/A	- -	- -	18	- -	136	- -	- -	33.0
1985	N/A	- -	- -	1	- -	48	- -	- -	4.0
1986	N/A	- -	- -	4	- -	64	- -	- -	5.0
1987	N/A	- -	- -	6	- -	28	- -	- -	7.0
1988-1990	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1991	N/A	- -	- -	- -	- -	85	- -	- -	- -
1992	N/A	- -	- -	- -	- -	29	- -	- -	- -
1993	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1994	N/A	- -	- -	- -	- -	329	- -	- -	- -
1995	15.68	- -	- -	- -	- -	58 + 300 lbs	- -	- -	- -
1996	9.75	- -	- -	- -	- -	33.5 + 650 lbs	- -	- -	- -
1997	12.40	- -	- -	5	- -	1,150 lbs	- -	0.39	3.0
1998	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1999	11.50	- -	- -	- -	- -	1,200 lbs	- -	- -	- -
2000	19.63	- -	- -	- -	- -	1,950 lbs	- -	0.23	- -
2001	21.5	- -	- -	- -	- -	2,195 lbs	- -	- -	- -
2002	8.25	- -	- -	- -	- -	825 lbs	- -	- -	- -
2003	12.55	0.09	- -	- -	- -	1,225 lbs	- -	- -	- -
2004	6.90	- -	- -	- -	- -	950 lbs	- -	- -	2.5
2005	6.05	- -	- -	- -	- -	585 lbs	- -	0.06	- -
2006	3.85	- -	- -	- -	- -	462 lbs	- -	- -	- -
2007	2.00	- -	- -	- -	- -	200 lbs	- -	- -	- -
Total	- -	17,434.09	- -	47	129,877	26,695 + 12,352 lbs	488	0.68	1,807.5

NOTE: N/A = Records are not available for this time period.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 14

CHEMICAL CONTROL OF AQUATIC PLANTS IN BEAVER LAKE: 1950-2003

Year	Total Acres Treated	Algae Control: Copper Sulfate (pounds)	Algae Control: Blue Vitriol (pounds)	Algae Control: Cutrine or Cutrine Plus (pounds)	Macrophyte Control: Sodium Arsenite (pounds)	Macrophyte Control: 2, 4-D (pounds)	Macrophyte Control: Diquat (gallons)	Macrophyte Control: Glyphosate (gallons)	Macrophyte Control: Endothall / Aquathol (gallons)
1950-1957	- -	- -	- -	- -	- -	- -	- -	- -	- -
1958	N/A	- -	- -	- -	- -	166	- -	- -	- -
1959-1960	- -	- -	- -	- -	- -	- -	- -	- -	- -
1961	N/A	- -	- -	- -	- -	120	- -	- -	- -
1962-2001	- -	- -	- -	- -	- -	- -	- -	- -	- -
2002	0.59	- -	- -	- -	- -	80	- -	- -	- -
2003	0.91	- -	- -	- -	- -	119	- -	- -	- -
2004-2005	- -	- -	- -	- -	- -	- -	- -	- -	- -
Total	- -	- -	- -	- -	- -	485	- -	- -	- -

NOTE: N/A = Records are not available for this time period.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Biological controls provide an alternative approach to controlling some nuisance plants. Classical biological control techniques have been successfully used to control both nuisance plants and herbivorous insects.[29] Recent evidence shows that *Galerucella pucilla* and *Galerucella calmariensis*, beetle species, and *Hylobius transversovittatus* and *Nanophyes brevis,* weevil species, have potential as biological control agents for purple loosestrife; such control has been used on Beaver Lake. *Eurhychiopsis lecontei*, an aquatic weevil species, has potential as a biological control agent for Eurasian water milfoil.[30] Extensive field trials conducted by the WDNR in the Southeastern Wisconsin Region during 1999 and 2000 have indicated that these insects can provide effective management of large infestations of purple loosestrife. In contrast, very few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control. Thus, while the use of insects as a means of wetland plant management is considered to be viable, the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control is not considered a viable option for use on either Lake at this time. Grass carp, *Ctenopharyngodon idella*, an alternative biological control used elsewhere in the United States, are not permitted in Wisconsin. Biological control of aquatic plant communities is subject to State permitting requirements pursuant to Chapter NR 109 of the *Wisconsin Administrative Code.*

FISHERIES AND WILDLIFE

The WDNR reports that largemouth and smallmouth bass are considered common in Pine Lake, while other species present include panfish, northern pike, and walleye.[31] As noted in the initial report, a 1975 lake inventory of Pine Lake conducted by the WDNR indicated that the fish community was comprised of bluegills, pumpkinseeds, yellow perch, logperch, green sunfish, banded killifish, blackchin shiner, blacknose shiner, mimic

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[29] *B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* LakeLine, *Vol. 17, No. 3, September 1997, pp. 20-21, 34-3; see also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities, *1984, pp. 659-696; and C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology, *John Wiley, New York, New York, USA.*

[30] *Sally P. Sheldon, "The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report," Department of Biology Middlebury College, February 1995.*

[31] *Wisconsin Department of Natural Resources Publication No. PUB-FH-800 2005,* Wisconsin Lakes, *2005.*

Table 15

FISH STOCKED INTO PINE LAKE: 1995-2006

Year	Species Stocked	Number	Average Fish Length (inches)
1995	Northern pike	1,912	8.60
1995	Walleye	35,150	2.10
1996	Northern pike	1,517	4.30
1997	Walleye	22,768	1.65
1998	Northern pike	3,375	- -
1999	Walleye	73,064	2.00
2000	Northern pike	3,500	3.35
2001	Northern pike	1,700	2.90
2001	Walleye	73,160	2.70
2002	Northern pike	1,750	3.10
2003	Walleye	65,950	2.50
2005	Walleye	40,422	1.70
2006	Northern pike	4,000	2.40

Source: Wisconsin Department of Natural Resources and SEWRPC.

shiner, golden shiner, bluntnose minnow, black crappie, lake chubsucker, common carp, brook silverside, northern pike, and largemouth bass at that time. Additionally, surveys conducted by the Wisconsin Conservation Department (now the WDNR) in 1911 and 1917 found cisco and rock bass, the presence of the former species being confirmed in a 1984 survey conducted by the WDNR. In 1984, a summer fish kill of cisco in Pine Lake attributed to oxygen deprivation in the thermocline, was observed and documented by WDNR staff.[32] During 2005, the WDNR undertook both a comprehensive fisheries survey and creel survey of Pine Lake.[33] The inventory recorded the presence of bluegills, pumpkinseeds, yellow perch, bluntnose minnow, black crappie, common carp, northern pike, largemouth bass, smallmouth bass, rock bass, and walleye, the latter being the dominant species in terms of total biomass of fishes in the Lake. Largemouth bass were the most numerous. In addition to these species, the creel census indicated that muskellunge, green sunfish, warmouth, longnose gar, white bass, and yellow bullhead were harvested from Pine Lake. Of these fishes, the WDNR noted that Pine Lake proved to be an excellent smallmouth and largemouth bass and walleye fishery, the latter possibly sustained by the stocking program. The WDNR also noted that, in contrast to other lakes in the area, northern pike, bluegills, and black crappie were not targeted by anglers on Pine Lake. Recommended management measures included continuation of the alternate-year stocking of walleye and northern pike, continued monitoring of bluegills, acquisition of data on black crappie, and promotion of both catch-and-release angling techniques and shoreline habitat to enhance the survival and growth of largemouth and smallmouth bass. Pine Lake contains two State-listed Species of Special Concern: the lake herring (*Coregonus artedi*) and lake chubsucker (*Erimyzon* sucetta). As shown in Table 15, stocking records for Pine Lake show largely alternate year stocking of northern pike and walleye since 1995.

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[32]*Wisconsin Department of Natural Resources Memorandum from Randy Schumacher to James McNelly, file reference No. 3610-1, entitled* "Cisco Kill on Pine Lake, Waukesha County," *dated 23 August, 1984.*

[33]*Wisconsin Department of Natural Resources Memorandum from Ben Heussner and Steve Gospodarek to Sue Beyler, file reference No. 3600, entitled* "Pine Lake Comprehensive Survey, 2005," *dated 25 February 2008; Wisconsin Department of Natural Resources Memorandum from Benjamin Heussner, Steven Gospodarek, and Josh Krall to Sue Beyler, file reference No. 3600, entitled* "Pine Lake Creel Survey, 2005," *dated 2 April 2008.*

In Beaver Lake, the WDNR report panfish to be common, with northern pike and largemouth bass among other species present.[34] Beaver Lake also contains the lake chubsucker.[35] The WDNR currently does not stock fish into, do fish surveys on, or provide technical assistance for fishery management on Beaver Lake because the Lake is deemed to not have adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code,* as previously noted.

Given the land uses present around the shorelands of the Lakes, only smaller animals and waterfowl generally inhabit the Lakeshore. Muskrat, beaver, grey and fox squirrels, and cottontail rabbits are probably the most abundant and widely distributed fur-bearing mammals in the immediate riparian areas. Larger mammals, such as the whitetail deer, are generally confined to the larger wooded areas and the open meadows found in the park and open space lands within the tributary areas of the Lake. The tributary areas to the Lakes also support a significant population of migratory waterfowl including mallards, wood duck, and blue-winged teal. During the migration seasons a greater variety of waterfowl may be present and all of these migratory species will be present in greater numbers at these times.

Amphibians and reptiles are vital components of the Lake ecosystems, and include frogs, toads, and salamanders, and turtles and snakes, respectively. About 14 species of amphibians and 16 species of reptiles would normally be expected to be present in the Pine Lake and Beaver Lake area, with at least one species, the Blanding's turtle, being considered a State Threatened Species.

WDNR-Designated Sensitive Areas and SEWRPC-Designated Critical Species Habitat

The WDNR identifies sites within lakes that have special importance biologically, historically, geologically, ecologically, or even archaeologically. Areas are identified as Sensitive Areas pursuant to Chapter NR 107 authorities after a comprehensive examination and study is completed by WDNR staff from many different disciplines and fields of study. As shown in Map 12, Pine Lake contains several WDNR-designated Sensitive Areas. To protect aquatic life, as well as the water quality of the Lake itself, the WDNR may place restrictions on specific activities within such Sensitive Areas. These restrictions run the gamut from restrictions on aquatic plant management measures to restrictions on dredging, and include recommendations pursuant to parallel WDNR authorities such as those set forth in Chapter 30 of the *Wisconsin Statutes*. Such restrictions for the WDNR-delineated sensitive areas in Pine Lake include: limiting the use of aquatic herbicides to treatment of Eurasian water milfoil; prohibition of in-lake activities such as filling, pea gravel/sand blankets, aquascreen, concrete, timber, or steel seawalls; limiting the use of riprap to areas with erosion problems; individual and marina piers allowable only on a case by case basis; prohibition of mechanical harvesting other than that associated with a research program to increase the diversity of aquatic plants, although small hand-cleared areas for swimming or navigation are allowable; and the adoption and strict enforcement of construction site erosion control, shoreland, and wetland ordinances.

In addition to the foregoing WDNR actions, the SEWRPC regional natural areas and critical species habitat protection and management plan has identified Pine Lake and Beaver Lake as Critical Lakes of Southeast Wisconsin.[36] Pine Lake has been given a designation of AQ-2, identifying it as a lake of countywide or regional significance, while Beaver Lake has an AQ-3 rating, identifying it as a lake of local significance.

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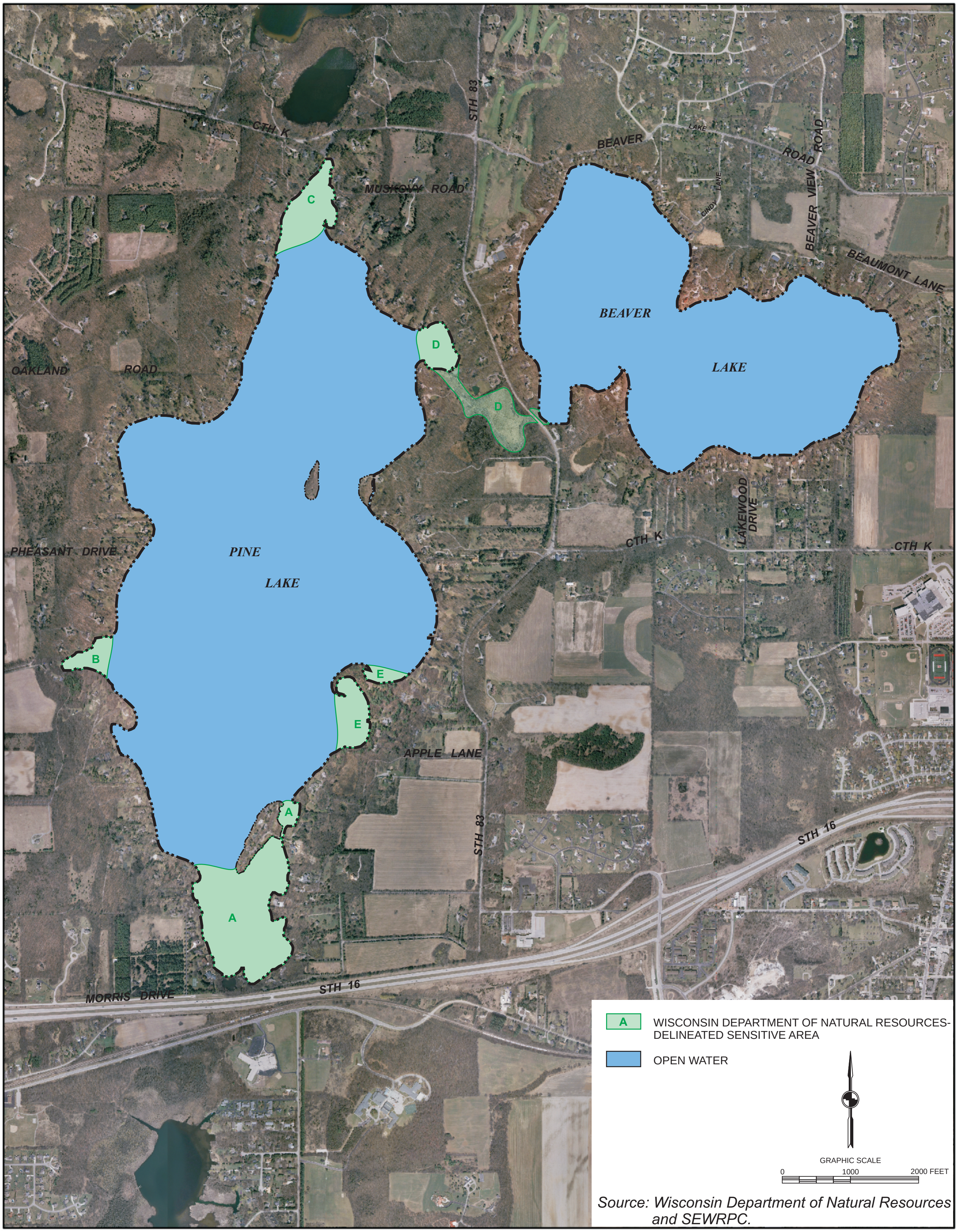
[34]*Wisconsin Department of Natural Resources Publication No. PUB-FH-800 2005,* op. cit.

[35]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997.*

[36]Ibid.

Map 12

SENSITIVE AREAS WITHIN THE VICINITY OF PINE AND BEAVER LAKES



DATE OF PHOTOGRAPHY: APRIL 2005

Table 16

WATERCRAFT DOCKED OR MOORED ON PINE LAKE: AUGUST 2005[a]

Type of Watercraft										
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Electric Boat	Paddleboat	Rowboat	Total
111	47	47	25	35	40	77	7	21	27	437

[a]*Including trailered watercraft and watercraft on land observable during survey.*

Source: SEWRPC.

Table 17

WATERCRAFT DOCKED OR MOORED ON BEAVER LAKE: AUGUST 2005[a]

Type of Watercraft									
Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Rowboat	Paddleboat	Total
75	46	98	21	22	45	71	19	8	405

[a]*Including trailered watercraft and watercraft on land observable during survey.*

Source: SEWRPC.

RECREATIONAL USES AND FACILITIES

As set forth in the regional water quality management plan, Pine Lake and Beaver Lake are multi-purpose waterbodies serving a variety of recreational uses.[37] Active recreational uses include boating, waterskiing, swimming, and fishing during the summer months, and cross-country skiing, snowmobiling, and ice-fishing during the winter. Public access to Pine Lake is provided by a paved ramp and parking facility operated by the Village of Chenequa located at the north end of the Lake; this facility meets the criteria set forth in Chapter NR 1 of the *Wisconsin Administrative Code,* which establishes quantitative standards for determining the adequacy of public recreation boating access, setting maximum and minimum standards based upon available parking facilities for car-top and car-trailer units. Beaver Lake has a carry-in facility with paved parking located along the western shoreline of the Lake adjacent to STH 83; this facility currently is judged to not meet standards for adequacy of public recreational boating access as described above.

