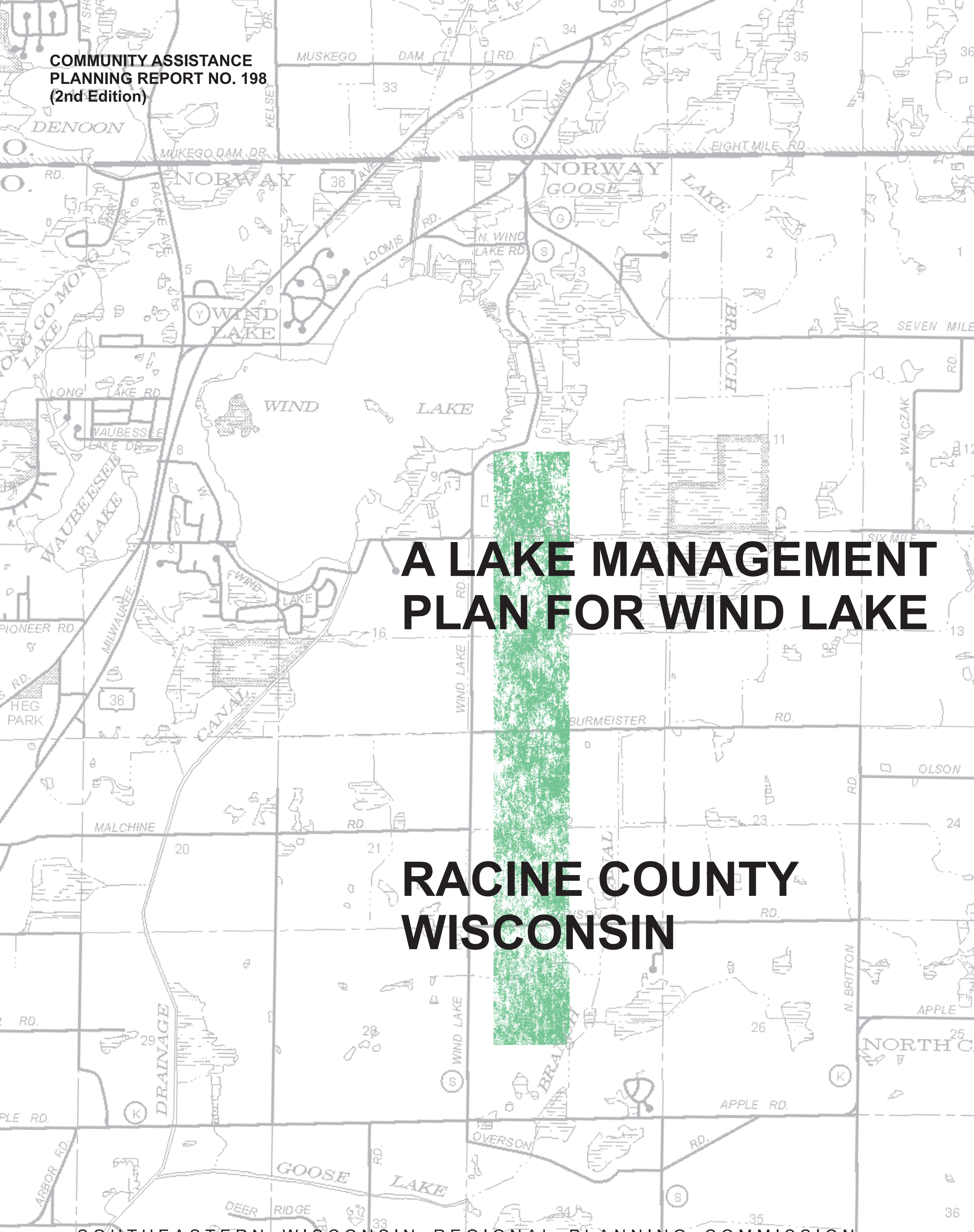
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 198
(2nd Edition)

A LAKE MANAGEMENT PLAN FOR WIND LAKE

RACINE COUNTY WISCONSIN



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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A LAKE MANAGEMENT PLAN FOR WIND LAKE
RACINE COUNTY, WISCONSIN

Prepared by the

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

Chapter IV

Chapter V

Chapter VI

Chapter VII

Chapter VIII

LIST OF FIGURES

LIST OF MAPS

Chapter I

INTRODUCTION

Wind Lake is a 936-acre through-flow lake, situated within U.S. Public Land Survey Sections 3, 4 8, 9, 10, 16, and 17, Township 4 North, Range 20 East, in the Town of Norway, Racine County, Wisconsin. The Lake drains to the Wind Lake Drainage Canal, which, in turn, drains to the Fox (Illinois) River and, ultimately, to the Mississippi River. The Lake offers a variety of water-based recreational opportunities to the Southeastern Wisconsin Region, and is the focus of a lake-oriented community surrounding the Lake. In recent decades, concerns over issues such as excessive aquatic plant growth, recreational use conflicts, water quality-related use limitations, and aesthetic degradation have led to the community initiating actions to protect and rehabilitate the lake environment. These actions have included the formation of a Chapter 33, *Wisconsin Statutes*, public inland lake protection and rehabilitation district serving the Wind Lake community. This District, in partnership with the Wisconsin Department of Natural Resources (WDNR) and other governmental and nongovernmental agencies, has undertaken an active program of lake management within Wind Lake and its drainage area.

Wind Lake has been the subject of various reports and plans, including a WDNR lake use report,[1] a U.S. Geological Survey (USGS) Water-Resources Investigations Report,[2] and a nonpoint source pollution abatement priority lakes plan.[3] During 1991, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) completed a lake management plan for Wind Lake,[4] the essential elements of which were included within and derived from the regional water quality management plan.[5] The lake management plan elaborated the water quality concerns identified in the regional water quality management plan, quantifying the surface water quality problems, identifying the major sources of impairment, and providing recommendations for abating those sources

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[1]*Wisconsin Department of Natural Resources Lake Use Report FX-5,* Wind Lake, Racine County, Wisconsin, *1969.*

[2]*U.S. Geological Survey Water-Resources Investigations Report 91-4107,* Hydrology and Water Quality of Wind Lake in Southeastern Wisconsin, *1993.*

[3]*Wisconsin Department of Natural Resources Publication No. WR-375-94,* Nonpoint Source Control Plan for the Muskego-Wind Lakes Priority Watershed Project*, October 1993.*

[4]*SEWRPC Community Assistance Planning Report No. 198,* A Management Plan for Wind Lake, Racine County, Wisconsin*, December 1991.*

[5]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *volume Two*, Alternate Plans, *February 1979; see also, SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

over time. Implementation of the recommended actions has contributed to the achievement of specific water use objectives and attendant water quality standards in the lake. Nevertheless, changing conditions within the drainage area tributary to the Lake and emerging threats to the continued maintenance of in-lake water quality, led the Wind Lake Management District (WLMD), during 2003, to request the assistance of SEWRPC in the conduct of the planning studies leading to the preparation of a second edition lake management plan for Wind Lake. This plan is the result of that request.

This refined lake management plan represents part of the ongoing commitment of the WLMD to sound planning with respect to the Lake, and forms a logical complement to the lake management actions that have been implemented on and around Wind Lake. The current plan was prepared by the Regional Planning Commission in cooperation with the WLMD, and incorporates the data and analyses developed in the aforementioned lake management-related studies as well as pertinent water quality and other data gathered by the USGS, the WDNR, and private consultants working under contract to the District. This report updates, refines, and presents feasible alternative measures for enhancing water quality conditions and providing opportunities for the safe and enjoyable use of the Lake. More specifically, this report describes the physical, chemical, and biological characteristics of the Lake, pertinent related characteristics of the tributary area, and the feasibility of various tributary area and in-lake management measures which may be applied to enhance the water quality conditions, biological communities, and recreational opportunities of the Lake.

The primary management objectives for Wind Lake include: 1) provision of water quality conditions suitable for the maintenance of fish and other aquatic life, 2) reduction of the severity of existing concerns resulting from, among others, excessive macrophyte and algal growth and limited water clarity which constrain or preclude intended water uses, and 3) improvement of opportunities for the conduct of water based recreational activities. This refined management plan should constitute a practical guide for the continuing management of the water quality of Wind Lake and for the management of the land surfaces which drain to this important body of water.

Chapter II

PHYSICAL DESCRIPTION

INTRODUCTION

The physical characteristics of a lake and its tributary area are important factors in any evaluation of existing and likely future water quality conditions and lake uses, including recreational uses. Characteristics, such as tributary area topography, lake morphometry, and local hydrology, ultimately influence water quality conditions and the composition of plant and fish communities within the Lake. These characteristics must be considered during the lake management planning process. Accordingly, this chapter provides pertinent information on the physical characteristics of Wind Lake, its tributary area, and on the climate and hydrology of the Wind Lake tributary area that create the foundation for possible interventions designed to maintain the Lake in a fishable and swimmable condition, the stated goal of the Federal Clean Water Act. Subsequent chapters deal with the land use conditions, and the chemical and biological environments of the Lake, that further form the basis for lake management actions.

WATERBODY CHARACTERISTICS

Wind Lake is located entirely in the Town of Norway, in Racine County, as shown on Map 1. Wind Lake is a drainage or through flow lake—having both a defined inflow and outflow—with a single distinct basin. The lake level is presently controlled artificially by a dam located at the outlet. There are two islands on the Lake: one on the western side of the main basin, and the other immediately north of the main basin.

Wind Lake lies in a preglacial erosion valley and is fed by inflow from the Muskego Canal, which enters at the northern side of the Lake. The Lake is drained by the Wind Lake Drainage Canal located on the southern side of the Lake. This outlet canal flows about 7.1 miles to its confluence with the Fox (Illinois) River. The lake basin originally was formed as a consequence of the retreat of continental glacier at the end of the Wisconsin stage of glaciation, approximately 12,500 years ago. The lake level was controlled naturally until about 1887, when work on a drainage canal began that would act to lower the level of Wind Lake by approximately four feet in order to expand the area available for cultivation. A second dredging of the Muskego Canal (inflow) and the Wind Lake Drainage Canal (outflow) during the 1890s lowered the lake surface elevation by a further four feet. Subsequently, local farmers, in an effort to restore the Lake to its pre-second-dredging level, constructed a rough stone dam across the Wind Lake Drainage Canal; however, this impoundment proved to be ineffective in raising the lake level, and this dam was replaced in 1903 by a concrete dam. The concrete dam accomplished the purpose of bringing the lake level back to its pre-second-dredging level, although it proved inadequate for controlling flood conditions. Consequently, this dam was replaced in 1973 by a new, 30-foot-wide broad-crested concrete dam, containing two 10-foot-wide Tainter gates, built by the Town of Norway.[1] The Tainter gates can be raised

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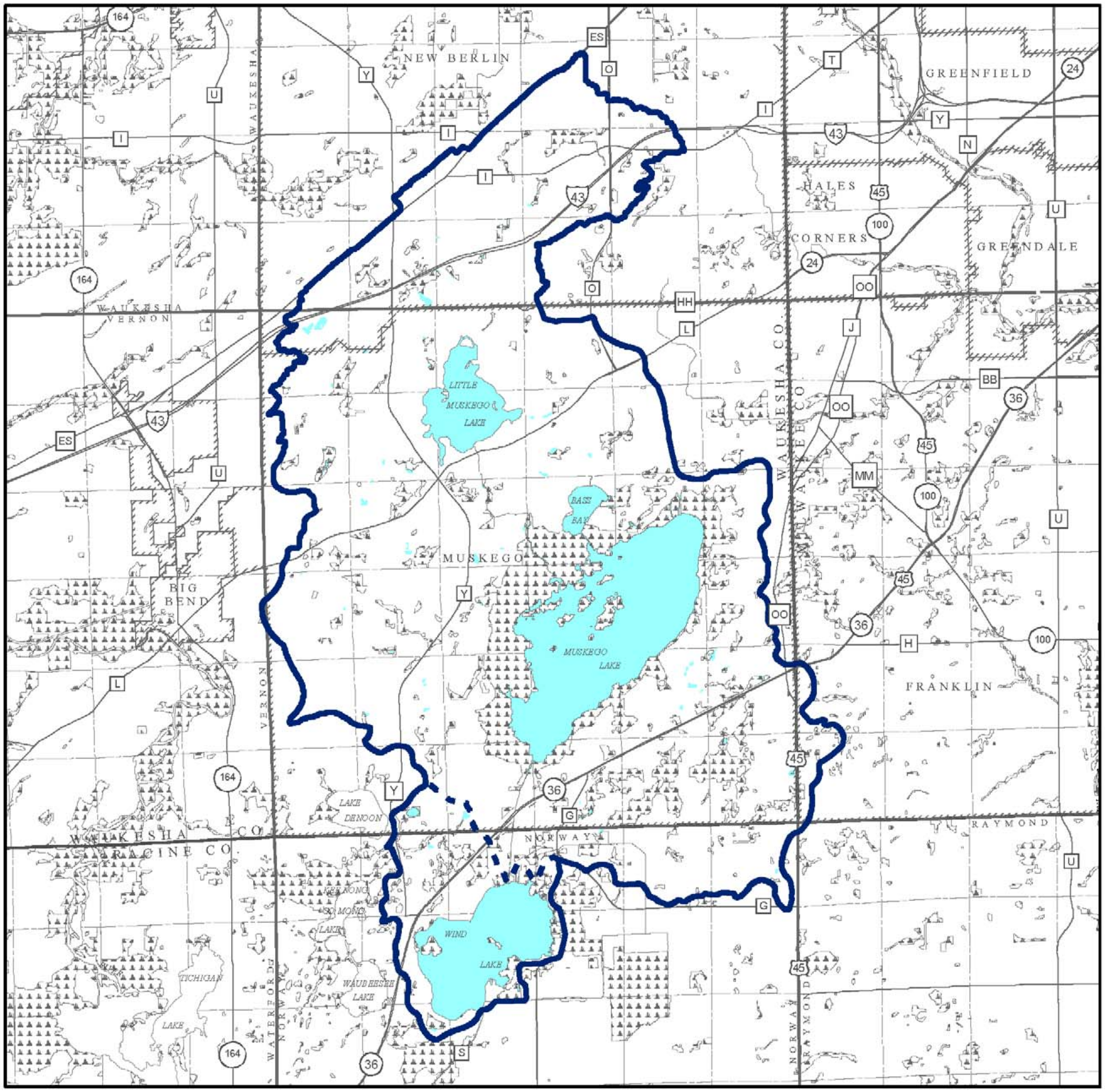
[1]*Wisconsin Department of Natural Resources, "Inspection Report for the Wind Lake Dam," Field File #51.06, dated June 25, 2007; the Wind Lake dam was found to be generally "in good condition." The dam is owned by Racine County and operated by the Racine County Public Works Department.*

Map 1

LOCATION OF WIND LAKE



Surface Water

Streams

Total Tributary Area Boundary

Direct Tributary Area Boundary

Source: SEWRPC.

N

0 1 2 3 4

Miles

manually to control high water levels, and have proven to be very effective for flood control. The present lake level is controlled by the 1973 dam at the outlet of the Lake to the Wind Lake Drainage Canal. The dam crest is at 768.44 feet above mean sea level.[2]

Wind Lake has a surface area of 936-acres, with a maximum depth of 52 feet and a mean depth of about 10 feet. Approximately 32 percent of the lake area is less than three feet deep, and about 15 percent of the lake area has a water depth of more than 20 feet. Wind Lake is 1.9 miles long and 1.1 miles wide at its widest point. The major axis of the Lake lies in a northeasterly-southwesterly direction. The lake shoreline is 9.3 miles long, with a shoreline development factor of 2.17, indicating that the shoreline is about 2.17 times longer than a circular lake of the same area. This somewhat large shoreline development factor indicates a fairly irregular shoreline, a feature enhanced by the presence of a number of constructed boat channels located along the eastern shoreline of the Lake as well as by the additional shoreline provided by the two small islands. The Lake has a total volume of approximately 8,995 acre-feet.[3] The hydrographical and morphometric data are presented in Table 1, and the bathymetry of the Lake is shown on Map 2.

The shoreline of Wind Lake is mostly developed for residential uses, with some scattered commercial uses comprised primarily of restaurants and businesses catering to lake users. In the 1993 USGS study, it was estimated that about 370 homes were in existence within 300 feet of the shoreline at that time, reinforcing the appraisal of Wind Lake being a relatively densely developed lake.[4] Nevertheless, several significant wetland areas occur along the lake shoreline: four along the eastern shoreline, one along the western shoreline adjacent to the larger island, and on the two islands themselves. There is no public beach, although a public recreational boating access, owned and operated by the Wisconsin Department of Natural Resources (WDNR), is located at the southwestern end of the Lake.

Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with recreational access and lake use. Such erosion is usually caused by wind-wave erosion, ice movement, and wakes from motorized boat traffic. In the initial SEWRPC study, a total of 133 shoreline protection structures were noted as being present along the Wind Lake shoreline with bulkheads constituting 47 percent of the total structures, revetments, 46 percent, and beaches, the remaining 7 percent. A survey of Wind Lake shoreline, conducted during the summer of 2005 by SEWRPC staff, indicated few changes in these shoreline structures. As during 1990, most of the developed shoreland of Wind Lake continued to have some form of shoreline protection during 2005. The existing shoreline protection structures around the Lake as of 2005 are shown on Map 3. Most were in a good state of repair. However, improperly installed and failing shoreline protection structures and the erosion of natural shorelines on Wind Lake, remain a limited cause for concern.

Lake bottom sediment types reported in the initial SEWRPC study consisted mainly of soft sediments, muck and marl, covering about 44 percent and about 42 percent of the bottom, respectively, with sand covering about a further 11 percent of the bottom and gravel covering the remaining 3 percent of the bottom, as shown on Map 4. It also was noted that small areas of peat were present. The WDNR noted that a lake with an unimpeded length of water over which wind could blow, or "fetch," of 1.9 miles could potentially experience wind waves with a maximum wave height of 1.9 feet. Waves of such amplitude would affect substrate to a maximum depth of four

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[2]*SEWRPC Community Assistance Planning Report No. 198,* A Management Plan For Wind Lake, Racine County, Wisconsin, *December 1991.*

[3]*Wind Lake was resurveyed during 1996 by the Wind Lake Management District; modifications in bathymetry related primarily to alterations in the lake surface datum from which water depth was assessed.*

[4]*U.S. Geological Survey Water-Resources Investigations Report 91-44107,* Hydrology and Water Quality of Wind Lake in Southeastern Wisconsin, *1993.*

Table 1

HYDROLOGY AND MORPHOMETRY CHARACTERISTICS OF WIND LAKE: 2005

Parameter	Measurement
Size (total)	
Surface Area	936 acres
Total Tributary Area	25,379 acres
Direct Tributary Area	1,460 acres
Volume	8,995 acre-feet
Residence Time[a]	0.6 year
Shape	
Maximum Length of Lake	1.9 miles
Maximum Width	1.1 miles
Length of Shoreline	9.3 miles
Shoreline Development Factor[b]	2.17
Depth	
Area of Lake Less than Three Feet	32 percent
Area of Lake Greater than 20 Feet	15 percent
Mean Depth	9.6 feet
Maximum Depth	52 feet

NOTE: Differences between measurements appearing in this table and those presented in the initial report are due to refinements in determining tributary area boundaries.

[a] *Residence Time: Time required for a volume equivalent to the full volume of the lake to enter the lake from the drainage area.*

[b] *Shoreline Development Factor: Ratio of shoreline length to that of a circular lake of the same area.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

feet, below which the natural sorting of bottom materials would not occur.[5] In Wind Lake, the effect of such wind-induced sorting is that sand and gravel predominate in the wave-washed areas of the shoreline, while muck and marl predominate in the protected bays.

TRIBUTARY AREA CHARACTERISTICS

The area tributary to Wind Lake, that is, the area which drains directly into the Lake, was determined to total about 25,380 acres, or 39.6 square miles, in areal extent, as shown on Map 1. This gives Wind Lake a tributary area-to-lake area ratio of about 27 to 1.[6] Wind Lake is fed by the Muskego Canal, entering the Lake from the north; the lake outlet, located on the southern shoreline, is the Wind Lake Drainage Canal which flows approximately 7.1 miles to the south and southwest before joining the Fox (Illinois) River in the Village of Rochester.

Soil Types and Conditions

Soil type, land slope, and land use are among the more important factors determining lake water quality conditions. Soil type, land slope, and vegetative cover are also important factors affecting the rate, amount, and quality of stormwater runoff. The texture of different soil types and the structure of soil particles influence the permeability, infiltration rate, and erodibility of soils. Land slopes are important determinants of stormwater runoff rates and of the susceptibility of soils to erosion. The erosivity of the runoff can be moderated or modified by vegetation. Soil types and land slope are discussed immediately below; land use is discussed in Chapter III of this report.

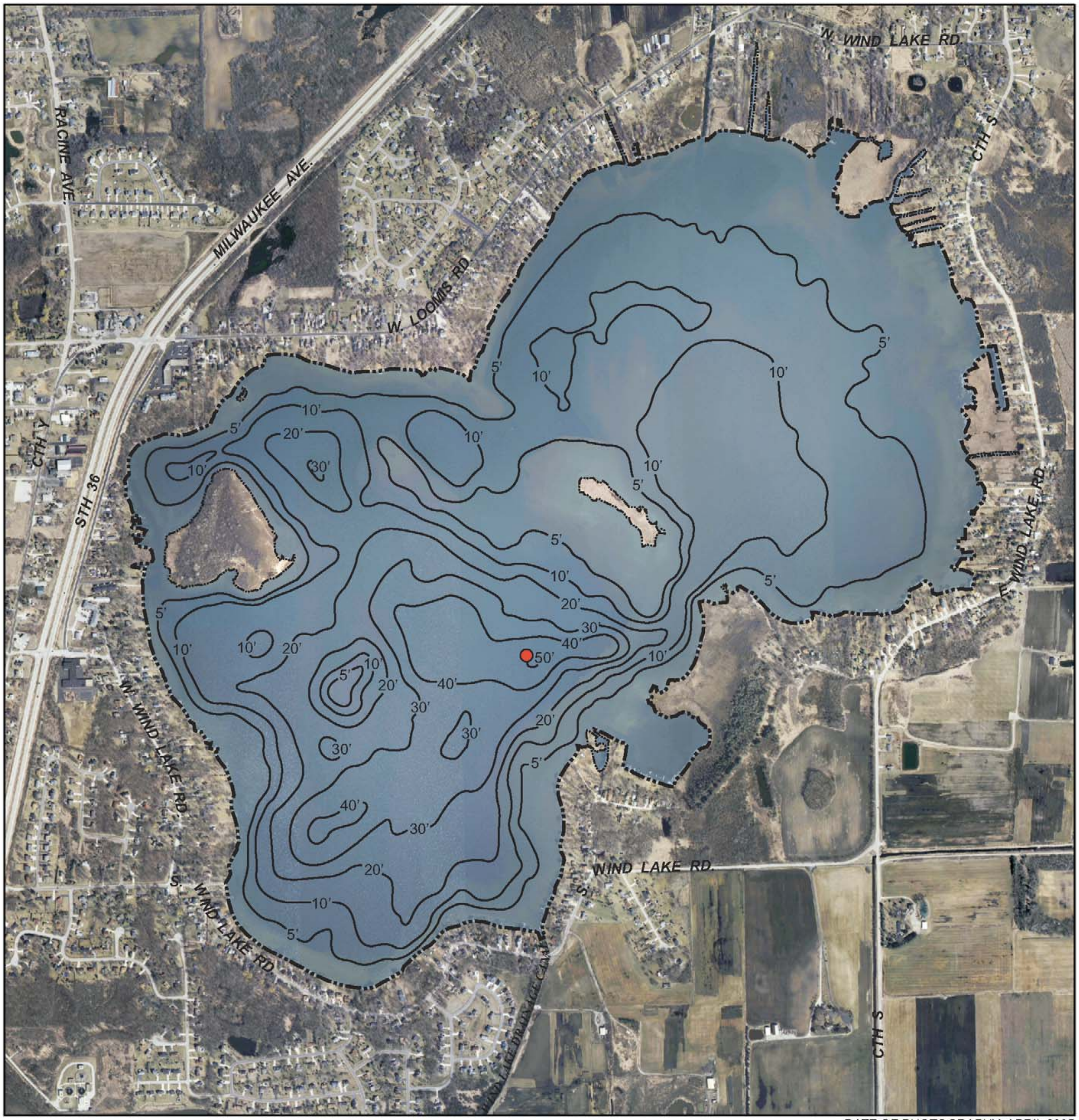
The U.S. Natural Resources Conservation Service, formerly the U.S. Soil Conservation Service, under contract to the Southeastern Wisconsin Regional Planning Commission (SEWRPC), completed a detailed soil survey of the

[5] *Wisconsin Department of Natural Resources Lake Use Report No. FX-5,* Wind Lake Racine County, Wisconsin, *1969.*

[6] *This tributary area represents a refinement of the 26,170 acre drainage area reported in the initial plan. Portions of the area tributary to Wind Lake, lying to the east of the lake basin, have extremely flat slopes, as reported below, with runoff from these lands being directed either northward into Wind Lake or southward into the Wind Lake Drainage Canal depending upon the placement of regulatory gates within the drainage system. Field investigations by SEWRPC staff during the current project period suggested that these gates were typically positioned in such a manner as to direct flows into the Wind Lake Drainage Canal downstream of the lake. Hence, the lands draining to this canal system were excluded from the tributary area for purposes of this planning program. This determination results in a slight reduction in the volume of water likely to enter Wind Lake, with a concomitant increase in the calculated water residence time reported in the water budget for the lake set forth at the end of this chapter.*

Map 2

BATHYMETRIC MAP OF WIND LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

Source: U.S. Geological Survey, Wind Lake Management District and SEWRPC.

GRAPHIC SCALE

0 750 1500 FEET

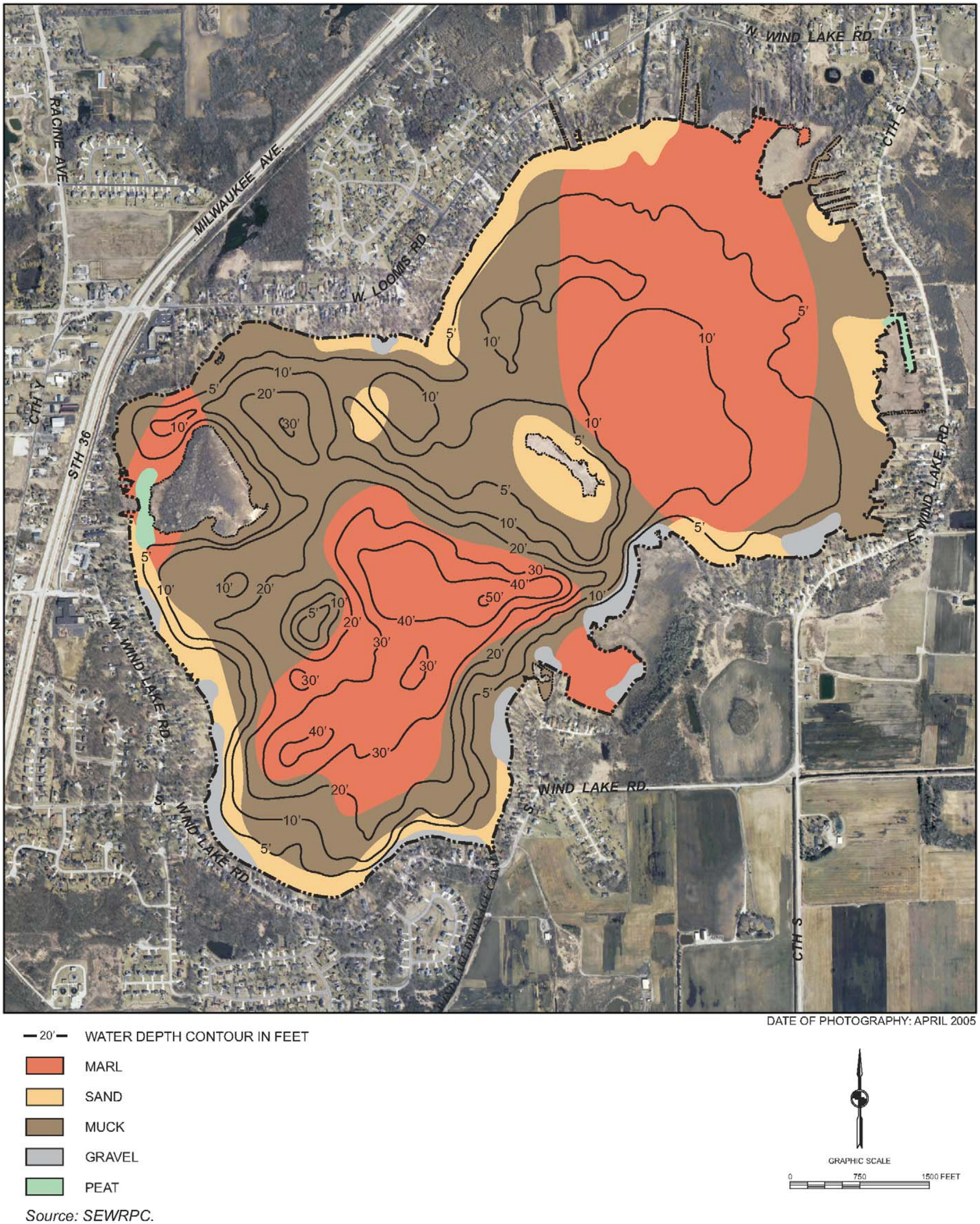
Map 3

SHORELINE PROTECTION STRUCTURES ON WIND LAKE: 2005

Source: SEWRPC.

Map 4

SEDIMENT SUBSTRATE DISTRIBUTION IN WIND LAKE: 1990



Source: SEWRPC.

Wind Lake area in 1966.[7] The major soil associations within the Wind Lake direct tributary area are: the Morley-Beecher-Ashkum association of well-drained to poorly drained soils that have a silty clay or silty clay loam character, located mainly in the western part of the tributary area; and the Houghton-Palms association of very poorly drained organic soils, located along most of the eastern shorelands of the Lake and in the eastern portions of the tributary area. Marsh soils are located along the eastern shoreline of the Lake and the islands, and in several isolated patches along the western and northern shorelines of the Lake. Blount silt loam is located along the western shoreline of the Lake; Sebawa silt loam is found along the southern shoreline and in a few isolated patches along the western shoreline; and, Matherton loam is found mostly along the southern shoreline. Morley-Beecher-Ashkum soils have a high natural fertility and are well suited to farming; Houghton-Palms soils lie mostly in depressions and low areas, consist of muck and mucky peat that, if drained, can be suitable for farming.

Within the total tributary area, the major soil associations are: the Montgomery-Martinton-Hebron-Saylesville association of poorly to well-drained soils overlying clay and clay loam, located primarily in the area around Big Muskego Lake; and the Ozaukee-Morley-Mequon association of somewhat poorly drained to well-drained soils that have a substratum of silty clay loam and silty clay, found in the area of Little Muskego Lake and continuing throughout the northern portions of the total tributary area of Wind Lake. The Montgomery-Martinton-Hebron-Saylesville soils generally are not well suited for housing developments, industrial developments or roads but can serve as pasture lands or wildlife habitat if not drained or improved. These soils also can be used for cropland if drained. Ozaukee-Morley-Mequon soils are well suited for farming, but require erosion control on the sloping portions.

Using the regional soil survey, an assessment was made of the hydrologic characteristics of the soils in the direct and total tributary areas of Wind Lake. Based upon this classification, the soils were categorized generally into four principal hydrologic groups, as indicated in Table 2. None of the area tributary to Wind Lake is covered by well-drained soils. Moderately well drained soils cover about 6 percent of the direct, and about 10 percent of the total, tributary areas; poorly drained soils cover a little more than half of the direct and total tributary areas; and very poorly drained soils cover about 40 percent of the direct, and about 25 percent of the total, tributary areas. The areal extent of these soils is shown in Table 2, and their locations within the total tributary area are shown on Map 5.

In addition to the identification and delineation of soil types, the soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. The suitability of the soils for urban residential development was assessed using common development scenarios. These ratings reflected the requirements of Chapter Comm 83 of the *Wisconsin Administrative Code* governing onsite sewage disposal systems as they existed prior to the year 2000. During 2000, the Wisconsin Legislature amended Chapter Comm 83 and adopted new rules governing onsite sewage disposal systems. These revised rules, which came into effect on July 1, 2000, significantly altered the existing regulatory framework, and effectively increased the area within which onsite sewage disposal systems may be utilized. Although the residential lands within the area directly tributary to Wind Lake currently are mostly served by a public sanitary sewerage system,[8] pursuant to recommendations set forth in the adopted regional water quality management plan as shown in Map 6,[9] the onsite sewage disposal system interpretations associated with the soil survey provide insights into the potential for land-

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[7]*SEWRPC Planning Report No. 8,* Soils of Southeastern Wisconsin, *June 1966*.