The Lakes are used year-round as visual amenities. Walking, bird watching and picnicking are popular passive recreational uses of these waterbodies, and they are heavily utilized during open water periods. In the initial study, a boat survey conducted on Pine Lake in 1996 indicated that about 330 boats were either moored in the water or stored on land in the shoreland areas around the Lake. During 2005, Commission staff completed similar surveys on Pine and Beaver Lakes which showed the number of boats on Pine Lake had increased to about 440; the complete results of both surveys are shown in Tables 16 and 17.

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[37]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978; Volume Two,* Alternative Plans, *February 1979; and Volume Three,* Recommended Plan, *June 1979. See also SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

Recreational boating is a popular active recreational use of the Lakes, with about half of all watercraft moored in the water or stored on land in the shoreline areas on both lakes capable of high speed operation. Of the motorized watercraft observed moored or stored, power boats represented the largest group on both lakes, with pontoon boats and fishing boats the next most common categories. Of the nonmotorized watercraft observed, kayaks represented the most common type on both lakes, with sailboats and canoes also observed in good numbers. The types of watercraft found on the Lakes included powered or ski boats, fishing boats, pontoon boats, paddleboats, canoes, sailboats, kayaks, and personal watercraft ("jetskis").

The types of motorized watercraft on the Lake as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the Lake, the residents. On Pewaukee Lake, for example, nearly 80 percent of all watercraft on the Lake are motorized compared to about 53 percent of the watercraft on Pine Lake and 59 percent on Beaver Lake. Additionally, of all watercraft on Pewaukee Lake, powerboats make up the largest portion, almost 40 percent; on Pine Lake, the largest portion of all watercraft is also power boats, but they represent only about 25 percent of all watercraft on the Lake; on Beaver Lake, pontoon boats constitute the largest category, comprising about 24 percent of all watercraft.

To assess the degree of recreational boat use on a lake, it has been estimated that, in southeastern Wisconsin, the number of watercraft operating at any given time is approximately 2 to 5 percent of the total number of watercraft docked and moored. On Pine Lake, this would amount to somewhere between nine and 22 boats of all kinds, about half of which would be motorized; on Beaver Lake, this would equate to between about eight and 20 boats, with about 60 percent being motorized. There is a range of opinions on the issue of what constitutes optimal boating density, or the numbers of acres of open water available in which to operate a boat on a lake. In the mid-1980s, an average area of about 16 acres per power or sail boat was, at that time, considered suitable for the safe and enjoyable use of a boat on a lake. For safe waterskiing and fast boating, an area of 40 acres per boat was suggested in the adopted Regional guidelines as the minimum area necessary for safe operations.[38] Using these guidelines, indirect estimates of boating densities of boats capable of high speeds on Pine and Beaver Lakes based on counts of watercraft docked or moored around the Lakes together with the abovedescribed percentage multipliers, would produce boating densities of between 29 and 79 acres per high-speed boat on Beaver Lake and between 70 acres to 175 acres per high-speed boat on Pine Lake.

Another way to assess the degree of recreational boat use on a lake is through direct counts of boats in use on a lake at a given time. In 2007, surveys to assess the types of watercraft in use on a typical summer weekday and a typical summer weekend day were conducted by Commission staff and by members of the Village of Chenequa Police force as part of their regular patrolling of the Lakes. The results of these surveys are shown in Tables 18 and 19. As shown in the Table 18, on Pine Lake, fishing boats were the most popular watercraft in use on a weekday morning, while fishing boats and sailboats were the most common watercraft in use on a weekend afternoon. On Beaver Lake, as shown in Table 19, watercraft activity on a weekday was relatively low, but on weekend days activity increased greatly with fishing boats being the most common watercraft in use in the morning and powerboats being the most commonly observed watercraft during the afternoon. During these periods, the densities of high-speed watercraft on Pine Lake ranged from about one boat per 54 acres on a weekend afternoon to about one boat per 58 acres on a weekday morning; on Beaver Lake, the high-speed watercraft densities ranged from about one boat per 24 acres on a weekend afternoon to about one boat per 316 acres on a weekday. The densities observed on Pine and Beaver Lakes as described above are consistent with those considered appropriate for the conduct of safe high-speed boating activities pursuant to the adopted Regional guidelines.

Table 20 shows how people were using Beaver Lake recreationally during a typical summer weekday and a typical summer weekend day in 2007; data for Pine Lake were not collected during the current study, but would assumed to be consistent with that for Beaver Lake due to the similar nature of the riparian communities of the

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[38]*See SEWRPC Planning Report No. 27,* A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000*, November 1977.*

Table 18

WATERCRAFT IN USE ON PINE LAKE: JULY 2007

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddleboat	Total
Friday, July 20 10:00 a.m. to 11:00 a.m.	4	1	10	2	0	0	0	0	17
Saturday, July 21 2:00 p.m. to 3:00 p.m.	4	3	8	2	8	1	0	0	26

Source: SEWRPC.

Table 19

WATERCRAFT IN USE ON BEAVER LAKE: JULY 2007

Date and Time	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddleboat	Total
Wednesday, July 18									
10:00 a.m. to 11:00 a.m.	0	0	0	1	0	0	0	0	1
2:00 p.m. to 3:00 p.m.	0	0	1	0	0	1	0	0	2
Saturday, July 21									
10:00 a.m. to 11:00 a.m.	0	0	4	0	0	1	0	2	7
2:00 p.m. to 3:00 p.m.	6	2	3	3	0	4	0	0	18

Source: SEWRPC.

Table 20

RECREATIONAL USE IN/ON BEAVER LAKE: 2007

Date and Time	Weekday Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Wednesday, July 18										
10:00 a.m. to 11:00 a.m.	0	0	0	0	2	0	1	0	0	3
2:00 p.m. to 3:00 p.m.	0	0	0	0	0	1	4	1	0	6
Total for the Day	0	0	0	0	2	1	5	1	0	9
Percent	0	0	0	0	22	11	56	11	0	100

Date and Time	Weekend Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Saturday, July 21										
10:00 a.m. to 11:00 a.m.	0	0	0	0	0	1	9	2	0	12
2:00 p.m. to 3:00 p.m.	0	21	6	0	4	17	5	7	0	60
Total for the Day	0	21	6	0	4	18	14	9	0	72
Percent	0	29	8	0	6	25	19	13	0	100

Source: SEWRPC.

Table 21

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO PINE AND BEAVER LAKES IN WAUKESHA COUNTY BY CIVIL DIVISION: 2004

Community	Type of Ordinance				
	General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Waukesha County..........	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
City of Delafield...........	Adopted	Adopted	Adopted	Adopted	Adopted
Village of Chenequa ...	Adopted	None[a]	Adopted	None	Adopted[b]
Village of Hartland	Adopted	Adopted	Adopted	Adopted	Adopted
Village of Nashotah.....	Adopted	None[a]	Adopted and Wisconsin Department of Natural Resources approved	Adopted	Adopted
Town of Merton...........	Adopted	County ordinance	County ordinance	Adopted	County ordinance

[a]*No flood hazard areas had been identified or mapped.*

[b]*Erosion control ordinance only.*

Source: SEWRPC.

two Lakes. The most popular weekday recreational activities on Beaver Lake included: swimming, fishing from boats, operating personal watercraft and canoeing/kayaking. The most popular weekend recreational activities observed were: pleasure boating, swimming, fishing from boats and canoeing/kayaking.

Recreational boating activities on Pine Lake and Beaver Lake are subject to State of Wisconsin boating and water safety laws as set forth in Chapter 30, *Wisconsin Statutes*. Additionally, the Lakes are subject to boating ordinances promulgated by the Village of Chenequa included herein as Appendix C.

LOCAL ORDINANCES

The Village of Chenequa has adopted general zoning, shoreland or shoreland-wetland ordinances, and construction site erosion control ordinances that are administered and enforced in the shoreland areas tributary to the Lakes, as shown in Table 21.

Chapter III

ALTERNATIVE AND RECOMMENDED AQUATIC PLANT MANAGEMENT PRACTICES

INTRODUCTION

There are a number of aquatic plant management-related issues of concern that impact the recreational use and protection of the Pine Lake and Beaver Lake ecosystems. These issues were identified in Chapter II and include: continuing urban-density residential development in the area tributary to the Lakes; the provision of adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code* for Beaver Lake; the presence of nuisance growths of Eurasian water milfoil and other aquatic plants in areas of Pine Lake, combined with an overall scarcity and lack of diversity of aquatic vegetation in Beaver Lake; the potential negative ecological impacts posed by invasive species such as Eurasian water milfoil, curly-leaf pondweed, zebra mussel, and purple loosestrife; the occurrence of potentially toxic blue-green algal (or cyanobacterial) blooms; and, the scarcity of water quality data, especially for Beaver Lake.

In some ways, a number of these issues of concern are interrelated. For example, in those areas of the Lake where Eurasian water milfoil is abundant, certain recreational uses may be limited, the aesthetic quality of the Lake impaired, and in-lake habitat degraded. The plant primarily interferes with recreational boating activities by clogging propellers and cooling water intakes, snagging paddles, and slowing sailboats by wrapping around keels and control surfaces. The plant also causes concern amongst swimmers who can become entangled within the plant stalks. Thus, without control measures, these areas can become problematic to boat navigation, fishing, and swimming. Native aquatic plants, generally found at slightly deeper depths, pose fewer potential problems for navigation, swimming, and fisheries. In addition, many native aquatic plants provide fish habitat and food resources and offer shelter for juvenile fishes and young-of-the-year.

Despite areas in Pine Lake where nuisance growths of Eurasian water milfoil occur, overall, the Lake appears to be improving in regards to the numbers and diversity of native aquatic plants. Beaver Lake, on the other hand, lacks a diverse submergent and floating vegetation community. The lack of diversity is likely to contribute to an imbalance in the fisheries community within the Lake, as there may not be enough forage for fish to utilize as a food source, nor enough cover to limit predation on juvenile fishes. This creates a situation which, over time, can lead to an imbalance in the fish community that includes limitations on the varieties of species found within the Lake, and a stunting of certain fish species. Similarly, the lack of numbers of aquatic macrophytes may encourage the growth of algae as the plants that will utilize the available nutrient resources. In the case of the 2007 algal blooms observed on both Pine Lake and Beaver Lake, the paucity of the macrophyte flora in Beaver Lake may have contributed to the greater intensity of the algal bloom on that Lake.

In this chapter, alternative and recommended management measures to address the identified issues of concern are presented. These measures include:

1. Aquatic plant and shoreland protection management measures designed to encourage native plant communities, limit the spread of nonnative, invasive species, and minimize the risks associated with blue-green algal blooms;

2. Water quality management measures designed to monitor water quality conditions within the Lakes;

3. Fisheries management measures designed to mitigate the habitat-related impacts of a changing aquatic flora and maintain an ecologically viable system;

4. Recreational management measures designed to promote safe recreational use, curtail the spread of invasive species, and provide the potential for the community to gain access to outside funding sources and lake enhancement services; and,

5. Land use management measures designed to limit the inputs of contaminants, especially nutrients, to the Lakes from their tributary areas.

Alternative and recommended management measures to address these concerns are described briefly below. The alternatives and recommendations set forth herein focus on those measures which are applicable to the Village of Chenequa, with lesser emphasis given to those measures which are applicable to other agencies with jurisdiction within the area tributary to the Lakes.

IN-LAKE AQUATIC PLANT AND RELATED MANAGEMENT MEASURES

The shoreland and aquatic macrophyte management elements of this plan consider alternative management measures consistent with the provisions of Chapters NR 103 and NR 107 of the *Wisconsin Administrative Code*. Further, the alternative aquatic plant management measures are consistent with the requirements of Chapter NR 7 of the *Wisconsin Administrative Code*, and with the public recreational boating access requirements relating to the grant program, set forth under Chapter NR 1 of the *Wisconsin Administrative Code*.

Aquatic Plant Management

As stated in Chapter II of this report, aquatic plant management activities in Pine Lake can be categorized primarily as chemical control. From 1950 through 1967, about 17,434 pounds of copper sulfate and 129,877 pounds of sodium arsenite were used to manage aquatic plants in Pine Lake. From 1968 to the present, about 26,665 gallons and 10,155 pounds of 2,4-D, along with about 0.62 gallons of glyphosate and about 1,720 gallons of endothall, have been used to manage aquatic plants in the Lake.

In contrast, chemical herbicides have been used sparingly and somewhat intermittently in Beaver Lake. In 1958 and 1961, 166 pounds and 120 pounds of 2,4-D, respectively, were used to control aquatic plants in Beaver Lake. No further chemical applications were made in Beaver Lake until 2002 and 2003 when 80 pounds and 119 pounds of 2,4-D, respectively, were used.

Individual householders on Pine and Beaver Lakes are known to engage in manual harvesting in the vicinities of their piers and docks.

Array of Management Measures

Aquatic plant management measures are classed into five groups: 1) physical measures, which include lake bottom coverings and water level management; 2) mechanical measures, which include harvesting; 3) manual removal; 4) chemical measures, which include the use of aquatic herbicides; and 5) biological control measures, which include the use of various organisms, including insects. All control measures are stringently regulated and require a State of Wisconsin permit; chemical controls are regulated under Chapter NR 107 of the *Wisconsin Administrative Code,* and all other aquatic plant management practices are regulated under Chapter NR 109 of the *Wisconsin Administrative Code*. Placement of bottom covers also requires a WDNR permit under Chapter 30 of the *Wisconsin Statutes*. Costs range from minimal for manual removal of plants using rakes and hand-pulling, to upwards of $50,000 for the purchase of a mechanical plant harvester, for which the operational costs can approach $2,500 to $15,000 per year depending on staffing and operation policies.

Physical Measures

Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboating. Sand and gravel are usually readily available and relatively inexpensive to use as cover materials, but plants readily recolonize areas so covered in about a year. Synthetic material, such as polyethylene, polypropylene, fiberglass, and nylon can provide relief from rooted plants for several years. However, because of the need to encourage aquatic plant growth, while simultaneously controlling the growth of Eurasian water milfoil, the placement of lake bottom covers as a method to control aquatic plant growth does not appear to be warranted and is not considered viable for Pine or Beaver Lakes.

Mechanical Measures

Aquatic macrophytes may be mechanically harvested with specialized equipment consisting of a cutting apparatus, which cuts up to five feet below the water surface, and a conveyor system that picks up the cut plants and hauls them to shore. Mechanical harvesting can be a practical and efficient means of controlling plant growth as it removes the plant biomass and nutrients from a lake. Mechanical harvesting is particularly effective as a measure to control large-scale growths of aquatic plants. Narrow channels can be harvested to provide navigational access and “cruising lanes” for predator fish to migrate into the macrophyte beds to feed on smaller fish. “Clear cutting” aquatic plants and denuding the lake bottom of flora should be avoided. However, top cutting of plants, such as Eurasian water milfoil, as shown in Figure 4, is suggested. The harvest of water lilies and other emergent native plants, however, should be avoided. Aquatic plant harvesting operations are subject to State permitting requirements.

The advantages of aquatic plant harvesting are that the harvester typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments. The disadvantages of mechanical harvesting are that the harvesting operation may cause fragmentation of plants and, thus, unintentionally facilitate the spread of some plants that utilize fragmentation as a means of propagation, namely Eurasian water milfoil. Harvesting may also disturb bottom sediments in shallower areas where such sediments are only loosely consolidated, thereby increasing turbidity and resulting in deleterious effects including the smothering of fish breeding habitat and nesting sites. Disrupting the bottom sediments also could increase the risk that an exotic species, such as Eurasian water milfoil, may colonize the disturbed area since this is a species that tends to thrive under disturbed bottom conditions. To this end, most WDNR-permitted harvesting does not allow harvesting in areas having a water depth of less than three feet. Nevertheless, if done correctly and carefully, harvesting has been shown to be of benefit in ultimately reducing the regrowth of nuisance plants when used under conditions suitable for this method of control.

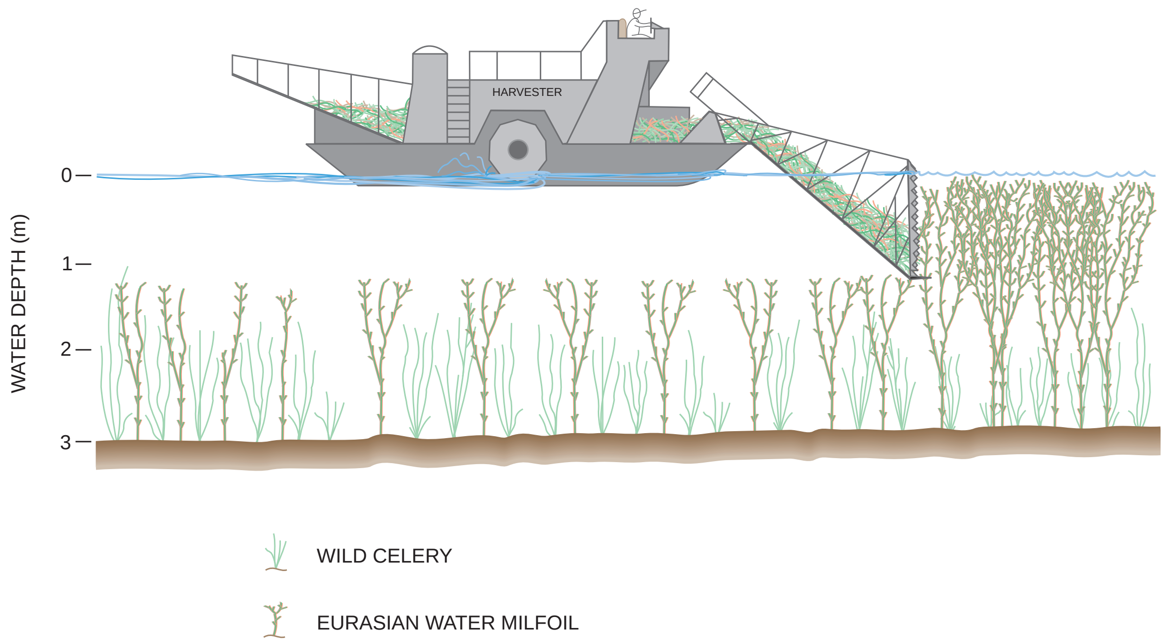
Given the loosely consolidated nature of the bottom sediments in the shallow water areas and the species composition with correspondingly dense growths of Eurasian water milfoil in these same areas, and, given the logistical problems likely to be encountered during the off-loading of plant material due to the lack of suitably located public access areas along the mostly privately owned shorelines of Pine and Beaver Lakes, mechanical harvesting in not considered a viable option for control of aquatic plants in the Lakes.

Manual Measures

The physical removal of specific types of vegetation by selective harvesting of plants provides a highly selective means of controlling the growths of nuisance aquatic plant species, including purple loosestrife and Eurasian water milfoil. Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, manual harvesting of aquatic plants within a 30-foot-wide corridor along a 100-foot length of shoreline would be allowed without a WDNR permit, provided the plant material is removed from the Lake. Any other manual harvesting would require a State permit, unless employed in the control of designated nonnative invasive species, such as Eurasian water milfoil or curly-leaf pondweed.

Figure 4

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



NOTE: Selective cutting or seasonal harvesting can be done by aquatic plant harvesters. Removing the canopy of Eurasian water milfoil may allow native species to reemerge.

Source: Wisconsin Department of Natural Resources and SEWRPC.

In the shoreland area, where purple loosestrife may be expected to occur, bagging and cutting loosestrife plants, for example, prior to the application of chemical herbicides to the cut stems, can be an effective control measure for small infestations of this plant. Loosestrife management programs, however, should be followed by an annual monitoring and control program for up to 10 years following the initial control program to manage the regrowth of the plant from seeds. Manual removal of such plants is recommended for isolated stands of purple loosestrife when and where they occur.

In the near shore area, specially designed rakes are available to assist in the removal of nuisance aquatic plants, such as Eurasian water milfoil. The use of such rakes also provides a safe and convenient method of controlling aquatic plants in deeper near shore waters around piers and docks. The advantage of the rakes is that they are relatively inexpensive, easy and quick to use, and immediately remove the plant material from the lake, without a waiting period. Removal of the plants from the lake avoids the accumulation of organic matter on the lake bottom, which adds to the nutrient pool that favors further plant growth. State permitting requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Should the Village of Chenequa acquire a number of these specially designed rakes, they could be made available for the riparian owners to use on a trial basis to test their operability before purchasing them.

Hand pulling of stems, where they occur in isolated stands, provides an alternative means of controlling plants, such as Eurasian water milfoil in the Lakes and purple loosestrife on the lakeshore. Because this is a more selective measure, and given the need to enhance the native aquatic plant community in both Lakes, the rakes being nonselective in their harvesting, manual removal of Eurasian water milfoil is recommended in Pine and Beaver Lakes, where practicable and feasible.

Chemical Measures

Chemical treatment with herbicides is a short-term method of controlling heavy growths of nuisance plants. Chemicals are generally applied to the growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophytes growth are the relatively low cost and the ease, speed, and convenience of application. The disadvantages associated with chemical control include unknown long-term effects on fish, fish food sources, and humans; a risk of increased algal blooms due to the eradication of macrophyte competitors; an increase in organic matter in the sediments, possibly leading to increased plant growth, as well as anoxic conditions which can cause fish kills; adverse effects on desirable aquatic organisms; loss of desirable fish habitat and food sources; and, finally, a need to repeat the treatment the following summer due to existing seed banks and/or plant fragments. Widespread chemical treatments can also provide an advantage to less desirable, invasive, introduced plant species to the extent that they may outcompete the more beneficial, native species. Hence, this is seldom a feasible management option to be used on a large scale. Nevertheless, limited chemical control is often a viable technique for the control of the relatively small-scale infestations of aquatic plants, such as Eurasian water milfoil, or shoreland plants, such as purple loosestrife. Widespread chemical treatment is not considered a viable option for Pine and Beaver Lakes.

To minimize the collateral impacts of de-oxygenation, loss of desirable plant species, and contribution of organic matter to the sediments, early spring or late fall applications should be considered. Such applications also minimize the concentration and amount of chemicals used due to the colder water temperatures that enhance the herbicidal effects. Use of chemical herbicides in aquatic environments is stringently regulated and requires a WDNR permit.

Use of early spring chemical controls, especially in those shoreline areas where mechanical harvesting would not be deemed viable, and targeting growths of Eurasian water milfoil would be possible. Targeted herbicide applications, specifically aimed at controlling Eurasian water milfoil and purple loosestrife in and around the Lakes, are recommended for Pine and Beaver Lakes. Early spring chemical controls targeting curly-leaf pondweed, before other pondweed species become established, should also be considered.

Biological Measures

Biological controls provide an alternative approach to controlling nuisance plants, particularly Eurasian water milfoil. Classical biological control techniques have been successfully used to control both nuisance plants and herbivorous insects.[1] Recent evidence shows that *Galerucella pucilla* and *Galerucella calmariensis*, beetle species, and *Hylobius transversovittatus* and *Nanophyes brevis*, weevil species, have potential as biological control agents for purple loosestrife, while *Eurhychiopsis lecontei*, an aquatic weevil species, has potential as a biological control agent for Eurasian water milfoil.[2] Extensive field trials conducted by the WDNR in the Southeastern Wisconsin Region during 1999 and 2000 have indicated that these insects can provide effective management of large infestations of purple loosestrife. In contrast, very few studies have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control. Thus, while the use of insects as a means of wetland plant management is considered to be viable, the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control is not considered a viable option for use on Pine and Beaver Lakes at this time. Grass carp, *Ctenopharyngodon idella*, an alternative biological control used elsewhere in the United States, are not permitted in Wisconsin. Biological control of aquatic plant communities is subject to State permitting requirements pursuant to Chapter NR 109 of the *Wisconsin Administrative Code.*

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[1]*B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* LakeLine, *Vol. 17, No. 3, September 1997, pp. 20-21, 34-3; see also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities, *1984, pp. 659-696; and C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology, *John Wiley, New York, New York, USA.*

[2]*Sally P. Sheldon, "The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report," Department of Biology Middlebury College, February 1995.*

Recommended Management Measures

The most effective plans for managing aquatic plants rely on a combination of methods and techniques such as those described above. Therefore, to enhance the use of Pine and Beaver Lakes while maintaining the quality and diversity of the biological communities, the following recommendations are made:

- Manual harvesting around piers and docks is the recommended means of controlling nonnative nuisance species of plants in those areas. In this regard, the Village could consider purchasing several specialty rakes designed for the removal of vegetation from shoreline property and make these available to riparian owners. This would allow the riparian owners to use the rakes on a trial basis before purchasing their own. Although the rakes do not require a permit for use, except in WDNR-designated NR 107 sensitive areas, State permitting requirements for manual aquatic plant harvesting mandate that the harvested material be removed from the lake. Where feasible and practicable, hand pulling of stems, where they occur in isolated stands, is also recommended as an alternative means of controlling Eurasian water milfoil and purple loosestrife. Manual control should target nonnative species.

- It is recommended that the use of chemical herbicides be limited to controlling nuisance growth of exotic species, particularly Eurasian water milfoil, purple loosestrife, and curly-leaf pondweed. It is recommended that chemical applications, if required, be made by licensed applicators in early spring subject to State permitting requirements to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as-needed basis. Only herbicides that selectively control milfoil and curly-leaf pondweed, such as 2,4-D and endothall, should be used. In areas where Eurasian water milfoil occurs in scattered, monospecific patches, 2,4-D in granular form is typically more effective than its liquid counterpart, especially with early season treatment.

- Algicides, such as Cutrine Plus, are not recommended because there are typically few significant, recurring filamentous algal or planktonic algal problems in Pine and Beaver Lakes.[3] Specifically, the application of algicides is not generally recommended for the treatment of blue-green algal blooms, such as those observed during 2007, as such treatments can potentially release any toxins present in the algal cells into the water. Additionally, too aggressive treatment can impact valuable macroscopic algae, such as *Chara* and *Nitella*, which can be killed by this product.

- Few lakes in Southeastern Wisconsin lack aquatic plant growth. Beaver Lake is one of a limited number of lakes that would benefit from a greater density and diversity of aquatic plants.[4] Low-growing plants, such as spiny naiad and muskgrass, which provide food and shelter for fish and

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[3]*During the summer of 2007, algal blooms were observed on both Pine Lake and Beaver Lake. Given that these blooms were comprised almost totally of blue-green algae or cyanobacteria, and that there were toxin-producing forms present, the use of algicides might be warranted; however, such applications should be undertaken by licensed applicators and with the recognition that lysing or disrupting the algal cells can release any toxic materials contained within the cells into the water column. Hence, it is recommended that any such applications be undertaken with caution. It is more strongly recommended that the community implement yard care and good housekeeping practices designed to minimize nutrient loading to the Lakes, thereby reducing the mass of available nutrients that sustain such blooms. These and other recommendations are set forth in more detail in Appendix B. See also the section entitled "Water Quality Management" below.*

[4]*See, for example, SEWRPC Community Assistance Planning Report No. 47, 2nd Edition,* A Water Quality Management Plan for Lac La Belle, Waukesha County, Wisconsin, *May 2007, and SEWRPC Memorandum Report No. 144,* An Aquatic Plant and Recreational Use Management Plan for Booth Lake, Walworth County, Wisconsin, *September 2003.*

waterfowl, do occur in the Lake. However, because of their low-growing height, these species are often outcompeted by Eurasian water milfoil. Eurasian water milfoil grows rapidly to the lake surface, capturing the available sunlight and shading out the native species. Thus, control of the Eurasian water milfoil, using manual and chemical means as noted above, is recommended as a means of promoting the growth of native plants, and is recommended for Beaver Lake. Additionally, while there have been some attempts, notably in Lac La Belle in Waukesha County,[5] to transplant native aquatic plants between Lakes within the Region, the transplantation of aquatic plants is subject to a State of Wisconsin permit, extremely labor-intensive, and not always entirely successful. Therefore, it is not considered to be a viable option for Beaver Lake.[6]

- Aquatic plant surveys are recommended to be conducted at about five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of both the major areas of nuisance aquatic plant growth and areas chemically treated. Regular monitoring of the aquatic plant community is recommended in the interim period between surveys for the early detection and control of future-designated nonnative species that may occur.

- Through informational programming, riparian owners should be encouraged to monitor their shoreline areas as well as open-water areas of the Lakes for new growths of nonnative aquatic plants and report such growths immediately to the Village Forester or designee so that a timely and effective response can be implemented. Such responses could be effected with the assistance of funds provided under the Chapter NR 198 Aquatic Invasive Species Control Grant Program, and should be undertaken as soon as possible once the presence of a nonnative, invasive species is observed and confirmed, reducing the risk of spread from waters where they are present and restoring native aquatic communities. Control of invasive species currently designated pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* is recommended to be undertaken throughout the Lake, using appropriate, permitted control measures.[7]

Shoreline Protection Management

Shoreline protection management measures refer to a group of measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, boat wakes, or related actions of the water. Currently, about 75 percent of the Pine Lake shoreline and about 50 percent of the Beaver Lake shoreline is protected by some type of structural measure, mainly riprap, designed to stabilize the shoreline. Most of the observed shoreline protection measures were in a good state of repair.

Array of Management Measures

Four shoreline erosion control techniques are commonly used: vegetative buffer strips, rock revetments or riprap, wooden and concrete bulkheads, and beaches or sand/pea gravel blankets. It should be noted that bulkheads are no longer being permitted as these vertical structures form barriers to aquatic life utilizing the shoreland zone, and sand/pea gravel blankets are limited to two cubic yards of material under the general permit set forth under

[5]*SEWRPC Community Assistance Planning Report No. 47, 2nd Edition,* A Water Quality Management Plan for Lac La Belle, Waukesha County, Wisconsin*, May 2007.*

[6]*Note: The creation of additional aquatic habitat in shoreland areas through the use of vegetated buffer strips and provision of structure through deadfalls or placement of other structures into the Lake is considered viable for fisheries management purposes and is recommended.*

[7]*Appropriate control measures include, but are not limited to, any permitted aquatic plant management measure, placement of signage, and use of buoys to isolate affected areas of the Lake. Such measures as may be appropriate should be determined in consultation with WDNR staff and conducted in accordance with required permits under Chapters NR 107, NR 109, and NR 198, amongst others, of the* Wisconsin Administrative Code*.*

Chapter NR 328 of the *Wisconsin Administrative Code*. Maintenance of a vegetated buffer strips immediately adjacent to the Lake is the simplest, least costly, and most natural method of reducing shoreline erosion. This technique employs natural vegetation, rather than maintained lawns, within five to 10 feet of the lakeshore and the establishment of emergent aquatic vegetation from two to six feet lakeward of the shoreline. The use of such natural shorescaping techniques is generally required pursuant to Chapter NR 328 of the *Wisconsin Administrative Code*, except in moderate- to high-energy shorelines where more robust structural approaches may be required. A Worksheet is provided within Section NR 328.08 Table 1 as a means of assisting property owners who wish to install or modify existing shoreline protection structures.

Desirable plant species that may be expected and encouraged to invade a buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium eurycarpum*), and blue flag (*Iris versicolor*) in the wetter areas; and jewelweed (*Impatiens biflora*), elderberry (*Sambucus canadensis*), giant goldenrod (*Solidago gigantea*), marsh aster (*Aster simplex*), red-stem aster (*Aster puniceus*), and white cedar (*Thuja occidentalis*) in the drier areas. In addition, trees and shrubs, such as silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), black willow (*Salix nigra*), and red-osier dogwood (*Cornus stolonifera*) could become established. These plants will develop a more extensive root system than the lawn grass and the aboveground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. A narrow path to the Lake can be maintained as lake access for boating, swimming, fishing, and other activities. A vegetative buffer strip would also serve to trap nutrients and sediments washing into the Lake via direct overland flow. This alternative would involve only minimal cost.

Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. These structures are already in place along the majority of the shoreline of Pine Lake and about half of the shoreline of Beaver Lake. The technique involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of rock revetments are that they are highly flexible and not readily weakened by movements caused by settling or ice expansion, they can be constructed in stages, and they require little or no maintenance. The disadvantages of rock revetments are that they limit some uses of the immediate shoreline. The rough, irregular rock surfaces are unsuitable for walking; require a relatively large amount of filter material and rocks to be transported to the lakeshore; and can cause temporary disruptions and contribute sediment to the lake. If improperly constructed, revetments may fail because of washout of the filter material. A rock revetment is estimated to cost $25 to $35 per linear foot.