[8]*SEWRPC Community Assistance Planning Report No. 247,* Sanitary Sewer Service Area for the Town of Norway Sanitary District No. 1 and Environs, Racine and Waukesha Counties, Wisconsin*, June 1999.*

[9]*See 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; SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

Table 2

GENERAL HYDROLOGIC SOIL TYPES WITHIN THE TOTAL AND DIRECT AREAS TRIBUTARY TO WIND LAKE

Group	Soil Characteristics	Direct Tributary Drainage Area (acres)	Percent of Land Area[a]	Total Tributary Drainage Area (acres)	Percent of Land Area[a]
A	Well drained; very rapidly to rapid permeability; low shrink-swell potential	0	0	0	0
B	Moderately well drained; texture intermediate between coarse and fine; moderately rapid to moderate permeability; low to moderate shrink-swell potential	90	6	2,473	10
C	Poorly drained; high water table for part or most of the year; mottling, suggesting poor aeration and lack of drainage, generally present in A to C horizons	791	53	12,482	53
D	Very poorly drained; high water table for most of the year; organic or clay soils; clay soils having high shrink-swell potential	589	40	6,197	26
Other	Group not determined	9	1	2,644	11
Water	- -	917	- -	2,520	- -
Total		2,396	100	26,315	100

[a]*Excludes water.*

Source: SEWRPC.

based sources of pollution to affect the lake water quality, both as a consequence of overland flows during storm events and through groundwater interflows into the Lake. As an index of the likelihood of contaminants entering Wind Lake, the soil ratings for onsite sewage disposal systems, shown on Map 7, suggest that less than 2 percent of the lands within the total area tributary to Wind Lake are covered by soils that are categorized as having few limitations for development. The major portion of the drainage area, over 83 percent of the total, is covered by soils that are classified as unsuitable for onsite sewage disposal systems, suggesting a potential sensitivity to disturbance and likelihood of being permeable to pollutants. The remaining 15 percent is covered by unclassified or undetermined soils.

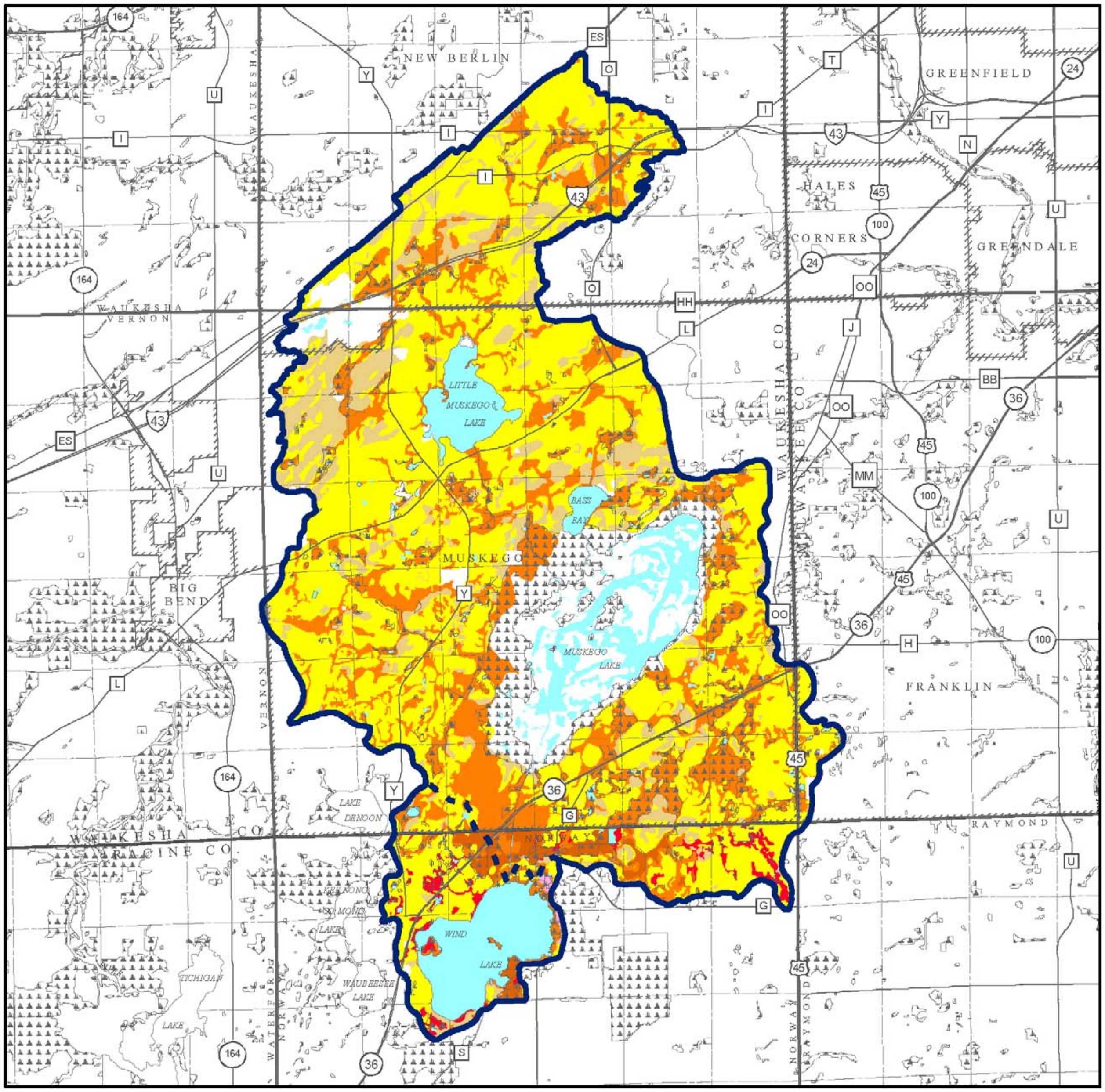
As stated above, land slope, along with soil type and vegetative cover, is an important factor affecting the rate, amount, and quality of stormwater runoff. Land surface slopes within the total area tributary to Wind Lake range from less than 1 percent to greater than 20 percent. In general, slopes of over 12 percent have limitations for urban residential development and, if developed, can present potential erosion and drainage problems. Based upon soil-slope interpretations, only about 617 acres, or about 2.5 percent of the total area tributary to Wind Lake, have slopes that exceed 12 percent. A further 1,572 acres, or about 6.6 percent of the total area, have slopes of between 6 percent and 12 percent, while about 212,069 acres, or about 89 percent of the area excluding surface waters, have slopes of less than 6 percent.

Climate and Hydrology

Long-term average monthly air temperature and precipitation values for the Wind Lake area are set forth in Table 3. These averages were taken from National Oceanic and Atmospheric Administration (NOAA) records for the weather recording station at the General Mitchell International Airport, Milwaukee, Wisconsin. The records of this station may be considered typical of the lake area.

Map 5

HYDROLOGIC SOIL GROUPS WITHIN THE AREA TRIBUTARY TO WIND LAKE



- GROUP A/D: Well-drained soil/Very poorly drained soil[1]
- GROUP B: Moderately drained soil
- GROUP B/D: Moderately drained soil/Very poorly drained soil[2]
- GROUP C: Poorly drained soil
- GROUP C/D: Poorly drained soil/Very poorly drained soil[3]
- GROUP D: Very poorly drained soil
- OTHER
- Surface Water
- Total Tributary Area Boundary
- Direct Tributary Area Boundary

1 Well-drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.

2 Moderately drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.

3 Poorly drained soil if water table is lowered through provision of a drainage system. Very poorly drained soil if water table is not lowered.

N

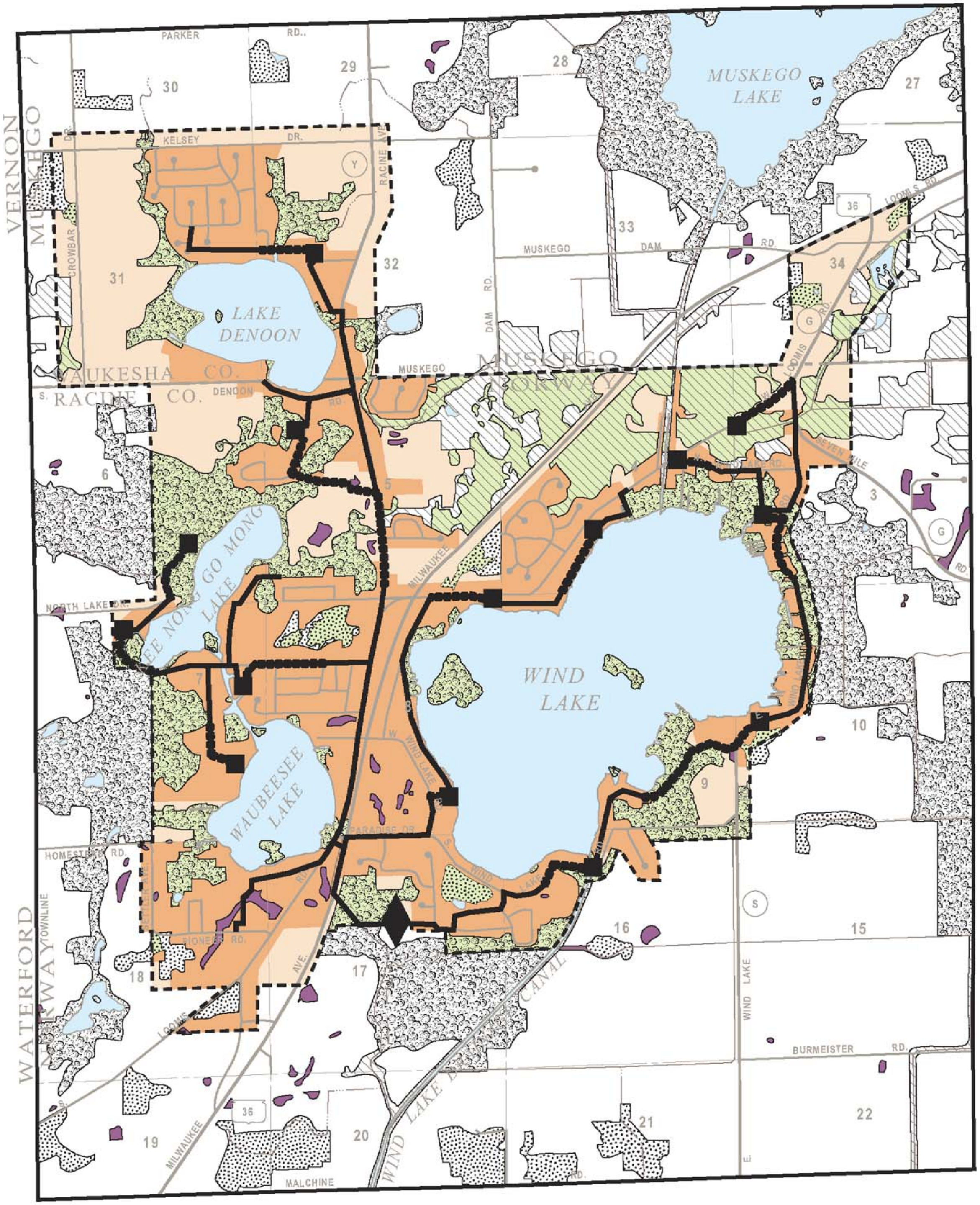
0 1 2 3 4

Miles

Source: U.S. National Resource Conservation Service and SEWRPC.

Map 6

SANITARY SEWER SERVICE AREA FOR THE TOWN OF NORWAY SANITARY DISTRICT NO. 1 AND ENVIRONS: 2020



PRIMARY ENVIRONMENTAL CORRIDOR

SECONDARY ENVIRONMENTAL CORRIDOR

ISOLATED NATURAL RESOURCE AREA

WETLANDS AND SURFACE WATER AREAS LESS THAN FIVE ACRES IN SIZE

LANDS WITHIN THE PLANNED SANITARY SEWER SERVICE AREA INELIGIBLE FOR SEWER SERVICE

EXISTING AREA SERVED BY PUBLIC SANITARY SEWER SYSTEM: 1995

PLANNED SANITARY SEWER SERVICE AREA: 2020

PLANNED SANITARY SEWER SERVICE AREA BOUNDARY

EXISTING PUBLIC SEWAGE TREATMENT FACILITY

EXISTING TRUNK SEWER

EXISTING FORCE MAIN

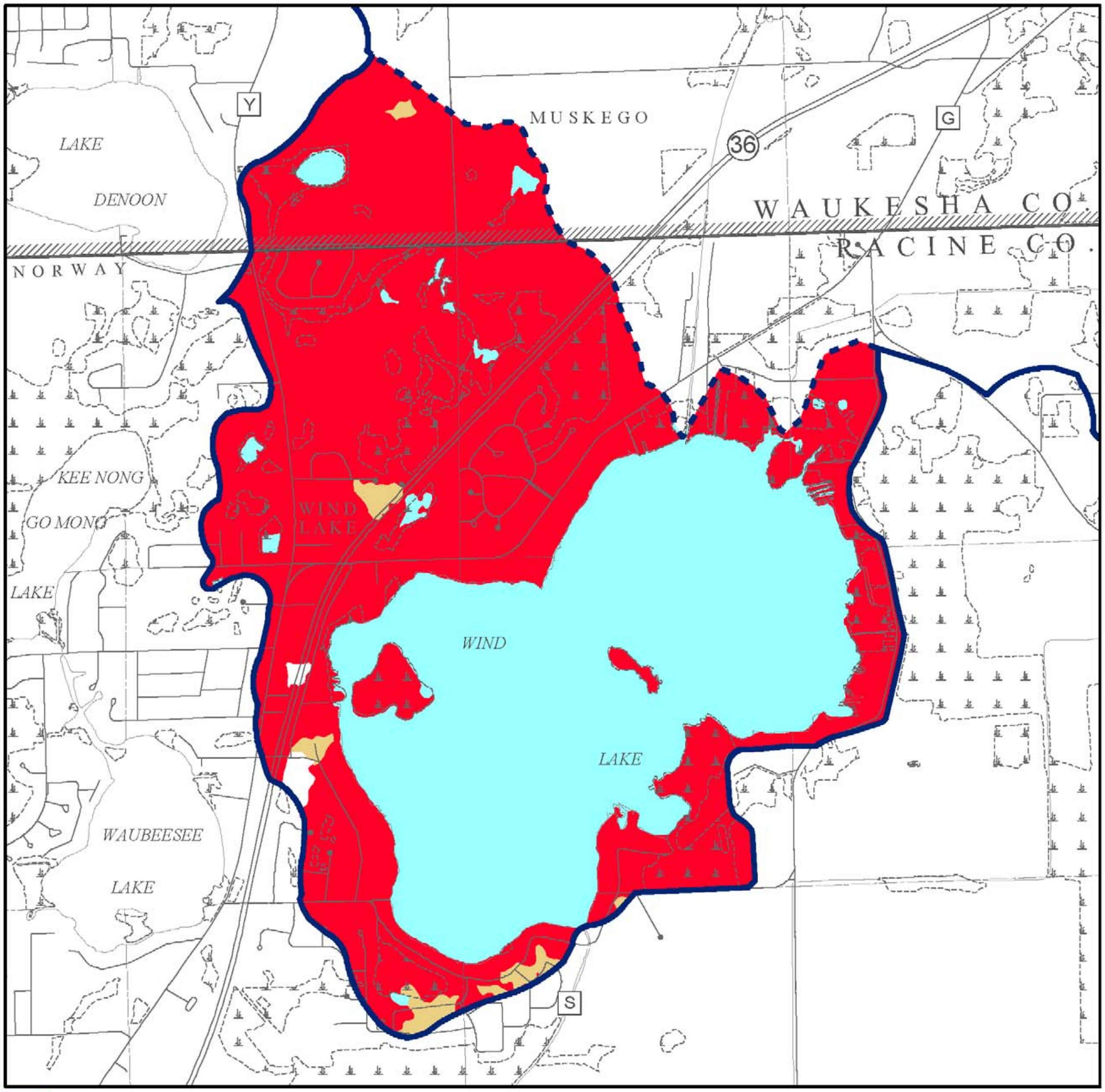
EXISTING PUMPING STATION

GRAPHIC SCALE

Source: SEWRPC.

Map 7

GROUNDWATER CONTAMINATION POTENTIAL WITHIN THE AREA DIRECTLY TRIBUTARY TO WIND LAKE



UNSUITABLE: Areas covered by soils which have a high probability of not meeting the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems

UNDETERMINED: Areas covered by soils having a range of characteristics and or slopes which span the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems so that no classification can be assigned

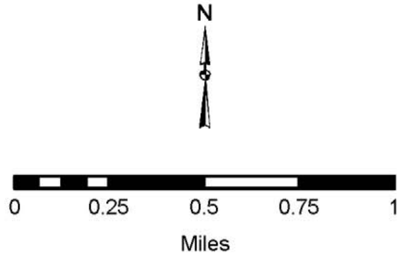
SUITABLE: Areas covered by soils having a high probability of meeting the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Aministrative Code* governing conventional onsite sewage disposal systems

OTHER: Areas consisting for the most part of disturbed land for which no interpretive data are available

SURFACE WATER

Total Tributary Area Boundary

Direct Tributary Area Boundary



Source: U.S. Natural Resources Conservation Service and SEWRPC.

Table 3

LONG-TERM AND 2004 STUDY YEAR TEMPERATURE, PRECIPITATION, AND RUNOFF DATA FOR THE WIND LAKE AREA

Temperature													
Air Temperature Data (°F)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	20.7	25.4	34.9	45.2	56.1	66.3	72.0	70.6	63.0	51.4	38.4	26.2	47.5
2004 Mean Monthly	17.9	26.5	39.0	46.9	54.8	63.7	69.1	66.5	65.7	52.9	42.3	27.4	47.7
Departure from Long-Term Mean	-2.8	1.1	4.1	1.7	-1.3	-2.6	-2.9	-4.1	2.7	1.5	3.9	1.2	0.2

Precipitation														
Precipitation Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean	Total
Long-Term Mean Monthly	1.85	1.65	2.59	3.78	3.06	3.56	3.58	4.03	3.30	2.49	2.70	2.22	2.90	34.81
2004 Mean Monthly	1.43	1.10	3.99	1.87	8.18	4.07	3.25	3.43	0.24	1.47	2.38	1.53	2.75	32.94
Departure from Long-Term Mean	-0.42	-0.55	1.40	-1.91	5.12	0.51	-0.33	-0.60	-3.06	-1.02	-0.32	-0.69	-0.15	-1.87

Runoff[a]													
Runoff Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	0.58	1.12	0.85	0.96	0.84	0.90	0.28	0.14	0.23	0.50	0.40	0.42	0.60
2004 Mean Monthly	0.02	0.00	0.12	0.25	1.16	0.12	0.11	0.11	0.11	0.11	0.13	0.39	0.22
Departure from Mean Monthly	-0.56	-1.12	-0.73	-0.71	0.32	-0.78	-0.17	-0.03	-0.12	-0.39	-0.27	-0.03	-0.38

[a]*Runoff data was computed for 2003, which was the most recent calendar year data available at time of print.*

Source: National Oceanic and Atmospheric Administration, U.S. Geological Survey and SEWRPC.

The long-term mean annual temperature of 47.5°F is similar to that reported from other recording locations in southeastern Wisconsin, and slightly warmer than the 45.6°F long term average temperature reported during the initial planning period. The 12-month period for calendar year 2004, as indicated in Table 3, was a period during which air temperatures were about normal, averaging 47.7°F. The greatest temperature deviations above normal were during the months of March and November, when temperatures were about 4°F above normal during each month; the greatest deviation below normal occurred during August, when the temperature was about 4°F below normal. Average monthly temperatures for January and July, 2004, were close to 3°F below normal.

The calendar year 2004 was a slightly drier year for the Wind Lake area and for the Southeastern Wisconsin Region in general, with nine of the 12 months experiencing below normal amounts of precipitation. Precipitation at General Mitchell International Airport during calendar year 2004 was about 32.94 inches, or about 5 percent below the normal long term mean annual precipitation at General Mitchell International Airport of about 34.81 inches. The greatest decrease from the long term average, of 3.06 inches, occurred during September 2004, and the greatest increase above the average, of 5.12 inches, occurred during May.

Table 3 also sets forth surface water runoff values derived from the U.S. Geological Survey (USGS) flow records for the Muskego (Big Muskego) Lake outlet upstream of Wind Lake. Typically, more than half the normal yearly precipitation falls during the growing season, from May to September. Runoff rates are generally low during this period, since evapotranspiration rates are high, vegetative cover is good, and soils are not frozen. Normally, about 20 percent of the summer precipitation is expressed as surface runoff, but intense summer storms occasionally produce higher runoff fractions. In contrast, approximately 45 percent of the annual precipitation occurs during the winter or early spring when the ground is frozen, and higher surface runoff may result during those seasons. As shown in Table 3, runoff during 2004 was somewhat below normal, a result consistent with the amount of precipitation which also was below normal during this period.

Lake Stage

The water level of Wind Lake is primarily determined by the dam located at the outlet of the Lake to the Wind Lake Drainage Canal. As described above, the dam crest is set at about 768.44 feet above mean sea level.[10] In the initial SEWRPC report, water level fluctuations for Wind Lake were reported for water years 1988 and 1989,[11] based on hydrologic data obtained from 17 monitoring sites in the Wind Lake tributary area. Most of these sites are no longer actively reporting sites.

During the earlier study, water levels in Wind Lake fluctuated in response to local precipitation. During dry periods, water levels in Wind Lake dropped below the dam crest, causing the lake discharge to Wind Lake Drainage Canal to drop to zero or near zero. During water year 1988, precipitation at Wind Lake was 5.88 inches, or about 18 percent, below normal. Water levels in Wind Lake during this period fluctuated by 2.93 feet, resulting in a net loss of water from the Lake of about 1,320 acre-feet. During the subsequent water year of 1989, precipitation at Wind Lake was 2.33 inches, or about 7 percent, above normal and water levels in Wind Lake increased by 1.1 feet, for a gain of about 1,050 acre-feet of water within the Lake.

Water Budget

In the initial SEWRPC report, water budgets for Wind Lake were computed based upon USGS inflow and outflow data collected during water years 1988 and 1989, the results of which are shown in Table 4. Inflows included water entering Wind Lake as a result of direct precipitation onto the lake surface, surface runoff from the land area directly tributary to Wind Lake, and water entering Wind Lake from the upstream drainage area through the Muskego Canal. Outflows included amounts lost through evaporation from the lake surface as well as through the Wind Lake Drainage Canal. Groundwater flows into and out of Wind Lake were determined to be minimal.

During the current study, long term and calendar year 2004 water budgets for Wind Lake were computed using USGS data obtained at the outlet to Big Muskego Lake. During calendar year of 2004, approximately 20,146 acre-feet of water entered the Lake. Of this total, about 1,952 acre-feet, or about 10 percent, were contributed from direct precipitation onto the lake surface. Runoff from the area directly tributary to the Lake contributed approximately 914 acre-feet, or 5 percent, of the total water entering the Lake. The remaining 17,280 acre-feet, or about 85 percent of the total volume of water entering Wind Lake, were contributed from the Muskego Canal. Of the water lost from Wind Lake during the study year, about 2,262 acre-feet evaporated from the lake surface, and about 17,884 acre-feet were discharged through the Wind Lake Drainage Canal.

The results of the long term water budget for Wind Lake also are shown in Table 4 and represented graphically in Figure 1. About 2,700 acre-feet of water, or 10 percent of the total inflow, enter the Lake annually as a result of direct precipitation onto the lake surface; about 1,264 acre-feet, or 5 percent, enter as surface runoff from the area directly tributary to the Lake; and about 23,901 acre-feet, or 85 percent, enter the Lake through the Muskego Canal. Over the long-term, about 2,262 acre-feet of water, or 8 percent, of the water lost from Wind Lake annually is lost as a result of evaporation from the lake surface, with the remaining 92 percent being lost as outflow to the Wind Lake Drainage Canal. No net change in lake level is assumed over this long term period.

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[10]*SEWRPC Community Assistance Planning Report No. 198,* op. cit.

[11]*U.S. Geological Survey "water years" run from October 1st to September 30th, with the year being that of the period from January 1st to September 30th; hence, water year 1988 runs from October 1, 1987 through September 30, 1988.*

Table 4

COMPARISON OF WATER BUDGETS DEVELOPED FOR WIND LAKE

Year	Water Inputs			Water Outputs	
	Precipitation to Lake Surface (percent)	Runoff from the Direct Tributary Area (percent)	Inflow from the Muskego Canal (percent)	Evaporation (percent)	Outflow to the Wind Lake Drainage Canal (percent)
1988	11	2	87	12	88
1989	22	3	75	19	81
2004	10	5	85	11	89
Long-Term	10	5	85	8	92

Source: SEWRPC.

Water Residence Time

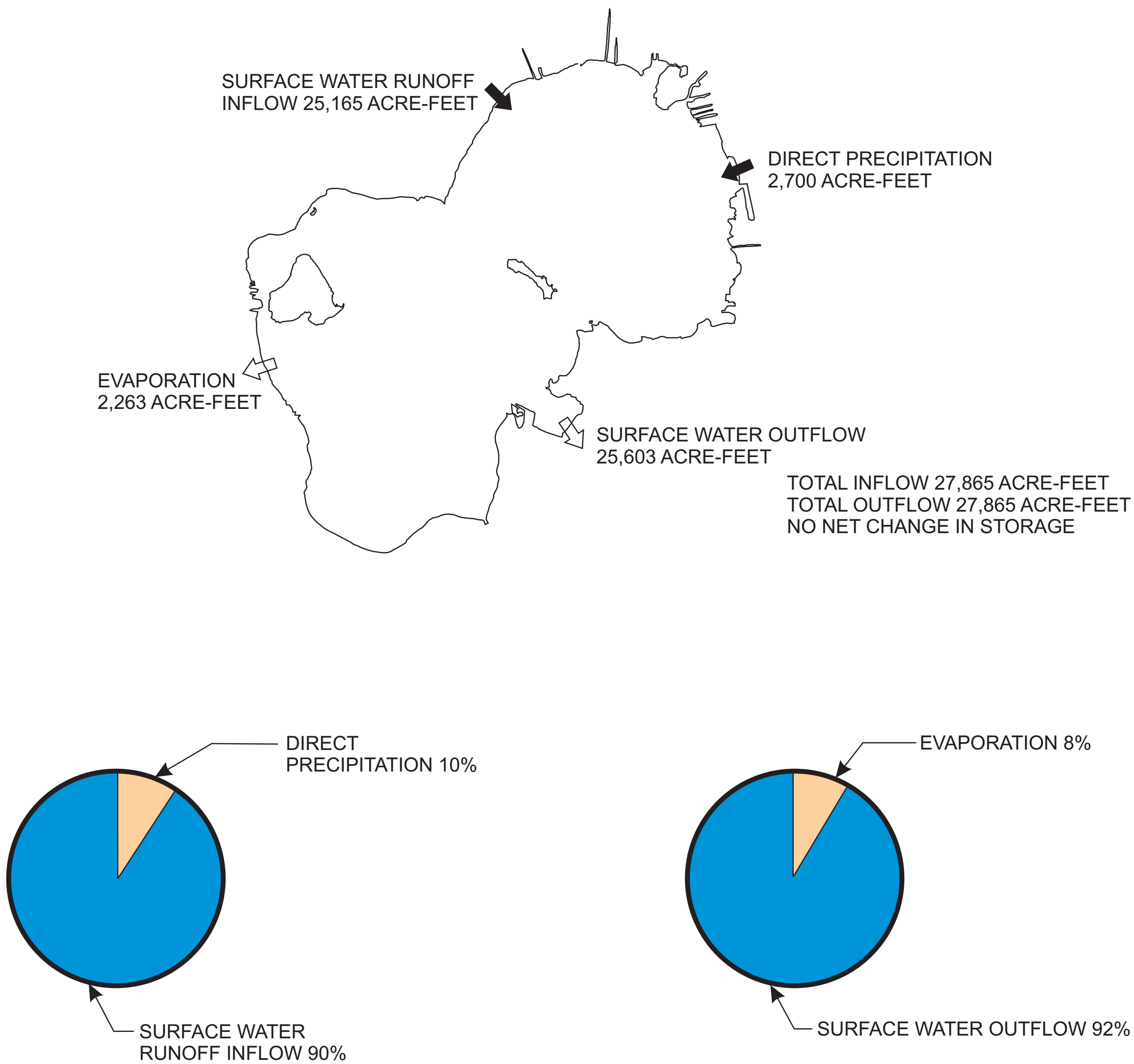
As was stated above, Wind Lake has a tributary area-to-lake surface area ratio of about 27 to 1. Lakes with large tributary area-to-lake area ratios typically have shorter residence times than lakes with smaller ratios. The hydraulic or water residence time, also referred to as the retention time or inverse of the flushing rate, is the time needed for a volume of water equivalent to the full volume of a lake to enter the lake. Residence time is important in determining the expected response time of a lake to increased or reduced nutrient and other pollutant loadings. Lakes having a short residence time of less than a year, such as small drainage lakes, through-flow lakes, and lakes with large amounts of groundwater inflow and outflow, will allow nutrients and pollutants to be flushed from the lake fairly rapidly. These rapidly flushed lakes generally respond well when nutrient inputs are decreased. Lakes with longer residence times, such as drained lakes with only out-flowing streams, typically respond more slowly to changes in their tributary area since it takes a long time for a volume equivalent to the full volume of the lake to enter the lake from its tributary area. Such lakes can accumulate nutrients for many years, recycling them each year during the periods spring and fall overturn, with the result that the effects of tributary area protection may not be immediately apparent. Wind Lake, as a drainage lake, falls into the former category.

In the 1969 Lake Use Report for Wind Lake, the WDNR estimated the water residence time to be 0.59 year.[12] This water residence time was refined as approximately 0.50 year in the initial SEWRPC report. During that initial planning period, water residence times were calculated to range from 0.46 year during water year 1988 to 1.05 years during water year 1989. During the current study, the residence time for Wind Lake based on the calendar year 2004 water budget was estimated to be 1.62 years, while the long-term water residence time was calculated to be approximately 0.68 year, or about 250 days. In all cases, the groundwater flows were assumed to be negligible. The long-term water residence time values indicate that Wind Lake is typically well-flushed, although this flushing rate is highly dependent upon rainfall volumes during any given year. In terms of contaminant loadings, discussed in Chapter IV of this plan, this variation in water residence time would suggest that there is likely to be significant inter-annual variability in water quality depending upon precipitation volumes in any given year.

[12]*Wisconsin Department of Natural Resources Lake Use Report No. FX-5,* op. cit.

Figure 1

LONG-TERM HYDROLOGIC BUDGET FOR WIND LAKE



Source: U.S. Geological Survey and SEWRPC.

Chapter III

HISTORICAL, EXISTING, AND FORECAST LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, and the ultimate solutions to water pollution problems, are primarily a function of the human activities within the tributary area of a waterbody, and the ability of the underlying natural resource base to sustain those activities. This is especially true in the area directly tributary to a lake because lakes are highly susceptible to water quality degradation attendant to human activities in the direct tributary area. Such human-induced lake degradation is more likely to interfere with desired water uses, and is often difficult and costly to correct. Accordingly, the land uses and population levels in the tributary area of a lake are important considerations in lake water quality management. This chapter summarizes the human activities upon the landscape as a major determinant of the quality of the lake environment.

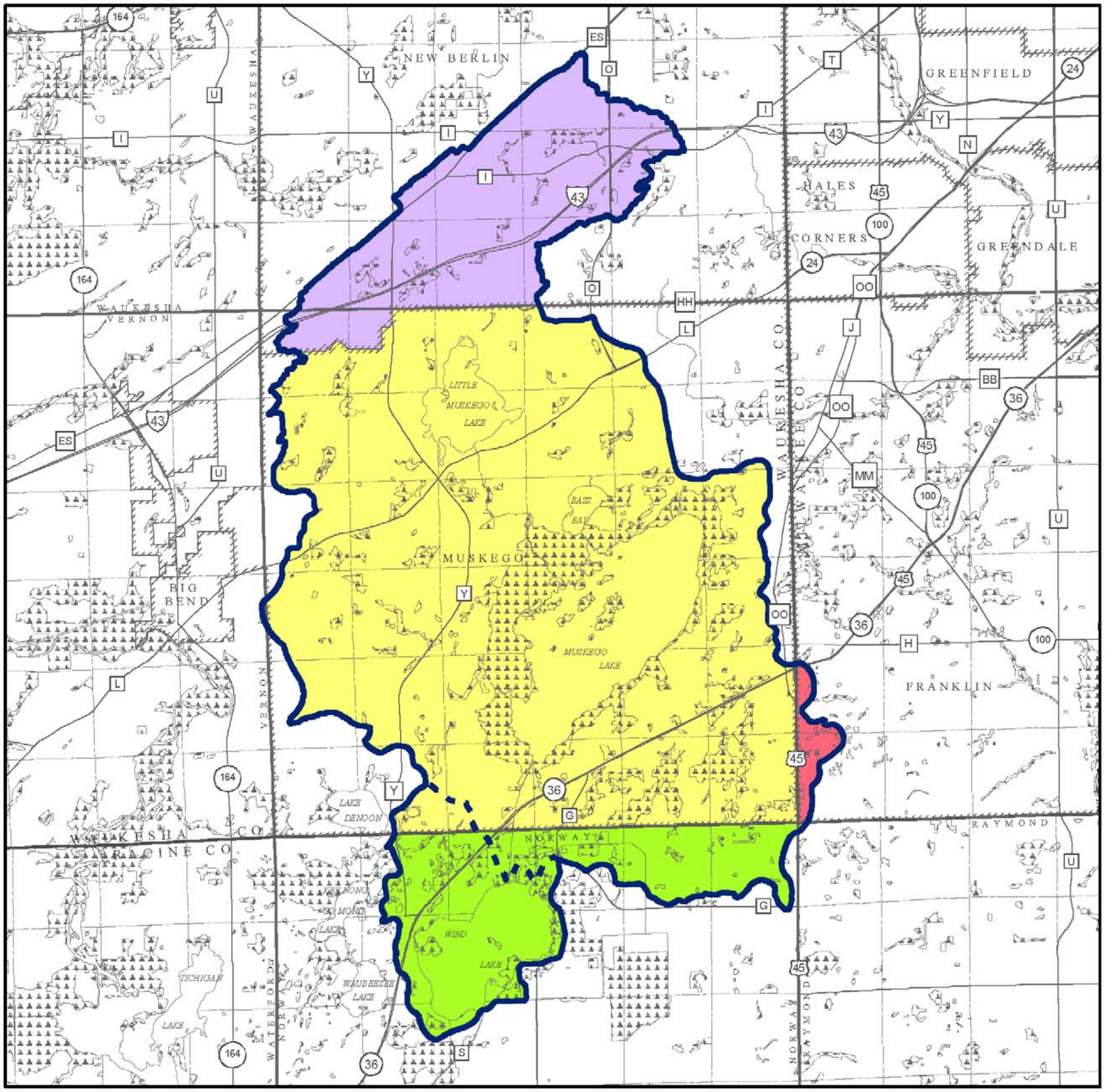
CIVIL DIVISIONS

The geographic, as well as functional jurisdictions of general and special purpose units of government, are important factors which must be considered in a lake water quality management. Superimposed on the irregular tributary area of Wind Lake are the local civil division boundaries, shown on Map 8. These governmental units include the Towns of Norway and Raymond in Racine County; the Town of Vernon and the Cities of Muskego and New Berlin in Waukesha County; and, the City of Franklin in Milwaukee County. The area and proportion of the tributary area lying within the jurisdiction of each civil division, as of 2000, are set forth in Table 5. The geographic boundaries of the civil divisions are important factors which must be considered in any water quality management planning effort for a lake, since these local units of government provide the basic structure for the decision-making framework within which intergovernmental environmental problems must be addressed. In addition, the county governments administer a number of programs and provide administrative services which relate directly to the unincorporated portions of the tributary area in Racine and Waukesha Counties. The Wisconsin Department of Natural Resources (WDNR), as the State agency tasked with environmental protection and management also oversees a number of programs and policies with relevance to Wind Lake and its tributary area.