Recommended Management Measures

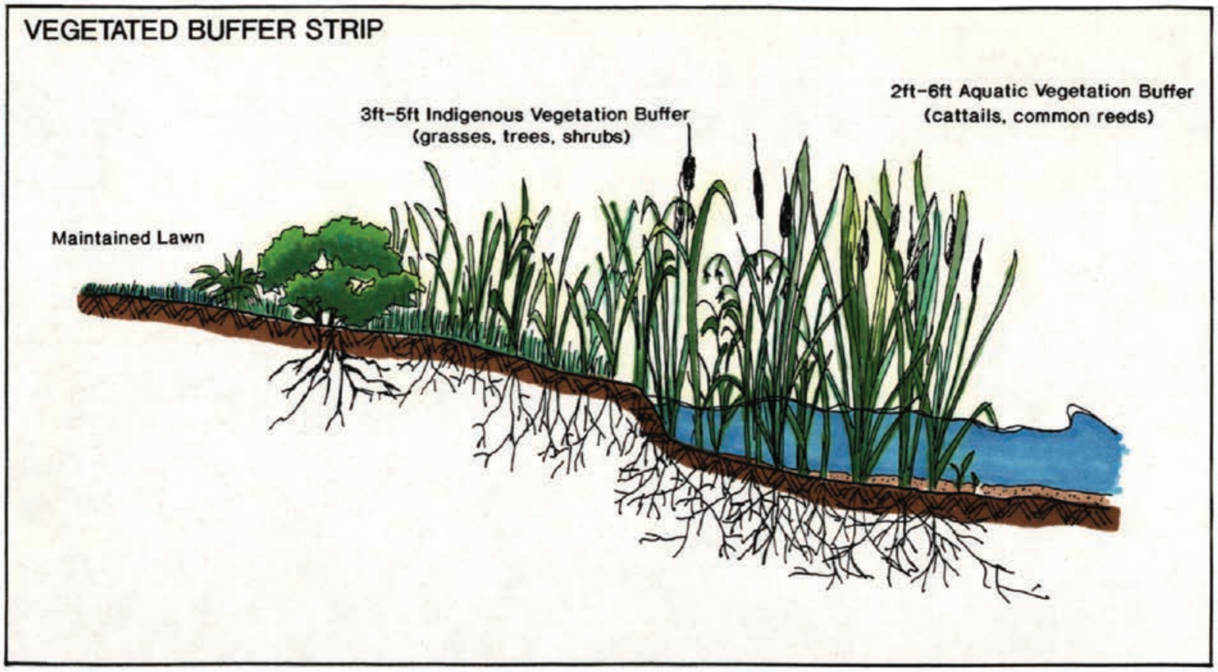
The use of vegetative buffer strips and riprap, as shown in Figure 5, is recommended. These alternatives were selected because they can be constructed, at least partially, by local residents; because most of the construction materials involved are readily available; because the measures would, in most cases, enable the continued use of the immediate shoreline; and because the measures are visually “natural” or “semi-natural” and should not significantly affect the aesthetic qualities of the lake shoreline. In those portions of the Lake subject to direct action of wind waves and ice scour, the use of riprap would provide a more robust means of stabilizing shorelines, while elsewhere along the lakeshore creation of vegetated buffer strips would provide not only shoreline erosion protection but also enhanced shoreland habitat for fish and wildlife. In this regard, it should be noted that the selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*.

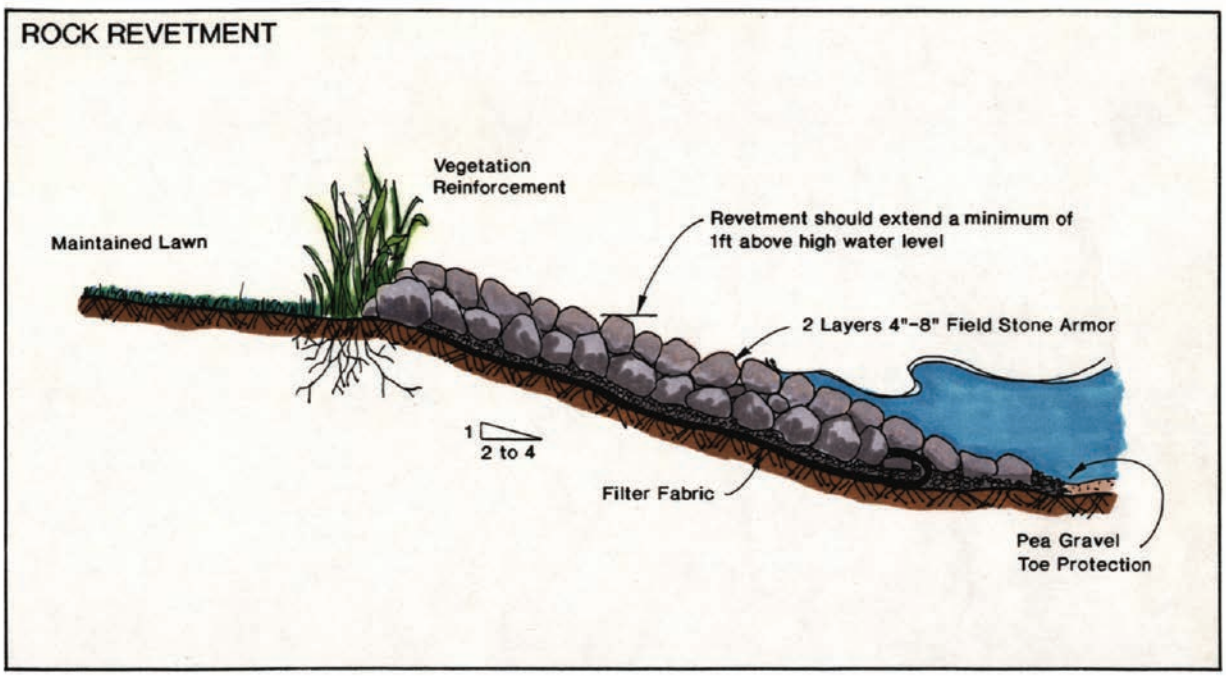
Water Quality Management

Water quality is one of the key parameters used to determine the overall health of a waterbody. The importance of good water quality can hardly be underestimated as it impacts nearly every facet of the natural balances and relationships that exist in a lake between the myriad of abiotic and biotic elements present. Because of the importance water quality plays in the functioning of a lake ecosystem, careful monitoring of this lake element represents a fundamental management tool.

Figure 5

RECOMMENDED ALTERNATIVES FOR SHORELINE EROSION CONTROL





NOTE: Design specifications shown herein are for typical structures. The detailed design of shoreline protection structures must be based upon analysis of local conditions.

Source: SEWRPC.

Array of Management Measures

The WDNR operates the Wisconsin Self-Help Monitoring Program, now the Citizen Lake Monitoring Network (CLMN) administered by the University of Wisconsin-Extension (UWEX). Volunteers enrolled in this program gather data on water clarity at regular intervals through the use of a Secchi disk. Because contaminants such as phosphorus, which encourages the growth of algae, and eroded sediments reduce water clarity, Secchi disk measurements are generally considered one of the key parameters in determining the overall quality of lake water as well as lake trophic status. Secchi disk measurement data are added to the WDNR-sponsored data base containing lake water quality information for most of the lakes in Wisconsin and accessible on-line through the WDNR website. The Expanded Self-Help Monitoring Program involves additional data collecting on key physical and chemical parameters, e.g., temperature, dissolved oxygen concentration, chlorophyll-*a* concentration, and total phosphorus concentration, in addition to the Secchi disk measurements. Under this program, samples of lake water are collected by volunteers at regular intervals and analyzed by the State Laboratory of Hygiene. The more extensive data collection places more of a burden on volunteers, but greatly increases the level of information available on lake water quality.

In addition to the volunteer-based CLMN program, the U.S. Geological Survey (USGS) also offers an extensive water quality monitoring program. USGS field personnel conduct a series of approximately four monthly samplings beginning with the spring turnover. Samples are analyzed for an extensive array of physical and chemical parameters. The University of Wisconsin-Stevens Point (UWSP) also offers several water quality analysis programs. Under these latter programs, volunteers collect water samples and send them to the UWSP Water and Environmental Analysis Laboratory (WEAL) for analysis.

The basic WDNR Self-Help Monitoring Program is available at no charge, but does require volunteers to be committed to taking Secchi measurements at regular intervals throughout the spring, summer, and fall. The Expanded Self-Help Program requires additional commitment by volunteers to take a more extensive array of measurements and samples for analysis, also on a regular basis. The UWSP turnover sampling program requires only once-a-year sampling, thereby requiring a smaller time commitment by the volunteers, but incurs a modest charge for the laboratory analysis and, because sampling is performed by volunteers, is subject to those variations identified above. Additionally, since samples need to be taken as closely as possible to the actual turnover period, which occurs only during a relatively short window of time, volunteers need to monitor lake conditions as closely as possible to be able to determine when the turnover period is occurring. As with any volunteer-collected data, standardized field protocols and volunteer training opportunities are in place to minimize variations in levels of individual expertise which can lead to variations in data and measurements, especially when volunteers change. The USGS program does not require volunteer sampling. All sampling and analysis is provided by USGS personnel using standardized field techniques and protocols. As a result, a more standardized set of data and measurements may be expected. However, the cost of the USGS program is significantly higher than the UWSP program, even with possible State cost-share availability under the Chapter NR 190 Lake Management Planning Grant Program.

Recommended Management Measures

The WDNR offers Small Grant cost-share funding under the Chapter NR 190 Lake Management Planning Grant Program that can be applied for to defray the costs of laboratory analysis and sampling equipment. Currently, Pine Lake would qualify for such a grant, Beaver Lake, due to its lack of adequate public recreational boating access, as defined in Chapter NR 1 of the *Wisconsin Administrative Code*, would not. Nevertheless, participation of volunteers in the WDNR Self-Help/CLMN Program and the WDNR Expanded Self-Help Program is recommended. Data gathered as part of this program should be presented annually by the volunteers at relevant meetings sponsored within the Pine and Beaver Lakes community, such as at the annual meeting of the Friends of Beaver Lake, Inc. Such presentations would allow recognition of the work of the citizen monitors, and contribute to an informed community. The WDNR Lake Coordinator for the South East Region can assist in enlisting volunteers in this program. The information gained at first hand by the public from participation in this program can increase the credibility of the proposed changes in the nature and intensity of use to which the Lakes are subjected.

The UWSP program and the USGS program are also worthy of consideration. The USGS program would be especially valuable as a means to attain a comprehensive water quality determination on a periodic basis,[8] every three to five years, while maintaining yearly Self-Help/CLMN data.

Fisheries Management

Based upon fisheries surveys described in Chapter II of this report, Pine Lake appeared to have a fairly diverse and healthy fishery, although a more recent fish population assessment would be required to better determine the nature of the current fish community. Fishery surveys have not been conducted on Beaver Lake as a consequence of that Lake lacking adequate public recreational boating access as defined in Chapter NR 1 of the *Wisconsin Administrative Code*.

Array of Management Measures

Pine Lake provides a suitable habitat for a warmwater fishery with adequate water quality and dissolved oxygen levels that can contribute to the maintenance of a fish population that is dominated by desirable sport fish. To this end, a more rigorous fisheries survey should be considered in order to better identify fish population composition, length-weight distributions, community age structure, and related life history information, such as proportion of available spawning habitat, spawning success, and juvenile recruitment, that will be important for making stocking-related decisions. Potential alternatives for improving the fishery include protecting existing fish spawning sites and establishing additional habitat sites through the development of a desirable aquatic plant community, especially in the shallow water habitat areas of the Lake. These alternatives can be supplemented by regulatory provisions relating to the removal of fishes from the Lake and the addition of fishes to the Lake by stocking. All of these measures appear to be appropriate for use in Pine Lake. However, in regards to stocking in Beaver Lake, it should be noted that the stocking of fishes by the WDNR is considered a lake enhancement service, the provision of which is subject to a lake being deemed to have adequate public access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*.

Habitat Protection

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat. These measures include restricting recreational and other intrusions into gravel-bottomed shoreline areas during the spawning season (for bass this is spring, mid-April to mid-June), use of natural vegetation in shoreland management zones, and other "soft" shoreline protection options that aid in habitat protection.

In lakes where vegetation is lacking or where plant species diversity is low, artificial habitat may need to be developed. This situation more accurately describes conditions in Beaver Lake than in Pine Lake, since results of the aquatic plant surveys of Beaver Lake indicate that there may be insufficient habitat for a healthy fish community. Pine Lake has a more robust and diverse aquatic plant community, typical of that which is generally capable of supporting a larger and more varied fish community. The use of natural shoreline landscaping techniques provides one alternative to enhance available fish and wildlife habitat around lakes. In addition,

[8]*Note: The Village of Chenequa presently has a contract with the USGS for the conduct of a comprehensive study of the water budgets of the four lakes within the Village: Beaver, Pine, Cornell, and North Lakes. On July 10, 2006, the Board of Trustees of the Village of Chenequa acted to approve an application for Chapter NR 190 Lake Management Planning Grant cost-share funds to develop a groundwater model and water budget for the Village and its environs. This model will build on and extend the existing regional groundwater model developed, in part, by SEWRPC, the USGS, Wisconsin Geologic and Natural History Survey, and University of Wisconsin. See SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin, *June 2002. Funds to support this project were awarded to the Village following the August 1, 2006, grant submission period, and the project was initiated during 2007. Ultimately, the Village has indicated their intent to request SEWRPC to prepare a comprehensive water resources management plan for the Village of Chenequa and its environs, inclusive of the four lakes.*

provision of additional shoreline cover, in the form of deadfalls or other structures to improve fish habitat into the nearshore waters, can add habitat and structure to the lake environment. Such structure would be intended to provide shelter for juvenile fishes and forage fishes, as well as substrate for aquatic invertebrates and algae that serve as their food stocks. It should be noted that placement of such structures may require a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*. Given the fact that the Lake surface is used for a variety of active water sports, due cognizance must be given to the placement of structures to avoid potential conflicts, including public safety concerns, with other recreational uses.

Modification of Species Composition
Species composition management refers to a group of conservation and restoration measures that include the stocking of desirable species designed to enhance the angling resource value of a lake. The mixture of species is determined by the stocking objectives. Stocking objectives are usually to: supplement an existing population, maintain a population that cannot reproduce itself, add a new species to a vacant niche in the food web, replace species lost to a natural or man-made disaster, or establish a fish population in a depopulated lake. While assistance in stocking programs and fisheries management is potentially available through the WDNR the ability of Beaver Lake to utilize such assistance is limited by the lack of adequate public recreational boating access, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*; however, assistance may be privately available from local commercial hatcheries. Fish stocking may require a WDNR permit.

Recommended Management Measures
The following fisheries management measures, designed to improve and enhance the fisheries in Pine and Beaver Lakes, are recommended to be considered:

- Encourage the use of natural vegetation and other “soft” shoreline protection options in shoreland management zones to aid in habitat protection;

- Monitor fish populations periodically through WDNR-conducted fisheries surveys on Pine Lake; in the event Beaver Lake becomes eligible for WDNR assistance, through provision of adequate public recreational boating access, conduct WDNR fisheries surveys and utilize stocking recommendations to promote a more robust and diverse fishery in the Lake;

- Continue the stocking of fishes in Pine Lake as per WDNR recommendations.

- Utilize fishing regulations to protect stocked fishes to improve the opportunity for their populations to become self-sustaining.

Recreational Use Management
Current public recreational boating standards as set forth in Sections NR 1.91(4) and NR 1.91(5) of the *Wisconsin Administrative Code*, establish minimum and maximum standards for public boating access development, respectively, to qualify waters for resource enhancement services provided by the WDNR. As noted in Chapter II, there is currently one public recreational boating access site on Pine Lake. This site, located at the northern end of the Lake, is owned and operated by the Village of Chenequa. The site provides 19 numbered car and trailer combination parking spaces, one of which is designated for handicapped use. The site employs a self-registration procedure for collection of a daily use fee. Based upon the standards described above, the Pine Lake facility meets current State public access recreational boating access standards.

The public recreational boating access site for Beaver Lake is located along the western shore of the Lake adjacent to STH 83. The site, which is owned and operated by the WDNR, provides 10 pull-in diagonal no-fee parking spaces for cars, trailers are prohibited, and is strictly a carry-in facility with no launch ramp for boats. At present, the Beaver Lake public access fails to conform to current State public recreational boating access standards.[9] Thus, provision for adequate public recreational boating access to Beaver Lake, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*, is an alternative to be considered by the Village of Chenequa and other lake-based organizations, such as the Friends of Beaver Lake, Inc., or the Beaver Lake Yacht Club, to gain eligibility for future grants from the WDNR for lake enhancement services.

Array of Management Measures

Given that the public recreational boating access site on Pine Lake meets current WDNR standards, no further development is deemed necessary. With regard to the public recreational boating access site on Beaver Lake, since the existing site currently does not conform to WDNR standards, there are several alternatives to consider. One alternative would be the purchase of a homestead property for conversion to a public recreational boating access site. Given the residential nature of the Beaver Lake community, acquisition of parking areas and operation of a public recreational boating access facility would require intrusion of such operations into the residential community, which intrusion is not considered to be feasible. It may, however, be feasible to develop a private provider agreement, as defined in Section NR 1.91(7) of the *Wisconsin Administrative Code*, between the WDNR and the Beaver Lake Yacht Club. The Yacht Club is the only private access point to the Lake and is situated on the northern shore of the Lake. Under such an agreement, the Yacht Club would provide parking and access to the Club launch ramp facility at rates commensurate with those in effect for use of similar launching facilities in a State park.[10] The numbers of parking spaces would be determined pursuant to the minimum and maximum public recreational boating access standards set forth in Chapter NR 1, which, based upon the boatable area of Beaver Lake, would be parking for approximately 10 to 21 car-trailer units, plus at least one handicapped-accessible space. A similar Section NR 1.91(7) private provider agreement with the Beaver Lake Country Club, located at the northwestern corner of Beaver Lake, is also considered a viable option.