In addition to these general purpose units of government, the Wind Lake Management District (WLMD) is a special-purpose unit of government created pursuant to Chapter 33 of the *Wisconsin Statutes* and having specific responsibilities for lake management. This District was formed in 1985 and encompasses the properties riparian to the lake and other surrounding properties. Public inland lake protection and rehabilitation districts, or lake management districts, may undertake programs of lake protection or rehabilitation including water quality,

Map 8

CIVIL DIVISION BOUNDARIIES WITHIN THE AREA TRIBUTARY TO WIND LAKE



City of Franklin

City of Muskego

City of New Berlin

Town of Norway

Town of Raymond

Town of Vernon

Total Tributary Area Boundary

Direct Tributary Area Boundary

N

0 1 2 3 4

Miles

Source: SEWRPC.

Table 5

AREAL EXTENT OF CIVIL DIVISION BOUNDARIES WITHIN THE TOTAL AREA TRIBUTARY TO WIND LAKE

Civil Division	Civil Division Area within Total Drainage Area (acres)	Percent of Total Drainage Area within Civil Division	Percent of Civil Division within Total Drainage Area
City of Franklin	286	1.0	1.3
City of Muskego	18,332	69.7	79.6
City of New Berlin	4,121	15.7	17.5
Town of Norway	3,565	13.5	15.6
Town of Raymond	5	<0.1	<0.1
Town of Vernon	6	<0.1	<0.1
Total	26,315	100.0	- -

Source: SEWRPC.

aquatic plant and fisheries management activities, and, under certain conditions, maintain and operate a water safety patrol, develop and enforce ordinances, and perform the functions of a town sanitary district.[1] The WLMD, among these other responsibilities, maintains an active program of community informational programming and lake water quality monitoring.

POPULATION

As indicated in Table 6, the resident population of the area tributary to Wind Lake has increased in a relatively steady manner since 1980. From 1980 to 1990, population grew by about 627 persons; from 1990 to 2000 the population increased about 672 persons. The period of greatest growth in both population and numbers of households in the area tributary to Wind Lake was from 1963 to 1970 during which period the population experienced an increase of nearly 200 percent. The numbers of households also doubled during this period. As of 2000, the resident population was reported to be approximately three and one-half times that of 1963, or about 2,684 persons, residing in about 944 housing units. The number of housing units reported within the area tributary to Wind Lake increased by about 223 units during the decade between 1980 and 1990, and by a further 284 units during the decade between 1990 and 2000.

As development in the local area continues over the next two decades, the population of the area tributary to Wind Lake also may be expected to continue to grow. This population growth may be expected to place continued and increasing stress on the natural resource base of the Wind Lake tributary area. Consequently, both water resource demands and water use conflicts may be expected to increase.

LAND USE

The type, intensity, and spatial distribution of the various land uses within the area tributary to Wind Lake are important determinants of lake water quality and recreational use demands. While even fallow or natural lands, such as woodlands, generate some (background) level of contaminant export, human activities on the land surface can greatly increase the magnitude of such export, as well as a greater range of potential contaminants that affect water quality and lake use. The existing land use pattern, placed in the context of the historical development of the area, therefore, is an important consideration in any lake management planning effort for Wind Lake.

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[1]*University of Wisconsin-Extension, Publication No. PUBL-FH-821.96,* A Guide to Wisconsin's Lake Management Law, Tenth Edition*, 1996.*

Table 6

POPULATION AND HOUSEHOLDS WITHIN THE AREA DIRECTLY TRIBUTARY TO WIND LAKE: 1963-2000

Year	Population	Households
1963	789	220
1970	1,557	453
1980	1,385	437
1990	2,012	660
2000	2,684	944

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

The movement of European settlers into the Southeastern Wisconsin Region began about 1830. Completion of the U.S. Public Land Survey in southeastern Wisconsin in 1836 and the subsequent sale of the public lands brought a rapid influx of settlers into the area. Map 9 shows the 1908 U.S. Public Land Survey for the Wind Lake area. Map 10 and Table 7 indicate the historic urban growth pattern in the total tributary area of the Lake since 1880. The largest increases in urban land use in the upstream tributary area occurred between 1969 and 1980. In the area directly tributary to the Lake, a significant increase in the amount of land converted to urban use, especially along the southern, western, and northern shorelands of the Lake, occurred between 1940 and 1950, with limited additional development occurring gradually since that time. By 1963, some additional shorelands along the southeastern portion of the Lake, as well as some offshore areas in the northeastern and western portions of the tributary area, were converted to urban use.

In the initial SEWRPC report, existing 1985 land uses and projected 2010 land uses were presented and compared. At that time, rural land uses were expected to decrease to a total of about 900 acres, or about 7 percent of the tributary area, during the period between 1985 and 2010. This was anticipated to be due primarily to the conversion of agricultural lands to urban land uses, mostly in the categories of residential and industrial uses. Even though there have been modest refinements to the size of the tributary area since the initial report, as noted in Chapter II of this report, these estimated changes in land usage predicted in the initial study appear to be somewhat conservative compared to actual 2000 land uses. There has been a larger-than-anticipated increase in urban land uses with a greater decrease in rural acreage, especially in the categories of agricultural and wetland uses.

As of 2000, as shown in Table 8, about 25 percent of the area directly tributary to Wind Lake was in various urban land uses, with the dominant urban land use being residential, encompassing about 397 acres, or about 16 percent of the direct tributary area. Rural land uses, such as agriculture, wetlands, woodlands, and surface waterbodies, comprised about 1,788 acres, or about 75 percent of the direct tributary area. Map 11 shows the land uses in existence during 2000 in the area directly tributary to Wind Lake.

Under planned 2020 conditions, the trend toward more intense urban land usage in southeastern Wisconsin is expected to be reflected in the area directly tributary to Wind Lake, as shown in Table 8 and Map 12. Much of this development is expected to occur as agricultural lands continue to be converted to urban lands, primarily for residential use. Within the area directly tributary to the Lake, urban residential uses are expected to increase by about 146 acres, to about 543 acres, and occupy approximately 23 percent of the Lake's tributary area. Most of the residential development is expected to occur on lands formerly devoted to agricultural uses. Rural agricultural uses are expected to further decrease, to about 246 acres or approximately 10 percent of the direct tributary area. If this trend continues, some of the open space areas remaining in the direct tributary area are likely to be replaced with large-lot urban residential development, resulting in the potential for increased pollutant loadings to the Lake. This development could occur in the form of residential clusters on smaller lots within conservation subdivisions, thereby preserving portions of the remaining open space and, thus, reducing the impacts on the lake.[2]

Existing and planned land use patterns in the total tributary area for Wind Lake are shown in Table 9 and on Maps 13 and 14. As of 2000, as shown in Table 9, about 27 percent of the total tributary area of Wind Lake was

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

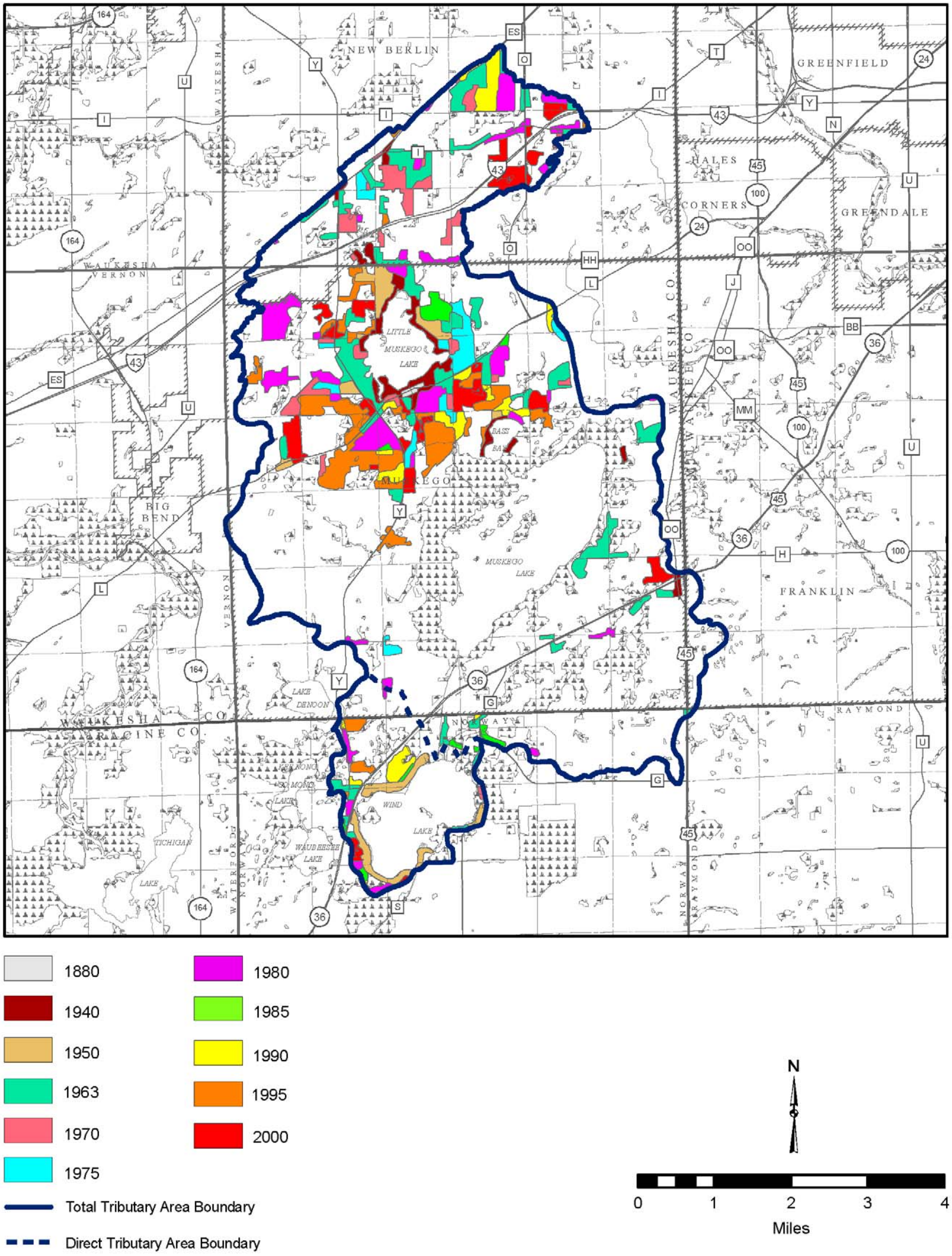
Map 9

HISTORICAL PLAT MAP FOR THE WIND LAKE AREA: 1908

Source: P.C. Hennessey and Company, Plat Book of Racine and Kenosha Counties, Wisconsin, 1908.

Map 10

HISTORIC URBAN GROWTH WITHIN THE AREA TRIBUTARY TO WIND LAKE



Source: SEWRPC.

Table 7

EXTENT OF HISTORIC URBAN GROWTH IN THE TOTAL TRIBUTARY AREA OF WIND LAKE: 1880-2000

Year	Tributary Area	
	Extent of New Urban Development Occurring Since Previous Period (acres)[a]	Cumulative Extent of Urban Development (acres)[a]
1880	16	16
1940	341	357
1950	393	750
1963	1,239	1,989
1970	425	2,414
1975	311	2,725
1980	849	3,574
1985	150	3,724
1990	405	4,129
1995	890	5,019
2000	664	5,683

[a]*Urban development, as defined for the purposes of this discussion, includes those areas within which houses or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of urban land uses. Scattered residential developments were not considered urban in this analysis.*

Source: SEWRPC.

in various urban land uses, with the dominant urban land use being residential. Residential lands encompassed about 4,227 acres, or about 16 percent, of the total tributary area. Rural land uses comprised about 19,189 acres, or about 73 percent, of the total tributary area. Map 10 shows the land uses in the total tributary area of Wind Lake as of the year 2000. Under planned 2020 conditions, the trend toward more intensive urban land use is expected to be reflected in the total tributary area of Wind Lake, as in the direct tributary area. Urban residential uses are expected to increase by about 2,365 acres to about 6,592 acres, or to approximately 25 percent of the total tributary area, as shown in Table 9 and Map 14. Rural land uses, mostly agricultural uses, are expected to decrease from about 73 percent of the total tributary area to about 58 percent of the area over the same time period.

Certain lands immediately surrounding the lake, together with connected areas containing a concentration of high-value woodlands, wetlands, and wildlife habitat areas as described in Chapter V of this report, have been designated as environmental corridor lands in the adopted regional land use plan.[3] Additional lands also have been designated as natural areas and critical species habitat in the regional natural areas and critical species habitat protection and management plan.[4] These lands largely are expected to be preserved in essentially natural or open space uses.

LAND USE REGULATIONS

The comprehensive zoning ordinance represents one of the most important and significant tools available to general purpose units of government in directing the proper use of lands within their area of jurisdiction. As already noted, the area tributary to Wind Lake includes portions of the Towns of Norway and Raymond in Racine County, the Town of Vernon and the Cities of Muskego and New Berlin in Waukesha County, and the City of Franklin in Milwaukee County. Table 10 shows the land use regulations adopted and in use within these various civil divisions in the total tributary area of Wind Lake.

General Zoning

Cities in Wisconsin are granted comprehensive, or general, zoning powers under Section 62.23 of the *Wisconsin Statutes*. The same powers are granted to villages under Section 61.35 of the *Statutes*. Counties are granted general zoning powers within their unincorporated areas under Section 59.69 of the *Statutes*. Racine and Waukesha counties have both adopted their own general zoning ordinances; Milwaukee County, being comprised entirely of incorporated municipalities, leaves general zoning and other land use regulations up to the local municipalities. The Towns of Vernon, Norway, and Raymond, parts of which lie within the area tributary to Wind

[3]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

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

Table 8

EXISTING AND PLANNED LAND USE WITHIN THE AREA DIRECTLY TRIBUTARY TO WIND LAKE: 2000 AND 2020

Land Use Categories[a]	2000		2020	
	Acres	Percent of Direct Tributary Drainage Area	Acres	Percent of Direct Tributary Drainage Area
Urban				
Residential	397	16.6	543	22.7
Commercial	21	0.9	26	1.1
Industrial	1	<1	2	0.1
Governmental and Institutional	8	0.3	8	0.3
Transportation, Communication, and Utilities	163	6.8	204	8.5
Recreation	18	0.8	18	0.8
Subtotal	608	25.4	801	33.5
Rural				
Agricultural	438	18.3	246	10.3
Wetlands	299	12.5	299	12.5
Woodlands	136	5.7	135	5.6
Water	915	38.1	915	38.1
Extractive	- -	- -	- -	- -
Subtotal	1,788	74.6	1,595	66.5
Total	2,396	100.0	2,396	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