Recommended Management Measures

The alternative which appears to be most feasible is the conclusion for a Section NR 1.91(7) private provider agreement between the WDNR and the Beaver Lake Yacht Club. The proposed parking facilities should conform to the guidance on accessibility contained in WDNR Publication No. PUBL-CA-003 88, *Handbook for Accessibility...A Reference to Help Develop Outdoor Recreation Areas to Include People with Disabilities*. Such access facilities would provide for greater convenience of the residents of Beaver Lake, as well as for the convenience and safety of the public at large, by providing an improved public launch site with adequate parking facilities. In addition, Beaver Lake would become eligible to receive grant funds from the WDNR for future lake improvement projects. Reasonable fees may be charged for the use of the public recreational boating access site.[11]

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[9]*Chapter NR 1 of the* Wisconsin Administrative Code *requires that public inland lakes have adequate public recreational boating access in order for the lake to be eligible for financial and/or technical assistance from the Wisconsin Department of Natural Resources. Such assistance includes the ability to access State lake rehabilitation, nonpoint source water pollution control, fish management, and/or water safety aides, including access to State cost-share funding for enhancement services.*

[10]*As an example of such an agreement in use, public recreational boating access to Pike Lake is provided through a private provider agreement signed between the Wisconsin Department of Natural Resources and a local marina. This agreement, pursuant to Chapter NR 1 of the* Wisconsin Administrative Code, *provides for the launching and recovery of watercraft at rates consistent with those charged for entry to State parks, and is subject to periodic review.*

[11]*Reasonable fees are considered to be equivalent to the daily entrance fee for Wisconsin State Parks, with the possibility that surcharges can be considered for provision of additional facilities, such as parking attendants, restrooms, and related amenities.*

In addition to the provision of adequate public recreational boating access, it is recommended that appropriate signage at the public recreational boating access sites on both Lakes be provided, with inclusion of information on Eurasian water milfoil and other nonnative species of plants and animals, consistent with the aquatic plant management measures set forth above.

RELATED TRIBUTARY AREA MANAGEMENT MEASURES

Land Use Management

A basic element of any management effort for a lake is the promotion of sound land use development and management in the tributary area. The type and location of future urban and rural land uses in the area tributary to Pine and Beaver Lakes will determine, to a large degree, the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various land management measures; and, to some considerable degree, the water quality of the Lakes themselves.

The recommended future land use conditions for the area tributary to the Lakes are set forth in the adopted regional land use and county development plans.[12] These plans present alternatives for the preservation of primary environmental corridor lands in essentially natural, open space use. The delineated environmental corridors contain most of the ecologically valuable lands in the vicinity and adjacent to the Lakes. Hence, the protection and preservation of the environmental corridor lands is recommended. All lakes, wetlands, and woodlands are recommended to be placed in conservancy protection districts.

With respect to the recommended future land use pattern, as set forth in Chapter II, projected year 2035 urban land uses are expected to comprise about 43 percent of the tributary area, as lands currently in agricultural use are developed into urban residential lands. These changes are anticipated to occur primarily in the southwestern and southeastern portions of the tributary area, along a portion of the shorelands on the eastern side of Pine Lake, and in the northeastern portion of the tributary area east of Beaver Lake. Some limited infilling of existing, platted lots would be expected to occur, and, in addition, the redevelopment and reconstruction of existing single-family homes on lakefront properties may be expected. Increases in urban land uses and associated impervious surfaces will increase runoff into the Lakes, subject to Chapter NR 151 guidance on runoff management, and may increase some nonpoint source pollutant loadings that represent a potentially significant threat to the Lake's water quality. Sources of nonpoint source pollutants include both rural and urban land uses, including land disturbing activities associated with construction and redevelopment within the tributary area.

Control of Nonpoint Source Pollution

The anticipated urbanization of the watershed under buildout conditions, as set forth in the aforereferenced regional land use and county development plans, when viewed in light of the recent USGS findings regarding the potential impacts of suburban lawn care practices on stormwater runoff in urbanized watersheds in Wisconsin,[13] has heightened concern among lakeshore residents that the water quality of the Lakes could deteriorate. As described in Chapter II, the primary sources of pollutant loadings to Pine and Beaver Lakes are nonpoint sourced, generated from within the areas tributary to the Lakes. Watershed management measures may be used to reduce nonpoint source pollutant loadings from such rural sources as runoff from cropland and pastureland; from such urban sources as runoff from residential, commercial, transportation, and recreational land uses; and from construction activities. The alternative, nonpoint source pollution control measures considered in this report are

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[12]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006; and, SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

[13]*U.S. Geological Survey Water-Resources Investigations Report No. 02-4130,* Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Lakeshore Lawns, Lauderdale Lake, Wisconsin, *July 2002.*

based upon the recommendations set forth in the regional water quality management plan[14] and information presented by the U.S. Environmental Protection Agency.[15]

Array of Protection Measures

To control nonpoint source pollution to Pine and Beaver Lakes and their tributary areas, application of both urban and rural nonpoint source controls is recommended. In addition, measures to control nonpoint source pollution loading during land development activities also are recommended. To this end, the Village of Chenequa has enacted fertilizer control ordinances, as set forth in Appendix D.

Urban Nonpoint Source Controls

Nonpoint Source Pollution Control in Developed Urban Areas

Potentially applicable urban nonpoint source control measures include wet detention basins, stormwater infiltration basins, grassed swales, and good urban housekeeping practices. Public informational programs can be developed to encourage good urban housekeeping practices, to promote the selection of building and construction materials which reduce the runoff contribution of metals and other toxic pollutants, and to promote the acceptance and understanding of the proposed pollution abatement measures and the importance of lake water quality protection. Good urban housekeeping practices and source controls include restricted use of fertilizers and pesticides; improved pet waste and litter control; the substitution of plastic for galvanized steel and copper roofing materials and gutters; proper disposal of motor vehicle fluids; increased leaf collection; street sweeping; and reduced use of street deicing salt. Generally, the application of low-cost urban housekeeping practices may be expected to reduce nonpoint source loadings from urban lands by about 25 percent.

Proper design and application of urban nonpoint source control measures such as grassed swales, detention basins, and infiltration basins requires the preparation of a detailed stormwater management system plan that addresses stormwater drainage problems and controls nonpoint sources of pollution. Management measures that can be applied within the Village of Chenequa in the immediate vicinity of Pine and Beaver Lakes are limited largely to good urban housekeeping practices, grassed swales, and vegetative lakeshore buffers. However, structural measures could be considered for installation as part of the development process in urbanizing areas within those currently undeveloped portions of the tributary area, and in those portions of the watershed along roadways where provision of measures to reduce runoff velocities from the impervious surfaces may be desirable.

Nonpoint Source Pollution Control in Developing Urban Areas

Developing areas can generate significantly higher pollutant loadings than established areas of similar size. These areas include a wide array of activities, including individual site development within the existing urban area, and new land subdivision development. As previously noted, additional urban development is presently occurring and/or planned within the area tributary to the Lakes. These construction sites may be expected to produce suspended solids and phosphorus loadings at rates several times higher than established urban lands, and control of sediment loss from construction sites is recommended.

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[14]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978, Volume Two,* Alternative Plans, *February 1979, Volume Three,* Recommended Plan, *June 1979; and SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[15]*U.S. Environmental Protection Agency, Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, *2nd Edition, August 1990; and its technical supplement, U.S. Environmental Protection Agency, Report No. EPA-841/ R-93-002,* Fish and Fisheries Management in Lake and Reservoirs: Technical Supplement to the Lake and Reservoirs Restoration Guidance Manual, *May 1993; and R.J. Hunt, Y. Lin, J.T. Krohelski, and P.F. Juckem, U.S. Geological Survey Water-Resources Investigations Report 00-4136,* Simulation of the Shallow Hydrologic System in the Vicinity of Voltz Lake, Wisconsin, Using Analytic Elements and Parameter Estimation, *2000.*

Construction erosion controls are important pollution control measures that can minimize localized loadings of phosphorus and sediment from the drainage area, and minimize the cumulative impacts of such loadings. The control measures include such revegetation practices as temporary seeding, mulching, and sodding; such runoff control measures as placement of filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins; and such site management practices as placement of tracking pads to limit the movement of soils from work sites. Construction site erosion controls may be expected to reduce pollutant loadings from construction sites by about 75 percent.

Rural Nonpoint Source Controls

Upland erosion from agricultural and other rural lands currently is a contributor of sediment and other contaminants within the areas tributary to Pine and Beaver Lakes. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the areas tributary to the Lakes were presented in Chapter II. As set forth, portions of the remaining agricultural lands within the area tributary to the Lakes will be replaced, over time, with urban density residential, commercial, and industrial development. While such development could potentially reduce the agro-chemical loadings to the Lakes, this benefit maybe offset by the fact that urban lands contribute a wider range of contaminants to surface waters and generally increased rates of surface runoff.

Recommended Management Measures

Insofar as future land usage reflects these latter recommendations, it is recommended that development proceed with due regard for the management of stormwater and other urban runoff so as not to impair the water quality of the Lakes. To wit, it is recommended that:

- Development within the area tributary to Pine and Beaver Lakes should occur at densities consistent with those set forth in the adopted regional land use and county development plans;

- Land use development, or redevelopment, proposals around the shoreline of the Lakes be carefully reviewed for potential impacts on the Lakes;

- Residential developments be placed in conservation developments on smaller lots, while preserving portions of the open space on each property or group of properties considered for development and preserving the natural and cultural resources to the extent practicable;[16]

- A regular program of inspection and maintenance, as necessary, be implemented with respect to onsite sewage disposal systems to ensure their continued capacity and functioning, until such time as public sanitary sewerage service may be provided;[17]

- Urban pollution control measures, including wet detention basins, infiltration basins, grassed swales, and good urban "housekeeping" practices, be encouraged to minimize pollutant loadings to the Lakes;

- Where new development or redevelopment is proposed, the provisions of the relevant Town of Merton and Village of Chenequa land division and construction site erosion control ordinances be strictly enforced within the area tributary to the Lakes; and,

- Sound rural land management practices be implemented to reduce soil loss and contaminant loadings through preparation of farm conservation plans and other rural practices adopted in accordance with the county land and water resource management plan.[18]

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[16]*See SEWRPC Planning Guide No. 7,* Rural Cluster Development Guide, *December 1996.*

[17]*SEWRPC,* Amendment to the Regional Water Quality Management Plan, Northwestern Waukesha County, A Regional Water Quality Management Plan for Southeastern Wisconsin—2000*, March 2001.*

[18]*Waukesha County,* Waukesha County Land and Water Resource Management Plan: 2006-2010*, January 2006.*

ANCILLARY PLAN RECOMMENDATIONS

Public Informational and Educational Programming

As part of the overall citizen informational and educational programming to be conducted in the Pine Lake and Beaver Lake communities, residents and visitors in the vicinity of the Lakes should be made aware of the value of the ecologically significant areas in the overall structure and functioning of the ecosystems of the Lakes. Specifically, informational programming related to the protection of ecologically valuable areas in and around the Lakes should focus on the need to minimize the spread of nuisance aquatic species, such as purple loosestrife and Eurasian water milfoil.

With respect to aquatic plants, distribution of posters and pamphlets, available from the UWEX and WDNR, that provide information and illustrations of aquatic plants, their importance in providing habitat and food resources in aquatic environments, and the need to control the spread of undesirable and nuisance plant species is recommended. Currently, many lake residents seem to view all aquatic plants as "weeds" and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impact. Inclusion of specific public informational and educational programming within the activities of the Village of Chenequa and Town of Merton is recommended. These programs should focus on the value of and the impacts of these plants on water quality, fish, and on wildlife; and on alternative methods for controlling existing nuisance plants, including the positive and negative aspects of each method. These programs can be incorporated into the comprehensive informational and educational programs that also would include information on related topics, such as water quality, recreational use, fisheries, and onsite sewage disposal systems.

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the lake management program, are available from the UWEX, the WDNR, Waukesha County, and many Federal government agencies. These brochures could be provided to homeowners through local media, direct distribution, or targeted library/civic center displays. Alternately, they could be incorporated into the newsletters produced and distributed by the Village of Chenequa and lake-oriented organizations involved in the management of Pine and Beaver Lakes. Many of the ideas contained in these publications can be integrated into ongoing, larger-scale activities, such as anti-littering campaigns, recycling drives and similar pro-environment activities.

Other informational programming offered by the WDNR, Waukesha County, and the UWEX, such as Project WET (Water Education Training), can contribute to an informed public, actively involved in the protection of ecologically valuable areas within the area tributary to Pine and Beaver Lakes. Citizen monitoring and awareness of the positive value of native aquatic plant communities are important opportunities for public informational programming and participation that are recommended for the Lakes.

SUMMARY

This plan, which documents the findings and recommendations of a study requested by the Village of Chenequa examines existing and anticipated conditions, potential aquatic plant management problems, and recreational use problems on Pine and Beaver Lakes. The plan sets forth recommended actions and management measures for the resolution of those problems. The recommended plan is summarized in Table 22 and shown on Maps 13 and 14.

Pine Lake was found to be a mesotrophic waterbody of average water quality, while Beaver Lake is considered a mesotrophic to oligo-mesotrophic waterbody of above average quality. Groundwater inflows to the Lakes are an important factor in maintaining high-quality lake water. Preservation of environmental corridor lands, and especially within the shoreland and nearshore areas situated immediately adjacent to the Lake, is recommended. Application of good urban housekeeping practices and maintenance of vegetated shoreline buffer strips form essential complements to the protection and preservation of the environmental corridor lands. Waukesha County, the Town of Merton, and the Village of Chenequa should support appropriate land management practices designed to reduce nonpoint source pollutant discharges in stormwater runoff and maintain the current inflow of high-quality groundwater to the Lake.

Table 22

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR PINE AND BEAVER LAKES

Plan Element	Subelement	Management Measures	Management Responsibility
In-Lake Management Measures	Aquatic Plant Management	Conduct periodic in-lake reconnaissance surveys of aquatic plant communities and update aquatic plant management plan every three to five years Limited use of aquatic herbicides for control of nuisance nonnative aquatic plant growth where necessary; specifically target Eurasian water milfoil, using granular form of 2,4-D in treating scattered, monospecific stands during early season[a]; early season treatment recommended for curly-leaf pondweed Encourage growth of native plants in Beaver Lake through use of vegetated buffer strips, deadfalls, or other structures Additional periodic monitoring of the aquatic plant community for the early detection and control of future-designated nonnative species that may occur	WDNR, Friends of Beaver Lake, Village of Chenequa
		Manually harvest around piers and docks as necessary[b] Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lake	Private landowners
		Monitor invasive species populations; where they occur, remove isolated stands of purple loosestrife through bagging, cutting, herbicide application to cut stems	WDNR, Friends of Beaver Lake, Village of Chenequa, private landowners
	Shoreline Protection Management	Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Waukesha County, Town of Merton, Village of Chenequa, WDNR, and private landowners
	Water Quality Management	Continue participation in WDNR Self-Help monitoring program and periodic participation in U.S. Geological Survey TSI or WDNR Expanded Self-Help monitoring programs	WDNR, USGS, Village of Chenequa, Friends of Beaver Lake
	Fisheries Management	Conduct periodic fish surveys to determine management and stocking needs; continue stocking; enforce size and catch limit regulations	WDNR
		Protect fish habitat, including environmentally sensitive lands such as wetlands; encourage use of natural vegetation in shoreland areas to aid in habitat protection	Village of Chenequa, Friends of Beaver Lake, WDNR, individuals
	Recreational Use Management	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines; enforce and periodically review boating regulations Maintain signage at public access sites regarding invasive species; provide disposal containers for disposal of plant material removed from watercraft	WDNR, Village of Chenequa
		Consider private provider agreement for public access to Beaver Lake in order to secure fisheries management services and state cost-share funding opportunities for qualified lake management and protection projects	WDNR, Beaver Lake Yacht Club, Friends of Beaver Lake
Tributary Area Management Measures	Land Use	Observe development area guidelines set forth in the regional land use plan; consider conservation development principles	Waukesha County, Village of Chenequa, and Town of Merton
		Establish adequate protection of wetlands and shorelands, and other environmental corridor lands and isolated natural resource features	Waukesha County, Village of Chenequa, Town of Merton, and WDNR
		Maintain historic lake front residential dwelling densities to extent practicable	Waukesha County, Town of Merton, and Village of Chenequa

Table 22 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility
Tributary Area Management Measures (continued)	Land Use (continued)	Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans in accordance with the regional land use management plan	USDA, WDATCP, and Waukesha County
		Promote sound urban housekeeping and yard care practices through informational programming; implement stormwater management measures	Waukesha County, Town of Merton, Village of Chenequa
		Strictly enforce construction site erosion control and stormwater management ordinances	Waukesha County, Town of Merton, Village of Chenequa
		Implement onsite sewage disposal system management, including inspection and maintenance, in those portions of the watershed not served by public sanitary sewerage systems	Waukesha County and private landowners
Ancillary Measures	Public informational and educational programming	Continue to provide informational material and pamphlets on lake-related topics, especially the importance of aquatic plants and the protection of ecologically significant areas; consider offering public informational programming on topics of lake-oriented interest and education	Village of Chenequa, Friends of Beaver Lake, Town of Merton, WDNR, and UWEX
		Encourage inclusion of lake studies in environmental curricula (e.g., Pontoon Classroom, Project WET, Adopt-A-Lake)	Area school districts, UWEX, WDNR, Village of Chenequa, and Friends of Beaver Lake

[a] *Use of aquatic herbicides requires a WDNR permit pursuant to Chapter NR 107 of the* Wisconsin Administrative Code*.*

[b] *Manual harvesting beyond a 30 linear foot width of shoreline is subject to WDNR permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code; *manual harvesting in WDNR-designated sensitive areas is also subject to WDNR permitting.*

Source: SEWRPC.