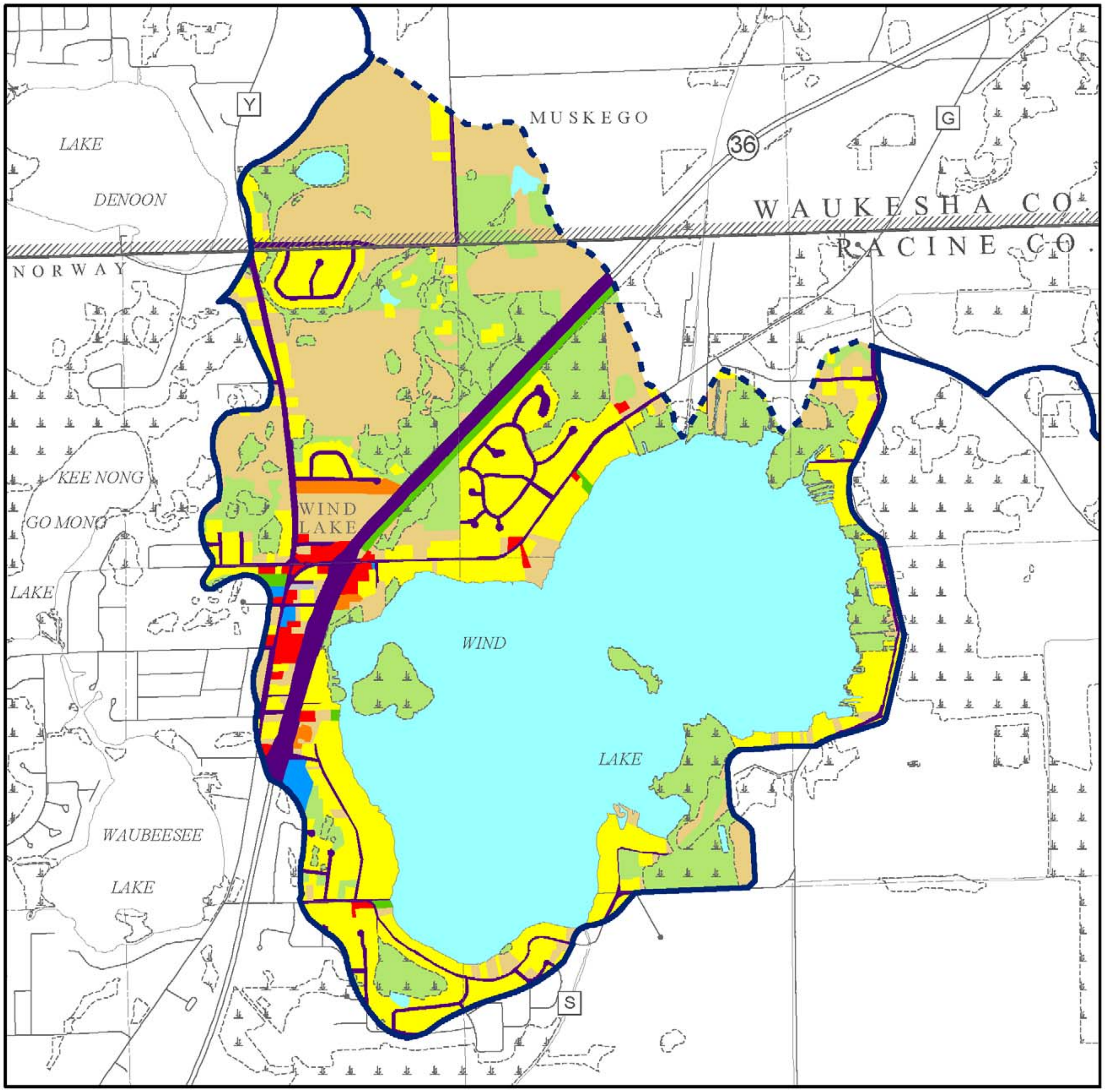
Lake, have adopted their county's general zoning ordinances, as shown in Table 10. The Cities of Franklin, Muskego, and New Berlin have each adopted their own general zoning regulations.

Floodland Zoning

Section 87.30 of the *Wisconsin Statutes* requires that cities, villages, and counties with respect to their unincorporated areas, adopt floodland zoning to preserve the floodwater conveyance and storage capacity of floodplain areas, and to prevent the location of new flood damage-prone development in flood hazard areas. The minimum standards which such ordinances must meet are set forth in Chapter NR 116 of the *Wisconsin Administrative Code*. The required regulations govern filling and development within a regulatory floodplain, which is defined as the area subject to inundation by the 100-year recurrence interval flood event, the event which has a 1 percent probability of occurring in any given year. Under Chapter NR 116, local floodland zoning regulations must prohibit nearly all forms of development within the floodway, which is that portion of the floodplain required to convey the 100-year recurrence peak flood flow. Local regulations also must restrict filling and development within the flood fringe, which is that portion of the floodplain located outside the floodway that would be covered by floodwater during the 100-year recurrence flood. Permitting the filling and development of the flood fringe area, however, reduces the floodwater storage capacity of the natural floodplain, and may thereby increase downstream flood flows and stages. It should be noted that towns may enact floodland zoning regulations which may be more restrictive than those in the county shoreland and floodland zoning ordinances. Within the total area tributary to Wind Lake, Racine and Waukesha Counties have each adopted a countywide floodland zoning ordinance. The Towns of Norway, Raymond, and Vernon have adopted their county's floodland zoning ordinance. The Cities of Franklin, Muskego, and New Berlin have adopted their own floodland zoning ordinances, as shown in Table 10.

Map 11

EXISTING LAND USE WITHIN THE AREA DIRECTLY TRIBUTARY TO WIND LAKE: 2000



Single-Family Residential

Multi-Family Residential

Commercial

Industrial

Transportation, Communications, and Utilities

Total Tributary Area Boundary

Direct Tributary Area Boundary

Governmental and Institutional

Recreation

Surface Water

Wetlands and Woodlands

Agricultural, Unused, and Other Open Lands

N

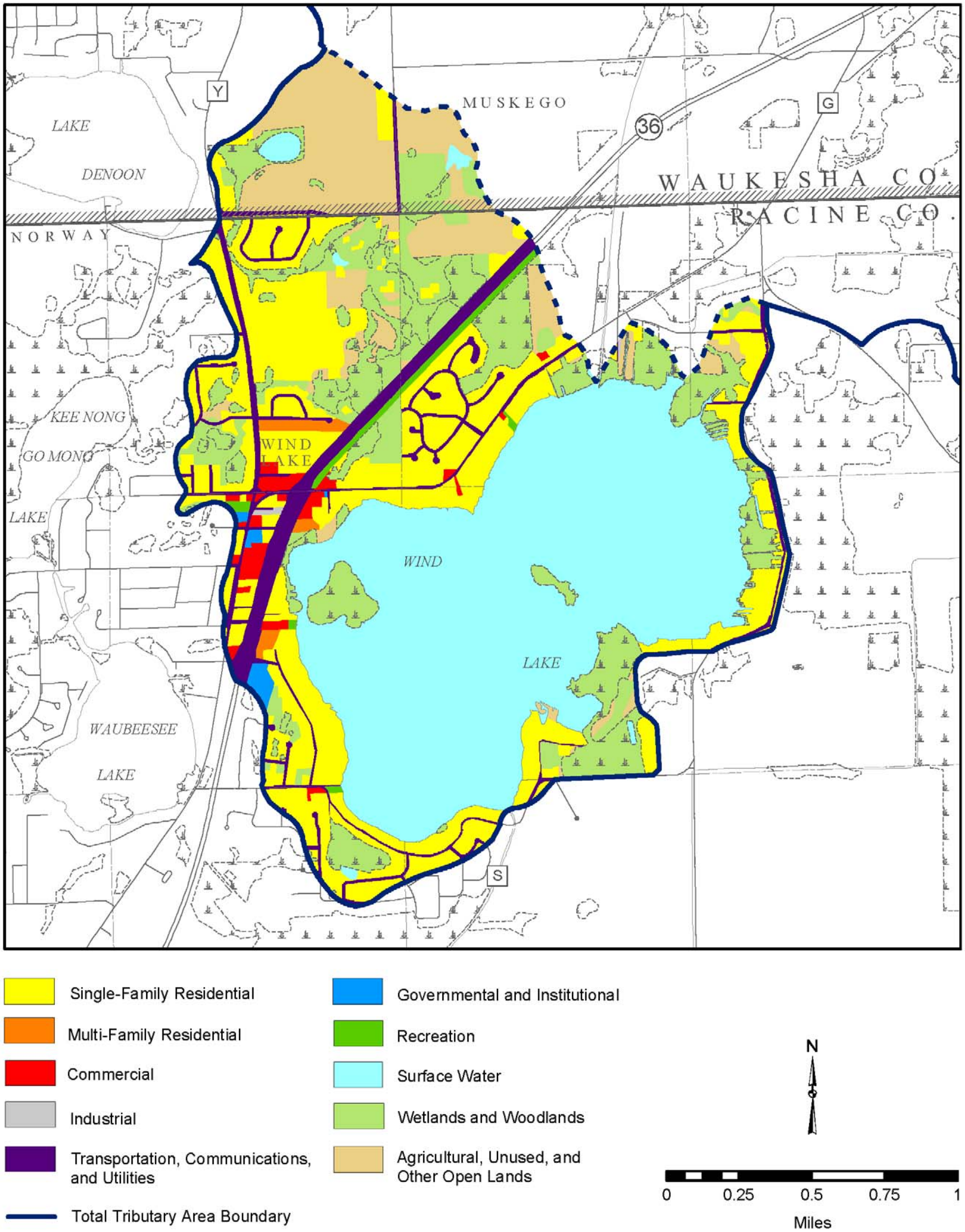
0 0.25 0.5 0.75 1

Miles

Source: SEWRPC.

Map 12

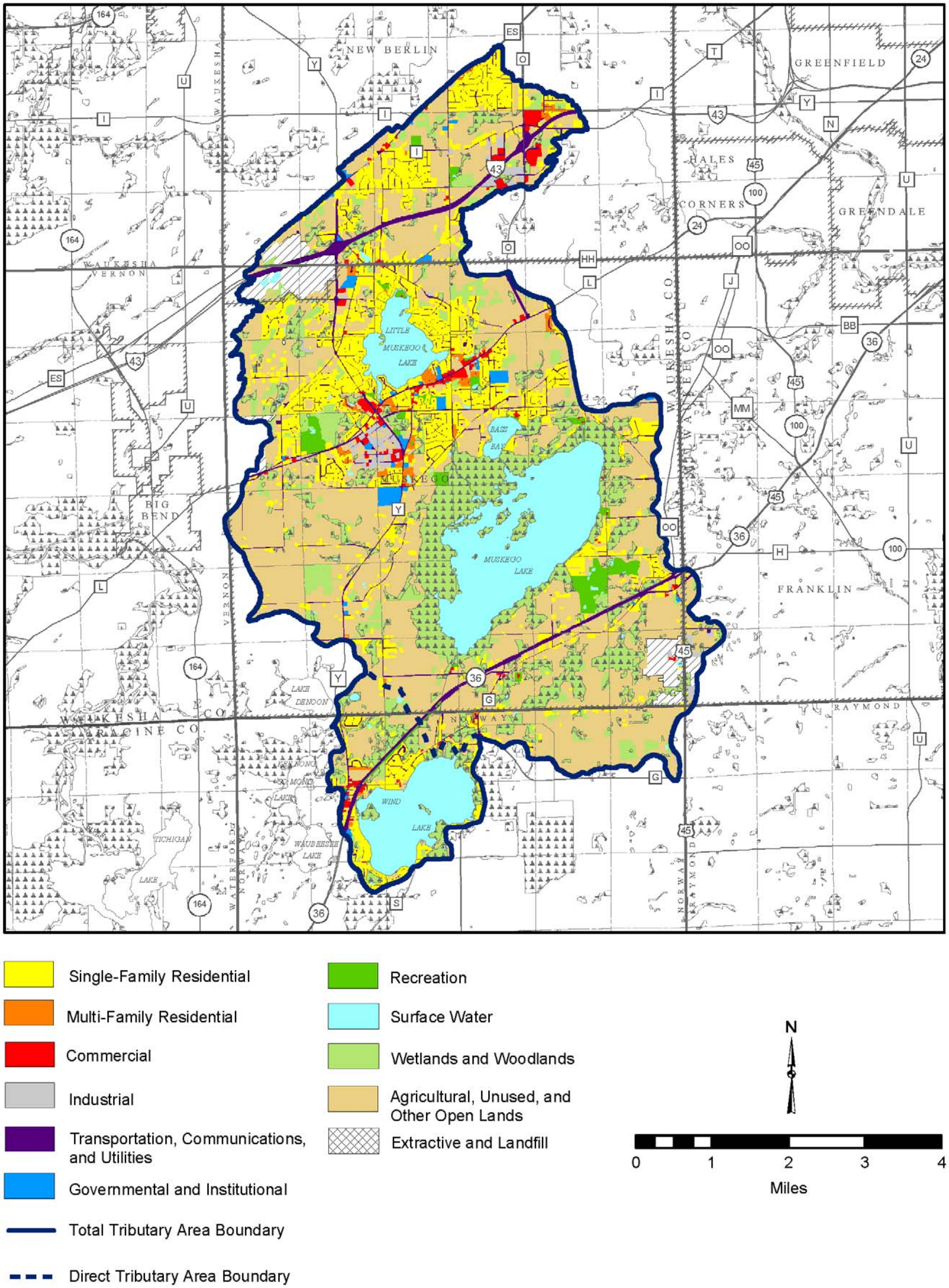
PLANNED LAND USE WITHIN THE AREA DIRECTLY TRIBUTARY TO WIND LAKE: 2020



Source: SEWRPC.

Map 13

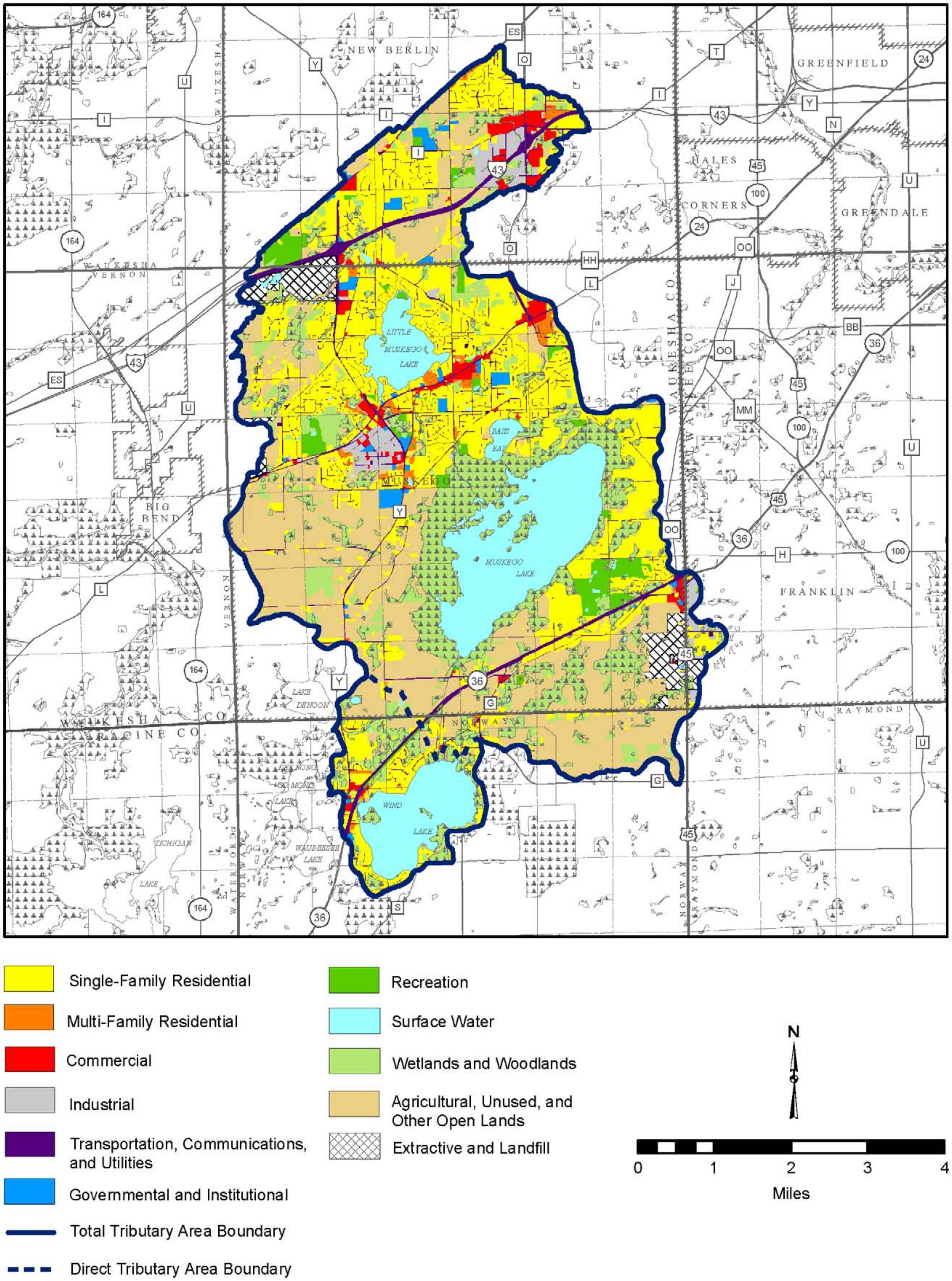
EXISTING LAND USE WITHIN THE AREA TRIBUTARY TO WIND LAKE: 2000



Source: SEWRPC.

Map 14

PLANNED LAND USE WITHIN THE AREA TRIBUTARY TO WIND LAKE: 2020



Source: SEWRPC.

Table 9

EXISTING AND PLANNED LAND USE WITHIN THE TOTAL AREA TRIBUTARY TO WIND LAKE: 2000 AND 2020

Land Use Categories[a]	2000 Acres	2000 Percent of Direct Tributary Drainage Area	2020 Acres	2020 Percent of Direct Tributary Drainage Area
Urban				
Residential	4,227	16.1	6,592	25.0
Commercial	225	0.9	445	1.7
Industrial	220	0.8	467	1.8
Governmental and Institutional	192	0.7	268	1.0
Transportation, Communication, and Utilities	1,873	7.0	2,620	10.0
Recreation	390	1.5	632	2.4
Subtotal	7,127	27.0	11,024	41.9
Rural				
Agricultural	10,262	39.0	6,404	24.3
Wetlands	3,358	12.8	3,358	12.8
Woodlands	1,333	5.1	1,297	4.9
Water	3,567	13.6	3,572	13.6
Extractive	369	1.4	302	1.1
Landfill	300	1.1	359	1.4
Subtotal	19,189	73.0	15,292	58.1
Total	26,316	100.0	26,316	100.0

[a]*Parking included in associated use.*

Source: SEWRPC.

Table 10

LAND USE REGULATIONS WITHIN THE TOTAL AREA TRIBUTARY TO WIND LAKE BY CIVIL DIVISION: 2000

Community	Type of Ordinance: General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Erosion Control and Stormwater Management
Racine County	Adopted	Adopted	Adopted	Adopted	None
Town of Norway	County	County ordinance	County ordinance	Adopted	Adopted
Town of Raymond	County	County ordinance	County ordinance	Adopted	Adopted
Milwaukee County	- -[b]	- -[b]	- -[b]	- -[b]	- -[b]
City of Franklin	Adopted	Adopted	Adopted	Adopted	Adopted
Waukesha County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources approved	Floodland and shoreland only	Adopted
City of Muskego	Adopted	Adopted	Adopted	Adopted	- -[a]
City of New Berlin	Adopted	Adopted	Adopted	Adopted	- -[a]
Town of Vernon	County	County ordinance	County ordinance	Adopted	- -[a]

[a]*Erosion control and stormwater management standards are built into other ordinances.*

[b]*Because Milwaukee County is comprised entirely of incorporated municipalities, all land use regulations are left to the local municipalities.*

Source: SEWRPC.

Shoreland Zoning
Under Section 59.692 of the *Wisconsin Statutes*, counties in Wisconsin are required to adopt zoning regulations within statutory shoreland areas, in their unincorporated areas. Statutory shoreland areas are defined as those lands within 1,000 feet of a navigable lake, pond, or flowage, or within 300 feet of a navigable stream, or to the landward side of the floodplain, whichever distance is greater. Minimum standards for county shoreland zoning ordinances are set forth in Chapter NR 115 of the *Wisconsin Administrative Code*. Chapter NR 115 sets forth minimum requirements regarding lot sizes and building setbacks; restrictions on cutting of trees and shrubbery; and restrictions on filling, grading, lagooning, dredging, ditching, and excavating that must be incorporated into county shoreland zoning regulations. In addition, Chapter NR 115, as recodified in 1980, requires that counties place all wetlands with an areal extent of five acres or larger and within the statutory shoreland zoning jurisdiction area in a wetland conservancy zoning district to ensure their preservation after completion of appropriate wetland inventories by the WDNR.

In 1982, the State Legislature extended shoreland-wetland zoning requirements to cities and villages in Wisconsin pursuant to Sections 62.231 and 61.351, respectively, of the *Wisconsin Statutes*. Cities and villages in Wisconsin are required to place wetlands with an areal extent of five acres or larger and located in statutory shorelands into a shoreland-wetland conservancy zoning district to ensure their preservation. Minimum standards for city and village shoreland-wetland zoning ordinances are set forth in Chapter NR 117 of the *Wisconsin Administrative Code*.

It should be noted that the basis for the identification of wetlands to be protected under both Chapters NR 115 and NR 117 is the Wisconsin Wetlands Inventory. Mandated by the State Legislature in 1978, the Wisconsin Wetlands Inventory resulted in the preparation of wetland maps covering each U.S. Public Land Survey township in the State. The inventory was completed for the counties in southeastern Wisconsin in 1982, the wetlands being delineated by the Regional Planning Commission on its 1980, one inch equals 2,000 feet scale, ratioed and rectified aerial photographs as noted in Chapter V of this report.

Within the total area tributary to Wind Lake, Racine and Waukesha Counties have each adopted a countywide shoreland zoning ordinance. The Towns of Norway, Raymond, and Vernon have adopted their county's shoreland zoning ordinance. The Cities of Franklin, Muskego, and New Berlin have adopted their own shoreland zoning ordinances, as shown in Table 10.

Subdivision Regulations
Chapter 236 of the *Wisconsin Statutes* requires the preparation of a subdivision plat whenever five or more lots of 1.5 acres or less in area are created, either at one time or by successive divisions within a period of five years. The *Statutes* set forth requirements for surveying lots and streets, for plat review and approval by State and local agencies, and for recording approved plats. Section 236.45 of the *Statutes* allows any city, village, town, or county that has established a planning agency to adopt a land division ordinance, provided the local ordinance is at least as restrictive as the State platting requirements. Local land division ordinances may include the review of other land divisions not defined as "subdivisions" under Chapter 236, such as when fewer than five lots are created or when lots larger than 1.5 acres are created.

The subdivision regulatory powers of towns and counties are confined to unincorporated areas. City and village subdivision control ordinances may be applied to extraterritorial areas, as well as to the incorporated areas. It is possible for both a county and a town to have concurrent jurisdiction over land divisions in unincorporated areas, or for a city or village to have concurrent jurisdiction with a town or county in the city or village extraterritorial plat approval area. In the case of overlapping jurisdiction, the most restrictive requirements apply. Within the total tributary area to Wind Lake, Racine and Waukesha Counties have each adopted a countywide subdivision zoning ordinance and the Towns and Cities within the tributary area have each adopted their own subdivision zoning ordinances, as shown in Table 10.

Construction Site Erosion Control and Stormwater Management Regulations
Section 62.23 of the *Wisconsin Statutes* grants authority to cities and villages in Wisconsin to adopt ordinances for the prevention of erosion from construction sites and the management of stormwater runoff from lands within their jurisdictions. Towns may adopt village powers and subsequently utilize the authority conferred on cities and villages under Section 62.23 to adopt their own erosion control and stormwater management ordinances, subject to county board approval where a county ordinance exists.

The administrative rules for the State stormwater discharge permit program are set forth in Chapter NR 216 of the *Wisconsin Administrative Code*, which initially took effect on November 1, 1994, and which was most recently recreated with effect from August 1, 2004. Within the total area tributary to Wind Lake, Milwaukee and Waukesha Counties, the Town of Vernon, and the Cities of Franklin, Muskego and New Berlin have been identified by the WDNR as being in urbanized areas that have been, or will be, required to obtain stormwater discharge permits unless they receive exemptions.

Through 1997 Wisconsin Act 27, the State Legislature required the WDNR and the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) to develop performance standards for controlling non-point source pollution from agricultural and nonagricultural lands and from transportation facilities.[5] Chapter NR 216 of the *Wisconsin Administrative Code* identifies several categories of municipalities, industries, and construction sites that must obtain permits. The permit requirements are based on the performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code*, which became effective on October 1, 2002 and which were revised in July 2004.

Agricultural Performance Standards
Agricultural performance standards cover the following areas:

- Cropland sheet, rill, and wind erosion control;
- Manure storage;
- Clean water diversions; and
- Nutrient management.

For existing lands that do not meet the Chapter NR 151 standards, and that was cropped or enrolled in the U.S. Department of Agriculture (USDA) Conservation Reserve Program (CRP) or Conservation Reserve Enhancement Program (CREP) as of October 1, 2002, agricultural performance standards are required to be met only if cost share funding is available. Existing cropland that met the standards as of October 1, 2002, must continue to meet the standards. New cropland must meet the standards, regardless of whether cost-share funds are available.

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[5]*The State performance standards are set forth in the Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code*. Additional Code chapters that are related to the State nonpoint source pollution control program include: Chapter NR 152, "Model Ordinances for Construction Site Erosion Control and Storm Water Management," Chapter NR 153, "Runoff Management Grant Program," Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions," and Chapter NR 155 "Urban Nonpoint Source Water Pollution Abatement and Stormwater Management Grant Program." Those chapters of the* Wisconsin Administrative Code *became effective in October 2002. Chapter NR 120, "Priority Watershed and Priority Lake Program," and Chapter NR 243, "Animal Feeding Operations," were repealed and recreated in October 2002. The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) revised Chapter ATCP 50, "Soil and Water Resource Management," to incorporate changes in DATCP programs as required under 1997 Wisconsin Act 27.*

Nonagricultural (urban) Performance Standards
The nonagricultural performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code* encompass two major types of land management. The first includes standards for areas of new development and redevelopment and the second includes standards for developed urban areas. The performance standards address the following areas:

- Construction sites for new development and redevelopment,
- Post construction phase for new development and redevelopment,
- Developed urban areas, and
- Nonmunicipal property fertilizing.

Chapter NR 151 requires municipalities with WPDES stormwater discharge permits to reduce the amount of total suspended solids, to the maximum extent practicable, in stormwater runoff from areas of existing development that were in place as of October 2004, according to the following standards:

- By March 10, 2008, a 20 percent reduction, and
- By October 1, 2013, a 40 percent reduction.

Also, permitted municipalities must implement: 1) public information and education programs relative to specific aspects of nonpoint source pollution control; 2) municipal programs for the collection and management of leaf and grass clippings; and, 3) site-specific programs for the application of lawn and garden fertilizers on municipally controlled properties with over five acres of pervious surface. Under the requirements of Chapter NR 151, by March 10, 2008, incorporated municipalities with average population densities of 1,000 people per square mile or more, that are not required to obtain municipal stormwater discharge permits, also must implement these same programs.

Regardless of whether a municipality is required to have a stormwater discharge permit under Chapter NR 216 of the *Wisconsin Administrative Code*, Chapter NR 151 requires that all construction sites that disturb one acre or more of land must achieve an 80 percent reduction in the sediment load generated by the site. With certain limited exceptions, those sites required to have construction erosion control permits must also have post-development stormwater management practices to reduce the total suspended solids load from the site by 80 percent for new development, 40 percent for redevelopment, and 40 percent for infill development occurring prior to October 1, 2012. After October 1, 2012, infill development will be required to achieve an 80 percent reduction. If it can be demonstrated that the solids reduction standard cannot be met for a specific site, total suspended solids must be controlled to the maximum extent practicable.

Stormwater management practices in urban areas, under the provisions of Section NR 151.12 of the *Wisconsin Administrative Code*, require infiltration, subject to specific exclusions and exemptions as set forth in Sections 151.12(5)(c)5 and 151.12(5)(c)6, respectively. In residential areas, either 90 percent of the predevelopment infiltration volume or 25 percent of the post-development runoff volume from a two-year recurrence interval, 24-hour storm, is required to be infiltrated. However, no more than 1 percent of the area of the project site is required to be used as effective infiltration area; in commercial, industrial and institutional areas, 60 percent of the predevelopment infiltration volume or 10 percent of the post-development runoff volume from a two-year recurrence interval, 24-hour storm, is required to be infiltrated, provided that no more than 2 percent of the rooftop and parking lot areas are required to be used as effective infiltration area. Impervious area setbacks of 50 feet from streams, lakes, and wetlands generally apply. This setback distance is increased to 75 feet around Chapter NR 102-designated Outstanding or Exceptional Resource Waters or Chapter NR 103-designated wetlands of special natural resource interest. However, reduced setbacks from less susceptible wetlands and drainage channels of not less than 10 feet may be allowed.

In addition to these provisions, Section NR 151.13 of the *Wisconsin Administrative Code* requires municipalities to implement informational and educational programming to promote good housekeeping practices in developed urban areas, as well as related operational programs in those municipalities subject to stormwater permitting requirements pursuant to Chapter NR 216 of the *Wisconsin Administrative Code*.

Within the total tributary area of Wind Lake, as of 2000, Waukesha County, the Town of Raymond, and the City of Franklin each had adopted their own construction site erosion control and stormwater management ordinances, and the Towns of Norway and Vernon and the Cities of Muskego and New Berlin had erosion control and stormwater management ordinances built into other ordinances. Racine County had not adopted erosion control or stormwater management ordinances.

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Chapter IV

WATER QUALITY

INTRODUCTION

The earliest data on water quality conditions in Wind Lake date back to the early 1900s, when E.A. Birge and C. Juday, widely recognized pioneering lake researchers from the University of Wisconsin-Madison, collected basic information on the Lake.[1] However, most water quality information is relatively recent. Prior to 1985, some limited data on Wind Lake water quality was collected by Tri-Lakes Conservation. A Wisconsin Department of Natural Resources (WDNR) study in 1966 indicated that the water quality of Wind Lake was in a state of decline.[2] Subsequently, the U. S. Geological Survey (USGS) and the Wind Lake Management District (WLMD) monitored various water quality parameters in Wind Lake between February 1985 and August 1987. The results of these investigations indicated that the lake had degraded water quality and was considered to be highly eutrophic. Consequently, the WLMD requested the USGS to conduct a hydrologic and water quality investigation of the Lake and its tributary area in order to determine phosphorus loads to the Lake from its tributary area, the atmosphere, and groundwater. Phosphorus generally is considered to be the nutrient most likely to cause enhanced growth of aquatic plants in inland lakes, and engender conditions that detract from the fishable and swimmable water quality goals of the Federal Clean Water Act. As part of this latter study, tributary area data were collected in 1988 and 1989 and in-lake water quality monitoring was undertaken in 1989 and 1990.[3] In 1990, the WLMD requested the Southeastern Wisconsin Regional Planning Commission (SEWRPC) to develop a comprehensive management plan for Wind Lake. The purpose of this planning project, among other things, was to describe, evaluate, and recommend measures to improve water quality in the Lake.[4]

Water chemistry data for Wind Lake have also been collected under the auspices of various WDNR programs: the Self-Help Monitoring Program from 1988 through 1990, the Base Line Monitoring Program in 2001, and the

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[1]*E.A. Birge and C. Juday*, *"The Inland Lakes of Wisconsin, 1. The Dissolved Gases and their Biological Significance,"* Bulletin of the Wisconsin Geological and Natural History Survey*, Volume 22, 1911*.

[2]*Wisconsin Department of Natural Resources Lake Use Report No. FX-5,* Wind Lake, Racine County, Wisconsin, *1969.*

[3]*U. S. Geological Survey Water-Resources Investigations Report 91-4107,* Hydrology and Water Quality of Wind Lake in Southeastern Wisconsin, *1993.*

[4]*SEWRPC Community Assistance Planning Report No. 198,* A Management Plan for Wind Lake, Racine County, Wisconsin, *1991.*

Small Lake Grant Program in 2005. USGS water quality monitoring at Wind Lake has been ongoing since 1985 to the present and has involved the determination of the physical and chemical characteristics of the lake water, including dissolved oxygen concentration and water temperature profiles, pH, specific conductance, water clarity, and nutrient and chlorophyll-*a* concentration measurements.

EXISTING WATER QUALITY CONDITIONS

Water quality data gathered primarily by the USGS, together with some data gathered under the auspices of the abovementioned WDNR programs, were used to assess water quality in Wind Lake. For purposes of the initial SEWRPC lake management plan for Wind Lake, USGS data for the period from 1985 through 1989 were used to determine water quality conditions in the Lake, and to characterize the suitability of the Lake for recreational use and for the support of fish and aquatic life. These data are supplemented with more recent data, collected during the period from 1989 through 2005, to determine and evaluate current water quality conditions in the Lake. Water quality samples generally were taken seasonally from the main basin of the Lake and from the lake outlet to the Wind Lake Drainage Canal, as shown on Map 15. In the discussion below, where it is appropriate as a means to reveal trends or draw comparisons, data from the aforereferenced 1966 WDNR report will be included in discussions comparing data from the initial SEWRPC report of 1991 with data collected as part of the current study.

Thermal Stratification

Thermal stratification, illustrated diagrammatically in Figure 2, is a result of the differential heating of the lake water, and the resulting water temperature-density relationships at various depths within the lake water column. Water is unique among liquids because it reaches its maximum density, or mass per unit of volume, at about 39 degrees Fahrenheit (°F). The development of summer thermal stratification begins in early summer, reaches its maximum in late summer, and disappears in the fall. Stratification may also occur during winter under ice cover. In certain shallow lakes, this cycle also can occur during periods of wind stress on the lake surface, causing such mixing to occur more frequently that two times per year. The annual thermal cycle within Wind Lake is described below.