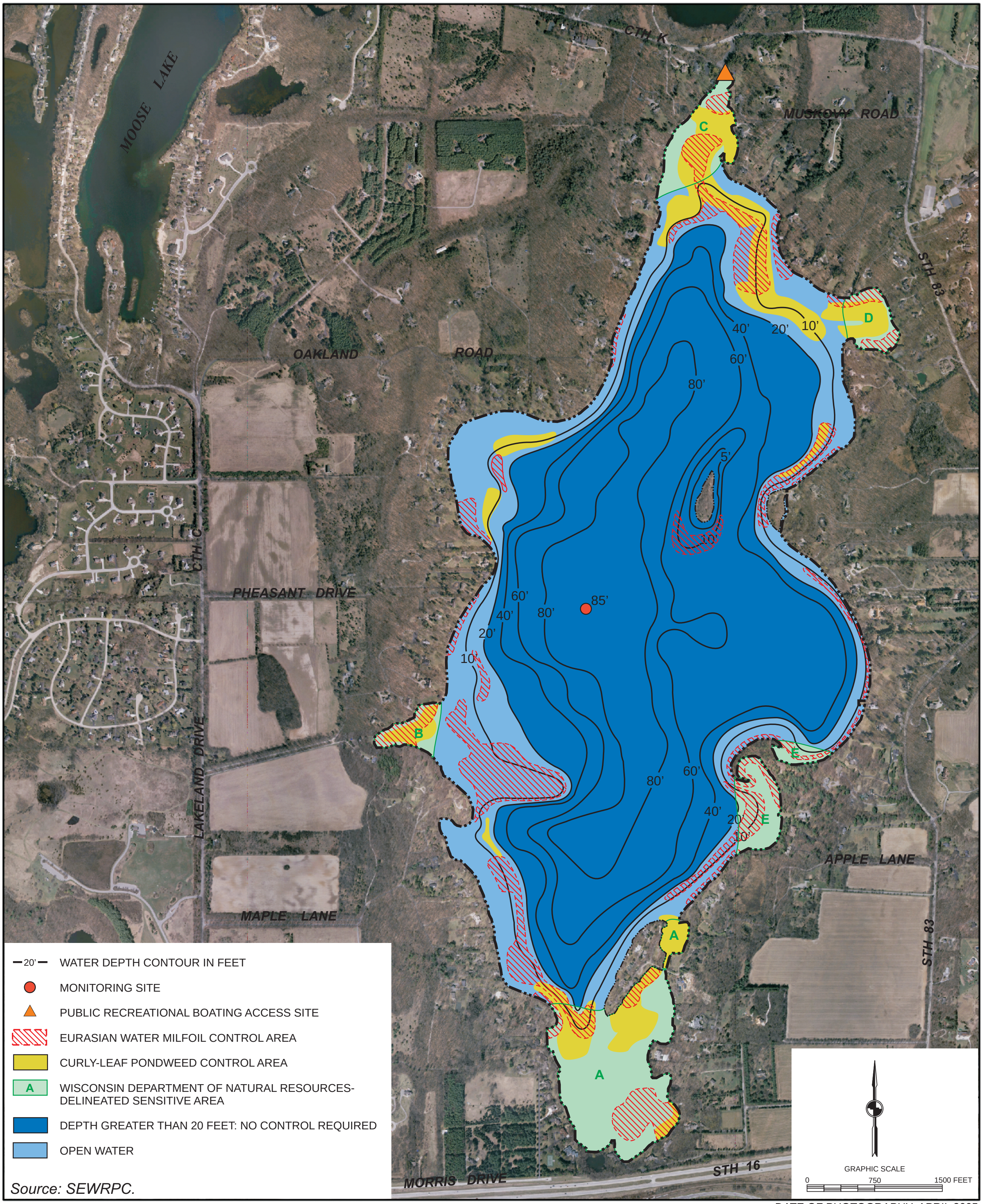
The shoreland and aquatic plant management elements of this plan recommend actions be taken to reduce human impacts on ecologically valuable areas in and adjacent to the Lake, and to limit the spread of nonnative invasive plant species. The plan recommends periodic in-lake aquatic plant surveys, limited use of chemical herbicides mainly in areas where nuisance levels of nonnative invasive species are present, manual harvesting of aquatic plants around piers and docks with subsequent removal of cut material from the Lakes, and monitoring of invasive species populations. The plan also recommends establishing nearshore native aquatic floating and emergent vegetation in Beaver Lake to increase species diversity and numbers, and thereby enhance habitat in that lake.

The plan recommends continued participation in the WDNR-sponsored, UWEX-administered CLMN volunteer water quality monitoring program with consideration of periodic USGS, or similar, comprehensive water quality surveys. With regard to fisheries, the plan recommends periodic WDNR-conducted fish surveys to determine management and stocking needs and recommends the use of natural vegetation in shoreland areas to aid in habitat protection. With respect to State enhancement services provided to Beaver Lake, the plan further recommends that consideration be given to developing a private provider agreement to provide adequate public recreational boating access for Beaver Lake which would qualify the Lake for State cost-share funding opportunities, secure fisheries management services, and enable access to other lake management and protection projects.

Finally, the recommended plan includes the continuation of ongoing programs of public information and education, focusing on providing riparian residents and lake users with an improved understanding of the lake ecosystems in Pine and Beaver Lakes. For example, additional options regarding household chemical usage, lawn and garden care, onsite sewage disposal system operation and maintenance, shoreland protection and maintenance, and recreational usage of the Lake should be made available to riparian property owners, thereby providing riparian residents with alternatives to traditional activities.

Map 13

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR PINE LAKE

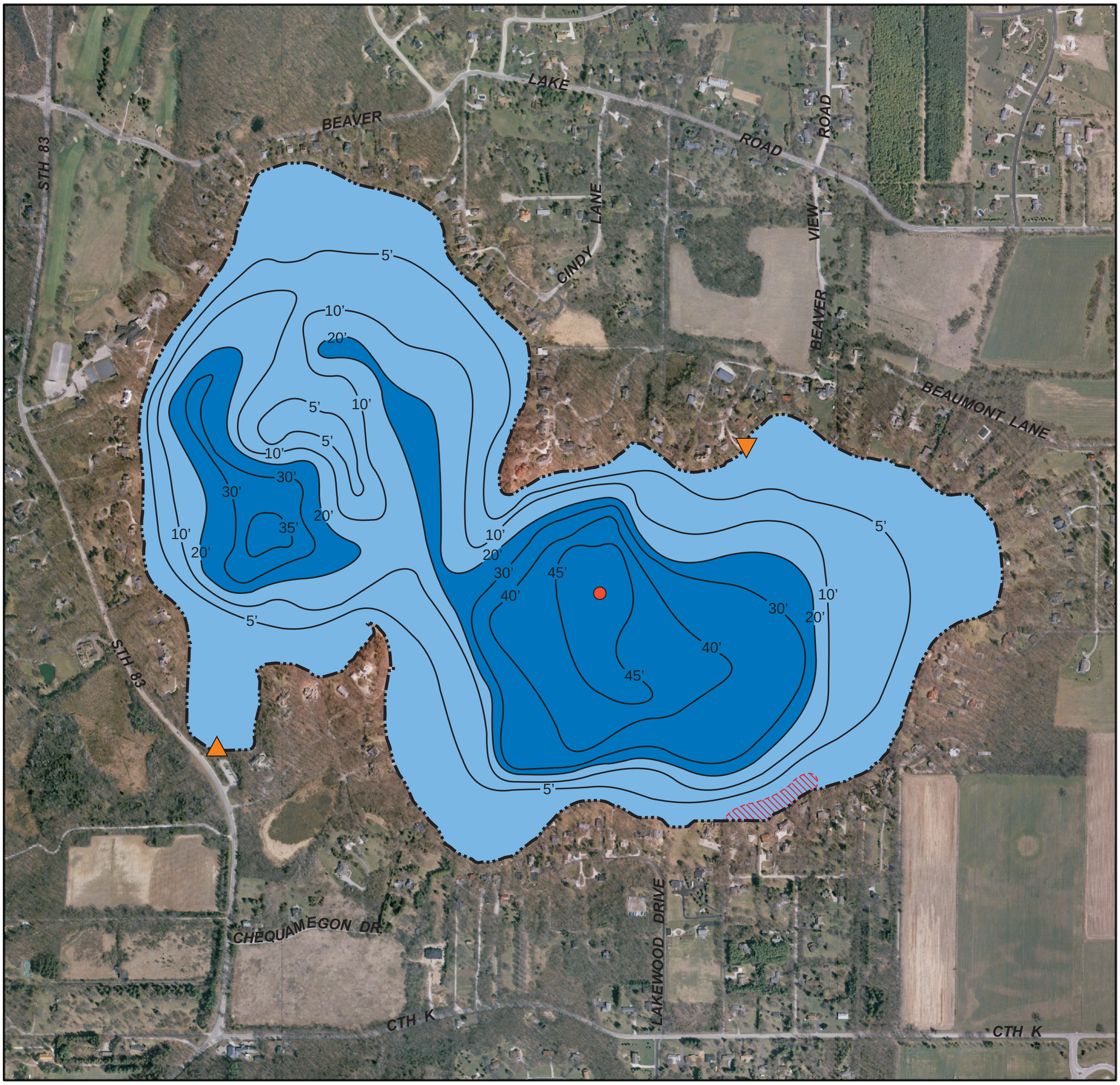


Source: SEWRPC.

DATE OF PHOTOGRAPHY: APRIL 2005

Map 14

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR BEAVER LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

20' WATER DEPTH CONTOUR IN FEET

MONITORING SITE

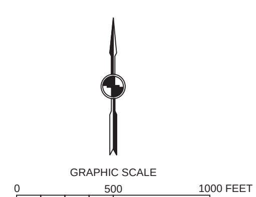
PUBLIC RECREATIONAL BOATING ACCESS SITE

CONSIDER PRIVATE RECREATIONAL BOATING ACCESS AGREEMENT PURSUANT TO CHAPTER NR 1

EURASIAN WATER MILFOIL CONTROL AREA

DEPTH GREATER THAN 20 FEET: NO CONTROL REQUIRED

OPEN WATER



Source: U.S. Geological Survey and SEWRPC.

APPENDICES

Appendix A

ALGAE AND ALGAL TOXIN ANALYSES OF SAMPLES OBTAINED FROM PINE AND BEAVER LAKES

PhycoTech, Inc.
620 Broad Street - Suite 100 - St. Joseph - MI 49085 - Phone: 269-983-3654 - Fax: 269-983-3653
info@phycotech.com - www.phycotech.com

Algae Analysis
Report and Data Set

Customer ID: 231

Tracking Code:	070001-231	**Sample ID:**	.	**Replicate:**	1
Customer ID:	231	**Sample Date:**	7/23/2007	**Sample Level:**	Epi
Job ID:	1	**Station:**	Waukesha Co., WI	**Sample Depth:**	0.5
System Name:	Beaver Lake	**Site:**	Public Access	**Preservative:**	Glutaraldehyde
Report Notes:	.				

Division: **Cyanophyta**

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Dominance**
4261	*Microcystis*	*aeruginosa*	.	.	.	.	Vegetative	1

Tracking Code:	070002-231	**Sample ID:**	.	**Replicate:**	1
Customer ID:	231	**Sample Date:**	7/23/2007	**Sample Level:**	Epi
Job ID:	1	**Station:**	Waukesha Co., WI	**Sample Depth:**	0.5
System Name:	Pine Lake	**Site:**	Public Access	**Preservative:**	Glutaraldehyde
Report Notes:	.				

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Dominance**
107474	*Anabaena*	*lemmermannii*	.	.	.	.	Vegetative	2
107564	*Lyngbya*	*birgei*	.	.	.	.	Vegetative	4
4261	*Microcystis*	*aeruginosa*	.	.	.	.	Vegetative	1

Species List

Division: **Cyanophyta**

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Authority
107474	Anabaena	lemmermannii	.	.	.	.	Vegetative	P. Richter
107564	Lyngbya	birgei	.	.	.	.	Vegetative	.
4261	Microcystis	aeruginosa	.	.	.	.	Vegetative	(Kutzing) Lemmermann

WISCONSIN STATE LABORATORY OF HYGIENE

Environmental Health Division
2601 Agriculture Dr.
P.O. Box 7996
Madison, WI 53707-7996
Phone: (608) 224-6202 • (800) 442-4618
FAX: (608) 224-6213

University of Wisconsin

August 15, 2007

Jeffrey Kante
Village of Chenequa
31275 W. Hwy. K
Chenequa, WI 53029

Dear Jeffrey,

A summary of the microcystin cyanotoxin results from the samples submitted to our laboratory are listed in the table. The samples were analyzed using an enzyme-linked immunosorbent assay (ELISA). For reference, the World Health Organization has set a chronic consumption maximum contaminant guideline level of 1.0 µg/L microcystin-LR in drinking water. I have also enclosed the cyanobacteria identification and enumeration screen results that correspond to these samples.

Microcystin Cyanotoxin Results via ELISA:

Sample ID	Collection Date	Laboratory Number	Microcystin (µg/L)
Pine Lake	8/13/2007	FS000115	< 0.10
Beaver Lake	8/13/2007	FS000116	0.38

Sincerely,

Dawn A.K. Perkins

Dawn A.K. Perkins, M.S.
Environmental Toxicologist

WISCONSIN STATE
LABORATORY OF HYGIENE

Environmental Health Division
2601 Agriculture Dr.
P.O. Box 7996
Madison, WI 53707-7996
Phone: (608) 224-6202 • (800) 442-4618
FAX: (608) 224-6213

University of Wisconsin

Algae Identification Report

Site: Pine Lake
Station/Location: Chenequa, WI
Depth: 0.5 m
Laboratory Number: FS000115

Collection Date: August 13, 2007
Identification Date: August 14, 2007
Identified By: Dawn Perkins

Taxa	Division	Concentration (Cells/mL)[a]
Microcystis sp.	Cyanophyta	1,100
	TOTAL	1,100

Notes/Comments: **Sample analyzed by the nannoplankton chamber screen technique. Test requested was for cyanobacteria identification and enumeration only.**

Signature and Date: Dawn Perkins 8/15/2007

a Method Reference = American Public Health Association et al. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed, Method 10200 F2b1

http://www.slh.wisc.edu

WISCONSIN STATE
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Phone: (608) 224-6202 • (800) 442-4618
FAX: (608) 224-6213

University of Wisconsin

Algae Identification Report

Site: Beaver Lake
Station/Location: Chenequa, WI
Depth: 0.5 m
Laboratory Number: FS000116

Collection Date: August 13, 2007
Identification Date: August 14, 2007
Identified By: Dawn Perkins

Taxa	Division	Concentration (Cells/mL)[a]
Microcystis sp.	Cyanophyta	3,800
	TOTAL	3,800

Notes/Comments: Sample analyzed by the nannoplankton chamber screen technique. Test requested was for cyanobacteria identification and enumeration only.

Signature and Date: Dawn Perkins 8/15/2007

a Method Reference = American Public Health Association et al. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed, Method 10200 F2b1

Appendix B

REPRESENTATIVE ILLUSTRATIONS OF AQUATIC PLANTS FOUND IN PINE AND BEAVER LAKES

Coontail (*ceratophyllum demersum*)

Muskgrass (*chara vulgaris*)

Waterweed (*elodea canadensis*)

Native Water Milfoil (*myriophyllum* sp.)

Eurasian Water Milfoil (*myriophyllum spicatum*)
Exotic Species (nonnative)

Bushy Pondweed (*najas flexilis*)

Spiny Naiad (*najas marina*)

Large-Leaf Pondweed (*potamogeton amplifolius*)

Curly-Leaf Pondweed (*potamogeton crispus*)
Exotic Species (nonnative)

Leafy Pondweed (*potamofeton foliosus*)

Variable Pondweed (*potamogeton gramineus*)

Illinois Pondweed (*potamogeton illinoensis*)

Floating-Leaf Pondweed (*potamogeton natans*)

Sago Pondweed (*potamogeton pectinatus*)

White-Stem Pondweed (*potamogeton praelongus*)

Small Pondweed (*potamogeton pusillus*)

Flat-Stem Pondweed (*potamogeton zosteriformis*)

White Water Crowfoot (*ranunculus longirostris*)

Eel Grass / Wild Celery (*valisneria americana*)

Water Stargrass (*zosterella dubia*)

Appendix C

FERTILIZER AND BOATING ORDINANCES OF THE VILLAGE OF CHENEQUA APPLICABLE TO PINE AND BEAVER LAKES

CHAPTER 3: LAND

3.12 REGULATION OF THE APPLICATION AND USE OF FERTILIZERS.
(added 12/10/07)

(1) PURPOSE AND INTENT. The Board of Trustees finds that the Village's lakes and streams are a natural asset which enhance the environmental, recreational, cultural and economic resources of the area and contribute to the general health and welfare of the public. The purpose of this ordinance is to set forth regulations which will enable the Village to protect its water resources for the health, safety and welfare of the public without detracting from the natural beauty of homeowner’s lawns and gardens. The Board of Trustees further finds that regulating the amount of nutrients and contaminants contained in fertilizer, including phosphorus, that enter the bodies of water as a result of runoff from lawns and turf will aid in the improvement and maintenance of lake water quality.

(2) APPLICABILITY. This ordinance applies in all areas of the Village.

(3) DEFINITIONS.

(a.) *Fertilizer* has the meaning set forth in §94.64(1)(e), Wis. Stats.

(b) *Impervious* surface means a highway, street, sidewalk, parking lot, driveway or other surface that prevents infiltration of water into the soil.

(c) *Lawn fertilizer* means any fertilizer, whether distributed by property owner or commercial entity, distributed for nonagricultural use such as for lawns, golf courses, parks and cemeteries. *Lawn fertilizer* does not include fertilizer products intended primarily for garden and indoor plant application.

(4) REGULATION OF APPLICATION OF LAWN FERTILIZER.

(a) No person shall apply lawn fertilizer within the Village of Chenequa that is labeled as containing more than 0% phosphorus or other compound containing phosphorus such as phosphate, except as provided in sec. (5).

(b) No lawn fertilizer shall be applied when the ground if frozen.

(c) No lawn fertilizer shall be applied when conditions exist which promote or create runoff.

(d) No person shall apply any fertilizer to any impervious surface. If such application occurs, the fertilizer must be immediately contained and either legally applied to turf or placed in an appropriate container.

(e) No person shall apply any fertilizer to any established natural buffer zones.

(f) No person shall apply any fertilizer within 20 feet of any wetland, pond, shoreline, or ordinary high mark of any lake or river as established by the Wisconsin Department of Natural Resources.

(5) EXEMPTIONS. The prohibition against the use of fertilizer under sub. (4) shall not apply to:

(a) Turf or lawn areas newly established via seed or sod procedures during their first growing season.

(b) Turf or lawn areas that soil tests, performed within the past three years by a state-certified soil testing laboratory, confirm are below phosphorus levels established by the University of Wisconsin Extension Service. The lawn fertilizer application shall not contain an amount of phosphorus exceeding the amount and rate of application recommended in the soil test evaluation.

(c) Agricultural uses, vegetable and flower gardens, or application to trees or shrubs.

(d) Yard waste compost, biosolids or other similar materials that are primarily organic in nature and are applied to improve the physical condition of the soil.

(6) ENFORCEMENT. This ordinance will be enforced by the Village Administrator or the Village Administrator’s designee.

(7) PENALTY. Any person or property owner who violates any provision of this ordinance shall be subject to penalties as provided in § 1.01(a) Penalties of the Village Code.

SECTION 2. SEVERABILITY. If any provision of this ordinance is invalid or unconstitutional, or if the application of this ordinance to any person or circumstances is invalid or unconstitutional, such invalidity or unconstitutionality shall not affect the other provisions or applications of this ordinance which can be given effect without the invalid or unconstitutional provision or application.

SECTION 3. EFFECTIVE DATE. This ordinance shall become effective on January 1, 2008, and upon passage and publication as required by law.

CHAPTER 4: LAKES

4.01 PROHIBITING PARKING OF BOATS.

(l) The parking or fastening of boats upon public property in the Village of Chenequa for longer than two hours consecutively is hereby prohibited, and declared unlawful.

(2) Any person violating the provisions of this section 4.01 shall be punished by a fine of Fifteen Dollars ($15.00) and the costs of prosecution.

(3) Police officers of the Village are authorized to remove any boat found parked for more than twenty-four hours in violation of this section 4.01 and to destroy or otherwise dispose of the same unless redeemed by the payment of the fine and costs for violation of this section 4.01 including hauling and storage, within thirty days from the date of seizure.

4.02 BOATING - PINE LAKE.

(l) PURPOSE. The Village Board of the Village of Chenequa determine and declare it to be in the interest of the public health, safety and welfare to adopt regulations relative to water traffic, boating and water sports on Pine Lake in the Village of Chenequa.

(2) APPLICABILITY. The provisions of this section 4.02 shall apply to the waters of Pine Lake in the Village of Chenequa.

(3) STATE BOATING AND WATER SAFETY LAWS ADOPTED. The statutory provisions describing and defining regulations with respect to water traffic, boats, boating and related water activities in the following enumerated sections of the Wisconsin statutes are hereby adopted and by reference made a part of this ordinance as if fully set forth herein. Any act required to be performed or prohibited by the provisions of any statute incorporated by reference herein is required or prohibited by this section 4.02.

30.50 Definitions

30.501 Capacity plates on boats

30.51 Certification of number and registration; requirements; exemptions

30.52 Certificate of number and registration; application; certification and registration period; fees; issuance

30.523 Certification or registration card to be on board; display of stickers or decals and identification number

30.541 Transfer of boat titles

30.55 Notice of abandonment or destruction of boat or change of address

30.60 Classification of motorboats

30.61 Lighting equipment

30.62 Other equipment

30.625 Rental of personal watercraft

30.64 Patrol boats

30.65 Traffic rules

30.66 Speed restrictions

30.67 Accidents and accident reports

30.675 Distress signal flag

30.68 Prohibited operation

30.681 Intoxicated boating

30.682 Preliminary breath screen test

30.683 Implied consent

30.684 Chemical tests

30.686 Report arrest to department

30.687 Officer's action after arrest for violating intoxicated boating law

30.69 Water skiing

30.70 Skin diving

30.71 Boats equipped with toilets

(4) SPEED RESTRICTIONS

(a) WITHIN TWO HUNDRED (200) FEET OF SHORELINE. A person operating a motorboat shall operate at slow-no-wake speed when within two hundred (200) feet of a shoreline.

(b) BOATS PASSING SWIMMERS, BOATS OR OTHER OBJECTS. A person operating a motorboat shall operate at slow-no-wake speed when within one hundred (100) feet of a swimmer, diving flag, canoe, rowboat, sail boat, non-operating motorboat or raft.

(c) AT NIGHT TIME. No person shall operate a motorboat at a high rate of speed from one hour after sunset each day until one hour before sunrise of the next day.

(d) OPERATION IN CIRCUITOUS COURSE. No person shall operate or use a motorboat or personal watercraft repeatedly in a circuitous course with a diameter of less than 200 feet at a speed in excess of slow-no-wake speed.

(5) SAFE OPERATION REQUIRED. No person shall operate, direct or handle a boat in such manner as to unreasonably annoy, unnecessarily frighten or endanger the occupants of his or other boats.

(6) RACING PROHIBITED. No person shall operate a motorboat in a race or speed contest with any other motorboat, except as provided in section 4.02(9).

(7) WATER SKIING.

(a) DISTANCE FROM SWIMMERS, BOATS OR OTHER OBJECTS. No person on water skis, aquaplane, surfboard or similar device shall pass, and no person operating a boat which is pulling or towing such skier or rider shall cause such skier or rider to pass within one hundred (100) feet of a swimmer, diving flag, canoe, row boat, sailboat, non-operating motorboat, raft or pier, except in the course of the skier or rider taking off from, or landing at, such pier.

(b) HOURS. No person shall operate a boat, while towing a person on water skis, aquaplane, surfboard or any similar device, at any time from sunset to sunrise.

(c) OCCUPANTS OF BOAT. No person shall operate a boat while pulling or towing any person on water skis, aquaplane, surfboard or any similar device, or permit himself to be towed for such purpose, unless there are two persons over 12 years of age in such boat, and the operator of the boat shall maintain a forward lookout.

(d) EXEMPTIONS FROM SPEED RESTRICTIONS. The following are exempt from the speed restrictions in section 4.02(4)(a): (i) a boat commencing to tow a person on water skis, aquaplane, surfboard or similar device, or landing such person, and (ii) a boat towing a water skier to make a jump over a ski jump platform anchored in the water within 200 feet from a shoreline, provided the location of such platform is approved in a permit issued therefore by the Chief of Police.

(8) ANCHORAGES AND STATIONARY OBJECTS.

(a) MOORING LIGHTS REQUIRED. No person shall moor or anchor any boat more than 100 feet from the shoreline between one hour after sunset and one hour before sunrise unless there is prominently displayed thereon a white light of sufficient size and brightness to be visible from any direction for a distance of 1500 feet on a dark night with clear atmosphere.

(b) RAFTS AND BUOYS. No person shall erect or maintain any raft, platform or buoy more than 100 feet from the shore unless it is so anchored that it has at least 10 inches of free board above the water line, and either (i) is painted white and has attached thereto not less than 12 inches from each corner or projection a red reflector in good condition not less than 3 inches in diameter, or (ii) is painted with a band at least three inches in width of luminous paint so as to be visible from any direction.

(9) RACES, REGATTAS, SPORTING EVENTS, EXHIBITIONS, COURSES AND JUMP PLATFORMS.

(a) PERMIT REQUIRED. No person shall direct or participate in any boat race, regatta, water ski meet, or other water sporting event or exhibition, nor shall any person set up or use a boat or waterski course or jump platform, unless such event, course or jump platform has been authorized and a permit issued therefor by the Chief of Police.

(b) PERMIT. A permit issued under this section shall specify the course or area of water to be used by the permittee for such event, course or jump platform and the permittee shall be required to place markers, flags or buoys approved by the Chief of Police designating the specified area. Any waterway markers authorized by the Chief of Police must meet the size and shape requirements as set forth in NR 5.09(7)(b), Wis. Adm. Code, or any successor thereto. Permits shall be issued only if in the opinion of the Chief the proposed use of the water can be carried out safely and without danger to or substantial obstruction of other watercraft or persons using the lake. Permits shall be valid only for the hours and areas specified thereon.

(c) RIGHT OF WAY PARTICIPANTS. Boats, waterskiers and participants in any such permitted event or who have received a permit to set up and use a boat or waterski course or jump platform shall have the right of way on the marked area and no other person shall obstruct such area during the race, event or other permitted use or interfere therewith.

(10) LITTERING WATERS PROHIBITED. No person shall deposit, place or throw any cans, paper, bottles, debris, refuse, garbage, solid or liquid waste into the water of, or upon the ice of, the lake.

(11) SPEAR GUNS. No person shall have in his possession any loaded spear gun.

(12) MARKERS AND NAVIGATION AIDS; POSTING ORDINANCE.

(a) DUTY OF CHIEF. The Chief of Police is authorized and directed to place and maintain suitable markers, navigation aids and signs in such water areas as shall be appropriate to advise the public of the provisions of this ordinance and to post and maintain a copy of this ordinance at all public access points within the jurisdiction of the village.

(b) STANDARD MARKERS. All markers placed by the Chief or any other person upon the waters of the lake shall comply with the regulations of the Wisconsin Department of Natural Resources.

(c) INTERFERENCE WITH MARKERS PROHIBITED. No person shall without authority remove, damage or destroy or moor or attach any watercraft to any buoy, beacon or marker placed in the waters of the lake by the authority of the United States, state or village or by any private person pursuant to the provisions of this ordinance.

(13) PENALTIES. Any person violating any provision of this Section 4.02 shall upon conviction thereof be subject to the penalties provided in Section 30.80 of the Wisconsin Statutes, which is hereby adopted and by reference made a part of this ordinance as if fully set forth herein, except that all references to fines are amended to forfeitures and all references to imprisonment deleted. Any violation of this Section 4.02 for which no specific penalty is provided in Section 30.80 of the Wisconsin Statutes shall be subject to the penalties provided in Section 30.80(1) of the Wisconsin Statutes.

4.03 BOATING - NORTH LAKE AND BEAVER LAKE.

(1) PURPOSE: The Town Board of the Town of Merton, and the Village Board of the Village of Chenequa, each being a municipality as defined in Chapter 30 of Wisconsin Statutes, and each having jurisdiction of a portion of North Lake and Beaver Lake, both being inland lakes, located in Waukesha County, do ordain jointly and identically in conformity with sections 30.77 and 30.81 of the Wisconsin Statutes, as follows:

(2) INTENT. The intent of this ordinance is to provide safe and healthful conditions for the enjoyment of aquatic recreation consistent with public rights and interest and the capability of the water resource.

(3) APPLICABILITY AND ENFORCEMENT. The provisions of this Ordinance shall apply to the waters of North Lake and Beaver Lake, within the jurisdiction of the Town of Merton and Village of Chenequa. The provisions of this ordinance shall be enforced by the officers of the Water Safety Patrol of the Town of Merton and/or the Village of Chenequa.

(4) STATE BOATING AND WATER SAFETY LAWS ADOPTED. The statutory provisions describing and defining regulations with respect to water traffic, boats, boating and related water activities and safety in the following enumerated sections of the Wisconsin Statutes, exclusive of any provisions therein relating to the penalties to be imposed or the punishment for violation of said statutes, are hereby adopted and by reference made a part of this ordinance.

30.50 Definitions

30.51 Operation of unnumbered motorboats prohibited

30.52 Certificate of number

30.523 Identification number to be displayed on boat; certificate to be carried

30.541 Transfer of ownership of numbered boat

30.55 Notice of abandonment or destruction of boat or change of address

30.60 Classification of motorboats

30.61 Lighting equipment

30.62 Other equipment

30.635 Motorboat prohibition

30.64 Patrol boats exempt from certain traffic regulations

30.65 Traffic rules

30.66 Speed restrictions

30.67 Accidents and accident reports

30.675 Distress signal flag

30.68 Prohibited operation

30.681 Intoxicated boating

30.682 Preliminary Breath Screening Test

30.683 Implied Consent

30.684 Chemical Tests

30.686 Report Arrest to Department

30.687 Officers Action After Arrest for Violating 30.681

30.69 Water skiing

30.70 Skin diving

30.71(1) Boats equipped with toilets

All deletions, additions and amendments which may be made to the sections of the state laws enumerated under subsection 4.03(4) above are hereby adopted and incorporated herein by reference as of the time of their respective effective dates, as if they were to be set out herein verbatim.

(5) DEFINITIONS.

(a) “Swimming zone” means an authorized area marked by regulatory markers to designate a swimming area.

(b) “Designated anchorage” means an area of water established and marked as an anchorage by lawful authority.

(c) “Public access’ means any access to the water by means of public property.

(d) “Navigation lane” means an area designated by authorized aids to navigation.

(e) “Slow-no-wake” is defined as the slowest possible speed so as to maintain steerage.

(6) SPEED RESTRICTIONS.

(a) NIGHT LIMIT. No person shall operate a boat at a speed in excess of slow-no-wake speed from one hour after sunset each day until one hour before sunrise of the next day.

(b) SPEED LIMIT -MAXIMUM. No person shall operate a boat at a speed in excess of 35 miles per hour on North Lake at any time.

(c) SPEED LIMIT - TURTLE BAY OF BEAVER LAKE. No person shall operate a boat at a speed in excess of slow-no-wake or at any time to exceed a maximum speed of three (3) miles per hour in Turtle Bay.

(d) OPERATION IN CIRCUITOUS COURSE. No person may operate or use a motor boat or personal watercraft repeatedly in a circuitous course with a diameter of less than 200 feet at a speed in excess of slow-no-wake speed.

(7) PROHIBITED OPERATION. INTOXICATED PERSON NOT TO RIDE IN BOATS. No person shall permit any person who is so intoxicated or under the influence of a controlled substance who would be unable to provide for his own safety, to be a passenger in a boat operated by him, except in a case of emergency.

(8) CAPACITY RESTRICTIONS. No person shall operate or loan, rent or permit a boat to leave the place where it is customarily kept for operation on the waters covered by this ordinance with more passengers or cargo than a safe load.

(9) STATIONARY OBJECTS.

(a) REFLECTORS REQUIRED. All piers, rafts, ski jumps or other stationary objects, extending into and/or located upon the waters covered by this ordinance, shall have red reflector signals on each side thereof and in the case of piers, such reflectors shall not be less than three (3) feet from the outer limits thereof and shall be at least three (3) inches in diameter.

(b) RAFTS. No person shall erect or maintain any raft or platform more than 100 feet from the shore unless it is so anchored that it has at least 10 inches of free board above the waterline, and either (i) is painted white and has attached thereto on each side above the waterline one or more reflectors in good condition not less than 3 inches in diameter, or (ii) is painted with a band at least three (3) inches in width of luminous paint so as to be visible from any direction.

(c) PERMITS REQUIRED. No water ski jump shall be placed upon the waters covered by this ordinance at any time unless a permit is obtained from the Water Safety Patrol. No raft or other stationary object shall be placed more than 100 feet from the shore unless a permit is obtained from the Water Safety Patrol.

(d) A permit issued under this section shall specify the location of the ski jump, raft or other structure, and in the case of ski jumps, the area of water to be used by users of such jump. Permits shall be issued only if in the opinion of the Water Safety Patrol, the proposed use of the water and location of the structure is such so as not to interfere with or obstruct navigation and other uses of the water.

(10) SAFE OPERATION REQUIRED. No person shall operate, direct or handle a boat in such manner as to unreasonably annoy, unnecessarily frighten or endanger the occupants of his or other boats.

(11) SWIMMING REGULATIONS. Any persons swimming more than 150 feet from the shoreline of the lakes covered by this ordinance and more than 50 feet from a diving raft anchored more than 100 feet from the

shoreline of said lakes shall be accompanied by a boat for the protection of the swimmer and as an aid to other boats in determining the location of the swimmer and such swimmer shall be not more than 50 feet from the boat accompanying him.

(12) LITTERING AND POLLUTING PROHIBITED. No persons shall deposit, place or throw from any boat, raft, pier, platform or similar structure or from the shore, any cans, paper, bottles, debris, refuse, garbage, solid or liquid waste, into the water.

(13) RACES, REGATTAS, SPORTING EVENTS AND EXHIBITIONS.

(a) PERMIT REQUIRED. No person shall direct or participate in any boat race, regatta, water ski meet or other water sporting events or exhibition unless such event has been authorized and a permit issued therefor by the Water Safety Patrol.

(b) PERMIT. A permit issued under this section shall specify the course of area or water to be used by participants in such event and the permittee shall be required to place markers, flags or buoys approved by the Water Safety Patrol, designating the specified area. Permits shall be issued only if in the opinion of the Water Safety Patrol, the proposed use of the water can be carried on safely and without danger to or substantial obstruction of other watercraft or persons using the lakes. Permits shall be valid only for the hours and area specified thereon.

(c) RIGHT-OF-WAY OF PARTICIPANTS. Boats and participants in any such permitted events shall have the right-of-way on the marked area and no other person shall obstruct such area during the race or event or interfere therewith.

(14) WATER SKIING.

(a) HOURS. No person shall water ski and no person shall operate a boat while towing a person on water skis aquaplane, surfboard or any similar device at any time between sunset of any day and 9:00 A.M. of the following day.

(b) All persons water skiing, aquaplaning, surfboarding or using any similar device must wear a personal flotation device.

(c) No persons shall water ski and no person shall operate a boat while towing a person on water skis, aquaplane, surfboard or any similar device on North Lake unless in a counter-clockwise direction. This restriction shall not apply to the operator of a boat attempting to pick up a skier who has fallen.

(d) No person shall tow another who is either barefoot or on water skis, aquaplane, kneeboard or other similar device, nor shall any person tow another on tubes, torpedoes or other similar inflated appliances, unless such person is wearing a Coast Guard approved personal flotation device or a wetsuit having flotation capabilities.

(15) MARKERS AND NAVIGATION AIDS: POSTING ORDINANCE.

(a) The Water Safety Patrol is authorized and directed to place and maintain suitable markers, navigation aids and signs in such water areas as shall be appropriate to advise the public of the provisions of this ordinance and to post and maintain a copy of this ordinance at all public access points on waters covered by this ordinance.

(b) STANDARD MARKERS. All markers placed by the Water Safety Patrol or any other person upon the waters covered by this ordinance shall comply with the regulations of the Department of Natural Resources.

(c) INTERFERENCE WITH MARKERS PROHIBITED. No person shall without authority remove, damage or destroy or moor or attach any watercraft to any buoy, beacon, or marker placed on the waters of any lake covered by this ordinance, by the authority of the United States, State, County or Town or by any private person, pursuant to the provisions of this ordinance.

(16) PENALTIES AND DEPOSITS.

(a) Any person violating any provision of this section 4.03 for which a penalty is not provided by subsection (b) below shall, upon conviction thereof, forfeit not more than Fifty ($50) Dollars together with the cost of prosecution and in default of payment of such forfeiture and costs, shall be imprisoned in the county jail until full payment thereof is made, but not to exceed thirty (30) days.

(b) Any persons violating subsection 30.67(1) or 30.68(1), adopted by reference in subsection 4.03(4) of this ordinance, shall, upon conviction thereof, forfeit not more than Two Hundred ($200) Dollars, together with the cost of prosecution and in default of such forfeiture and costs, shall be imprisoned in the county jail until full payment thereof is made, but not to exceed sixty (60) days.

(c) Any person violating sections 30.681 or 30.684(5) of the Wisconsin Statutes, as adopted by this ordinance, shall, upon conviction thereof, forfeit not less than $150 nor more than $300 together with the costs of prosecution and in default of such forfeiture and costs, shall be imprisoned in the county jail until full payment thereof is made, but not to exceed 60 days. In addition to any penalty, the court shall enter the orders required by subsections 30.80(6)(d) and (e) of the Wisconsin Statutes.

(d) MONEY DEPOSITS. Any officer arresting a person for violation of a provision of this ordinance who is unable to bring the person arrested before the proper court without unnecessary delay shall permit such person to make a money deposit as provided in section 30.76 of the Wisconsin Statutes. Such deposit shall be made to whom and at the office designated by the Water Safety Patrol Officer.

(17) WISCONSIN STATUTES DEFINED. Whenever used in this Ordinance the term “Wisconsin Statutes” shall mean the Wisconsin Statutes of 1973 and all amendments thereof.

(18) REPEAL OF CONFLICTING ORDINANCES. All ordinances regulating water traffic, boats, boating or water sports upon the waters covered by this ordinance and all ordinances or parts of ordinances in conflict with this ordinance, heretofore enacted by the Town Board of the Town of Merton and the Village Board of the Village of Chenequa, are hereby repealed.

(19) SEVERABILITY. The provisions of this ordinance shall be deemed severable and it is expressly declared that the Town Board of the Town of Merton and the Village Board of the Village of Chenequa would have passed the other provisions of this ordinance irrespective of whether or not one or more provisions may be declared invalid and if any provisions of this ordinance or the application thereof to any person or circumstances is held invalid, the remainder of the ordinance and the application of such provisions to other persons or circumstances shall not be affected thereby.

4.04 AUTOMOBILES AND TRUCKS ON NORTH LAKE.

(1) The Town Board of the Town of Merton and the Village Board of the Village of Chenequa, each being a municipality as defined in Chapter 30 of the Wisconsin Statutes, and each having jurisdiction of a portion of North Lake, an inland lake located in Waukesha County, do ordain jointly and identically in conformity with §30.77 and §30.81, Stats., as follows:

(2) No person shall operate or park or permit to be operated or parked any automobile or truck upon the ice of North Lake.

(3) The definitions contained in Chapter 340 and any amendments thereto are hereby incorporated by reference as if fully set forth herein.

(4) Any person violating any provision of this ordinance shall, upon conviction thereof, forfeit an amount set forth in the general penalties section of the General Code of Ordinances of the Town of Merton and the Municipal Code of the Village of Chenequa.

(5) All ordinances or parts of ordinances contravening or inconsistent with the provisions of this ordinance be and they are hereby repealed.

(6) Should any section, clause or provision of this ordinance be declared to be invalid, the same shall not affect the validity of the ordinance as a whole or any part thereof, other than the part so declared to be invalid.

4.05 OPERATION AND PARKING OF MOTOR VEHICLES ON ICE – CORNELL LAKE.

(1) PURPOSE. The Village Board of the Village of Chenequa determine and declare it to be in the interest of the public health, safety and welfare to prohibit the use, operation and parking of motor and other motorized vehicles, including without limitation snowmobiles, on the ice surface of Cornell Lake in the Village of Chenequa.

(2) PROHIBITING USE AND PARKING OF MOTORIZED VEHICLES. No person shall use, operate or park a motor or other motorized vehicle, including without limitation snowmobiles, on the ice surface of Cornell Lake in the Village of Chenequa.(5/10/93)

4.06 REGULATION OF USE OF PINE LAKE PUBLIC BOAT ACCESS FACILITY.

(1) FACILITY HOURS. The public boat access facility located on Pine Lake in the Village of Chenequa (the “Facility”) shall be open from 6:00 A.M. to 10:00 P.M., except on the general fishing opening weekend when the Facility shall be open on that first Saturday and Sunday from 4:00 A.M. to midnight. No boat or equipment incident to navigation (hereinafter referred to collectively as “boat”) may be launched during a time the Facility is not open, but a boat on the lake at the applicable closing time may be retrieved from the lake after such closing time and a vehicle in the designated parking area at such closing time may remain there until the boat transported by such vehicle is retrieved. Except as set forth above, no person shall enter or remain on the Facility premises and no parking shall be allowed on the Facility premises at a time when the Facility is not open.

(2) USE OF PUBLIC LAUNCH SITE RESTRICTED. No person shall launch a boat from the Facility launch site unless (a) at the time of such launching, there is an available parking place in the designated parking area for the vehicle which transported the boat and (b) such vehicle is then parked in a parking place in the designated parking area; provided, however, to assure that parking in the designated parking area is limited to the general public, no owner or tenant of property on Pine Lake shall be required or permitted to park in the designated parking area after launching a boat owned by such person at the Facility’s launch site.

(3) USE OF PARKING AREA RESTRICTED. A person shall only park a vehicle in the Facility’s designated parking area provided that:

(a) the vehicle is being used to transport a boat for use on Pine Lake or to transport persons for the purposes incident to navigation on Pine Lake,

(b) the person remains in the Facility or upon Pine Lake the entire time the vehicle remains in the designated parking area,

(c) the vehicle is parked in a marked parking place in the Facility’s designated parking area, and

(d) each parking stall contains no more than one (1) vehicle and one (1) trailer.

(4) USE OF FACILITY RESTRICTED. The Facility shall be used only for the launching of boats on Pine Lake and for providing access for purposes incident to navigation on Pine Lake and for parking associated therewith.

The Facility shall not be used for fishing, hunting, camping, picnicking, swimming, sunbathing, fish cleaning, maintenance of boats and/or motors or for other recreational purposes not expressly permitted above, or sales of products and services except for collection of fees for launching of boats and parking.

(5) PARKING FEES. Fees for parking of vehicles and vehicles with trailers at the Facility's designated parking area may be charged by the Village in amounts determined from time to time by the Village Board of the Village, but in no event shall such fees exceed the fees permitted under Sections NR 1.91 through 1.93 of the Wisconsin Administrative Code.

(6) PENALTY. Any person found guilty of a violation of any of the terms or provisions of this ordinance shall be subject to a fine of not less than $20.00 and not more than $200.00 for each violation.

(7) These Code provisions shall be in full force and effect upon the opening of Facility, as determined by the President of the Village of Chenequa, and publication as provided by law.

4.07 OPERATION AND PARKING OF MOTOR VEHICLES ON ICE -PINE LAKE.

(1) PURPOSE. The Village Board of the Village of Chenequa determine and declare it to be in the interest of the public health, safety and welfare to prohibit the use, operation and parking of motor and other motorized vehicles, including without limitation snowmobiles, on the ice surface of Pine Lake in the Village of Chenequa.

(2) PROHIBITING USE AND PARKING OF MOTORIZED VEHICLES. No person shall use; operate or park a motor or other motorized vehicle, including without limitation snowmobiles, on the ice surface of Pine Lake in the village of Chenequa.

4.08 MARINE REFUELING SERVICES.

(1) PURPOSE. The Village Board of the Village of Chenequa shall determine and declare that certain regulations and restrictions will be placed upon entities engaged in marine refueling services on the waterways of Pine Lake.

(2) PERMITTING. The permitting process to conduct marine refueling services will be administered by the Village of Chenequa Administrator and/or Village of Chenequa Police Department. Permits will be considered and issued on an annual basis. All permits will expire no later than the last day of each year.

(3) APPLICABILITY. The provisions of this section shall apply to the waterways of Pine Lake within the jurisdiction of the Village of Chenequa.

(4) LIMITATIONS/RULES OF APPROVAL. Any and all portions of this section shall function as the conditions of approval for permit(s) that could be granted by the Village Administrator and/or the Board of the Village of Chenequa in regard to marine refueling services along with such other conditions as the Village Administrator deems appropriate to carry out the purpose of this section including a reasonable permit fee. A violation of any portion of this section is considered material and could result in the revocation of a permit already granted under this section or the denial of a permit under this section.

(5) RULES OF OPERATION. Persons operating marine refueling services must comply with the following minimum requirements:

(a) Refueling services are restricted from being offered on weekends and holidays.

(b) Refueling services can only be offered from May 1 through September 30 of each year.

(c) A marine refueling service shall only make one round trip around Pine Lake per day.

(d) Refueling services shall operate from sunrise to no later than 3:00 p.m.

(e) Any marine craft used for refueling services shall be trailored at all times when not in use.

(6) WATER CRAFT LIMITATIONS. Water crafts under this section must comply with the following limitations:

(a) Water craft used for refueling services shall not exceed twenty-one (21) feet.

(b) Water craft used for refueling services shall be equipped with a seventy five foot long hose on a reel.

(c) Water craft used for refueling services shall be equipped with an electric fuel transfer pump.

(d) Water craft used for refueling services shall be equipped with an automatic shutoff nozzle.

(e) Water craft used for refueling services shall comply with all relevant requirements by applicable state and federal rules and regulations.

(7) SAFETY REQUIREMENTS. Persons operating marine refueling services shall observe the following minimal safety requirements:

(a) Persons operating marine refueling services shall adhere to all federal, state, county and local laws and ordinances when conducting marine refueling services within the jurisdiction of the Village of Chenequa.

(b) Any water craft used for refueling services shall operate within fifty (50) feet of the shoreline, at slow-no-wake speeds.

(c) Any water craft used for refueling services shall operate in no-wake zones.

(d) Refueling services shall not operate during weekends or holidays.

(e) Any water craft used for refueling services shall not be left unattended.

(f) All refueling equipment used by marine refueling services shall comply with all requirements and codes set forth by all relevant state and federal agencies.

(g) Any and all efforts shall be made by persons operating marine refueling services to prohibit or inhibit the spread of zebra mussels and Eurasian milfoil or other hazardous nuisance as determined by the Village Board.

(h) No fuel spills will be tolerated and could result in an immediate termination of a license which allows for marine refueling services.

(i) Any person operating a water craft used for marine refueling services must be at least twenty-one (21) years of age.

(j) Any water craft used by marine refueling services shall be primarily powered by two motors of equal power to aid in the maneuverability of the marine water craft.

(k) All operators of water craft used by marine refueling services shall be trained in regard to operating and emergency response procedures.

(l) Any water craft used by marine refueling services shall be equipped with proper on-board fire protection.

(m) The design and operation of any marine refueling service shall be in accordance with any and all information provided by the Wisconsin Department of Commerce.

(n) Refueling of any water craft used for marine refueling shall not take place through the use of a secondary fuel source within the Village of Chenequa.

(o) Marine refueling services shall be prohibited from operation if: (i) winds on Pine Lake exceed twenty (20) miles per hour; or (ii) a severe weather alert has been issued.

(p) Services shall not take place on those days when an organized outing is taking place and lake traffic is generally restricted.

(8) INSURANCE. Before commencing any services, any operator of a marine refueling service must present to the Village Administrator: a specific insurance policy which provides coverage for spills and environmental cleanup costs, property damage (through collision, fire, explosion, environmental) and personal injury; and proof that the coverage shall be in effect at all times, regardless of whether the marine refueling water craft is in the water, in transport or in storage.