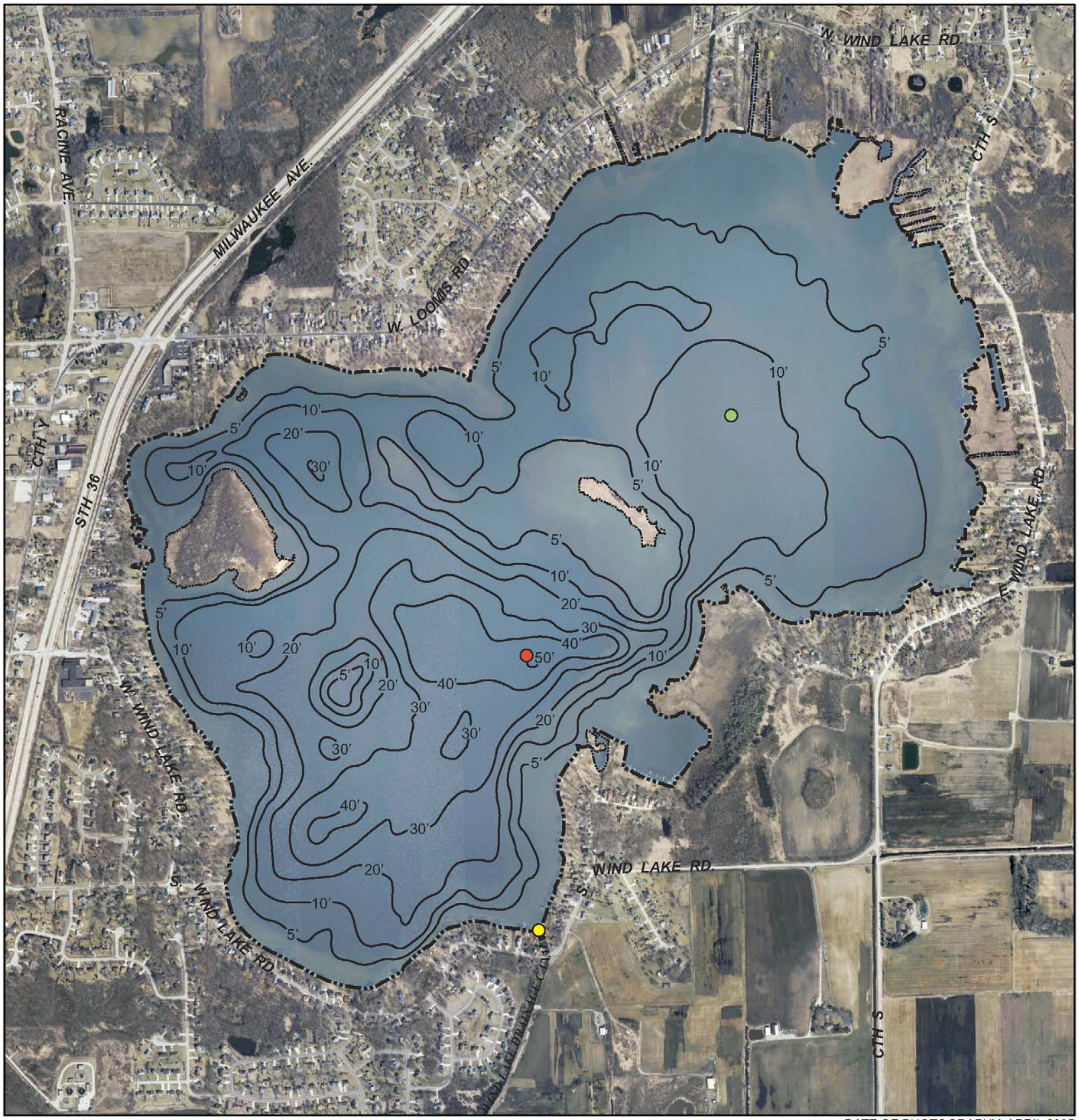
As summer begins, the Lake absorbs solar energy at the surface. Wind action and, to some extent, internal heat transfer mechanisms transmit this energy to the underlying portions of the waterbody. As the upper layer of water is heated by solar energy, a physical barrier, created by differing water densities between warmer and cooler water, begins to form between the warmer surface water and the colder, heavier bottom water, as shown in Figure 2. This "barrier" is marked by a sharp temperature gradient known as the thermocline (also called the metalimnion) and is characterized by a 1 degree Celsius (°C) drop in temperature per one meter of depth (or about a 2°F drop in temperature per three feet of depth) that separates the warmer, lighter, upper layer of water (called the epilimnion) from the cooler, heavier, lower layer (called the hypolimnion), as shown in Figure 3. Although this barrier is readily crossed by fish, provided sufficient oxygen exists, it essentially prohibits the exchange of water between the two layers. This condition has a major impact on both the chemical and biological activity in a lake.

During the WDNR study, Wind Lake was reported to stratify during summer at a depth of about 20 feet.[5] During the initial SEWRPC study period, Wind Lake thermal data indicated the Lake also was strongly thermally stratified during summer, with the epilimnion extending from the surface to a depth of about 13 feet in July. The thermocline or metalimnion extended from a depth of 13 feet to a depth of about 30 feet, while the hypolimnion extended from the 30 foot depth to the bottom. As shown in Figure 4, during the current study period, this pattern has continued, although the intensity of thermal stratification was stronger in some years compared with others. For example, during the period of record from 1994 through 2005, Wind Lake was weakly stratified with respect to temperature during June of 1996, during June of 2000, and during the summer of 2004. The thermocline during these latter periods was poorly developed in comparison with the intervening years, when there was a marked

[5]*Wisconsin Department of Natural Resources Lake Use Report No. FX-5,* op. cit.

Map 15

LOCATION OF WATER QUALITY SAMPLING SITES ON WIND LAKE



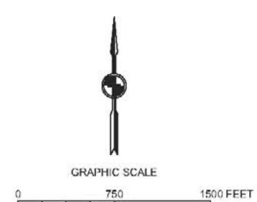
DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

MONITORING SITE (1985-2005)

MONITORING SITE (1985-2005)

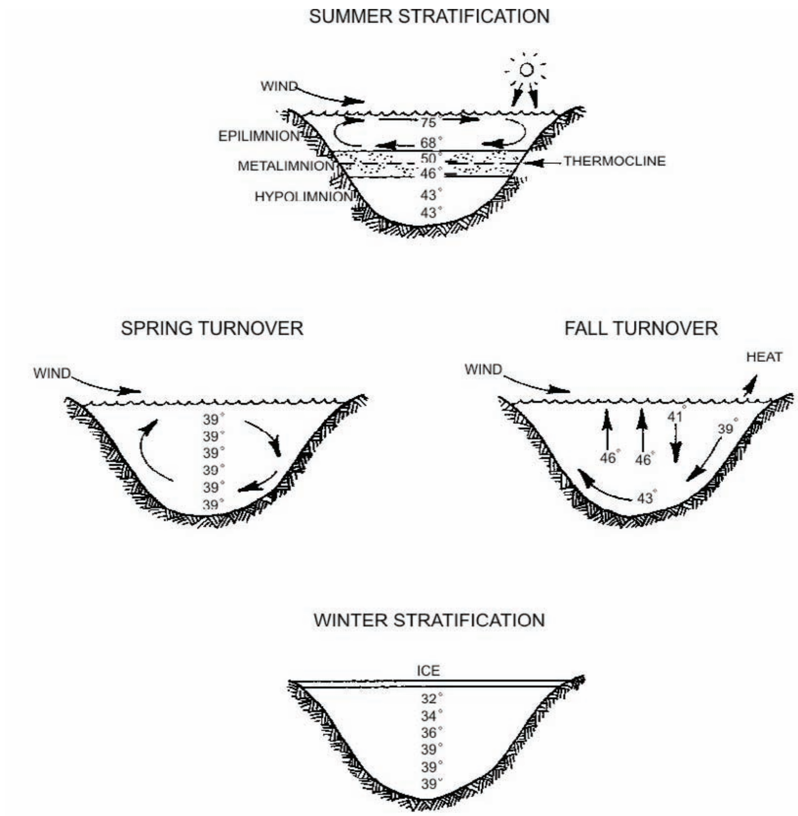
MONITORING SITE (1997-1998)



Source: U.S. Geological Survey and SEWRPC.

Figure 2

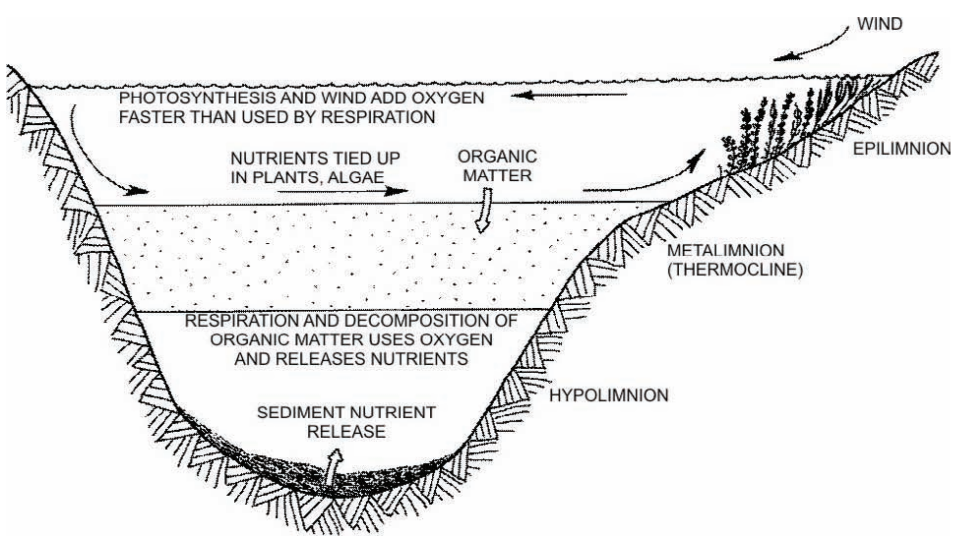
THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

Figure 3

LAKE PROCESSES DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

Figure 4

DISSOLVED OXYGEN AND TEMPERATURE PROFILES FOR WIND LAKE: 1994-2005

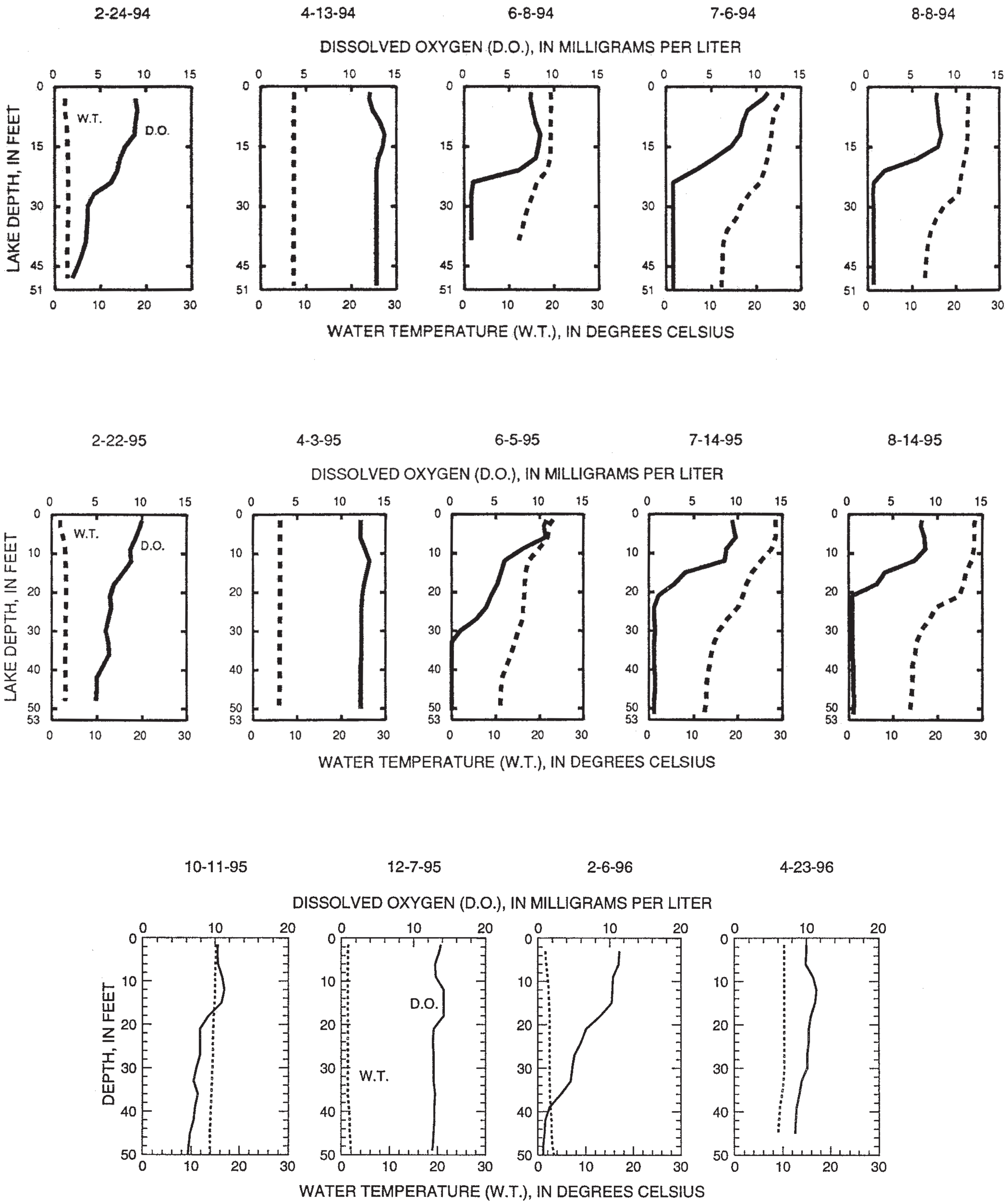


Figure 4 (continued)

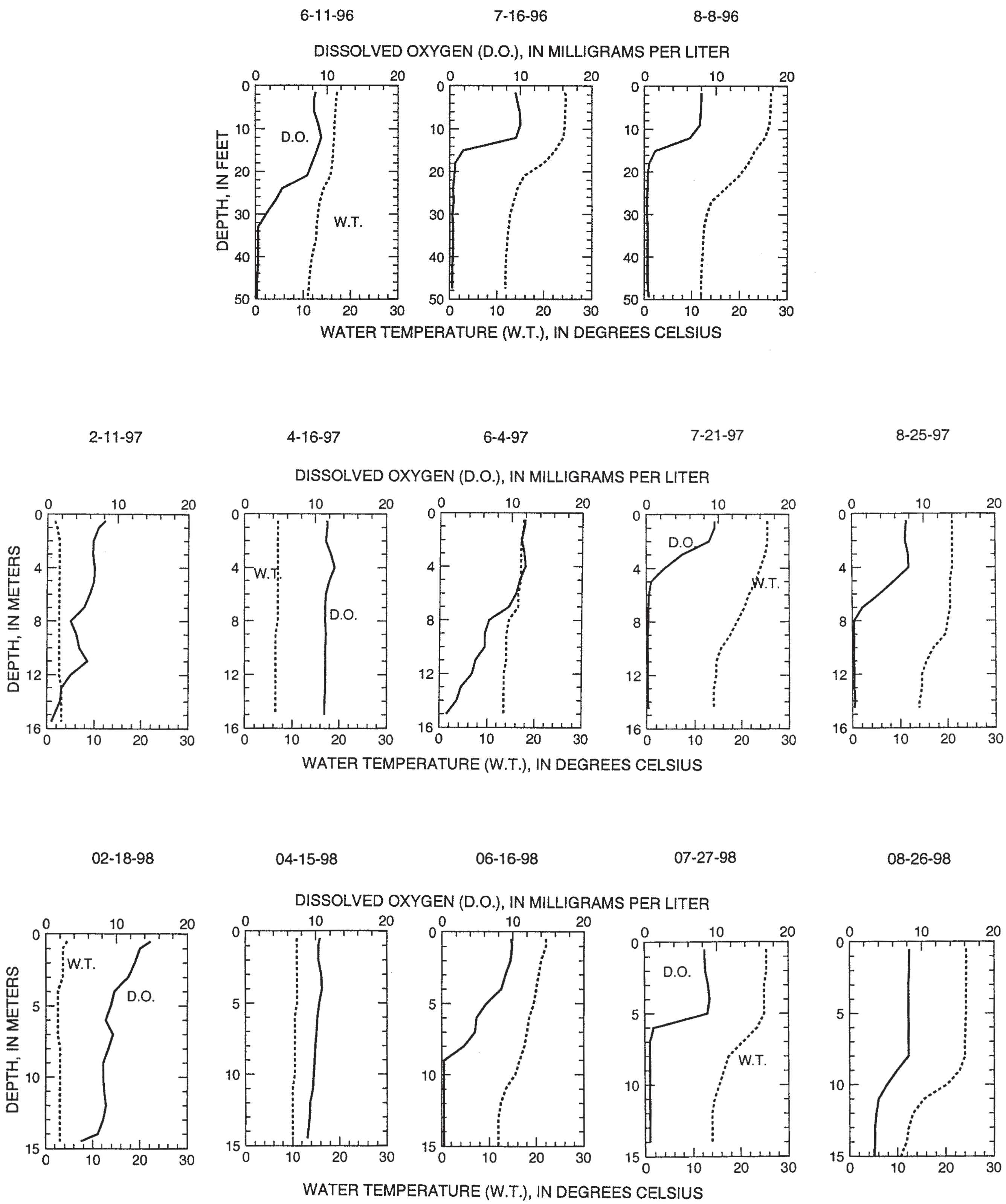


Figure 4 (continued)

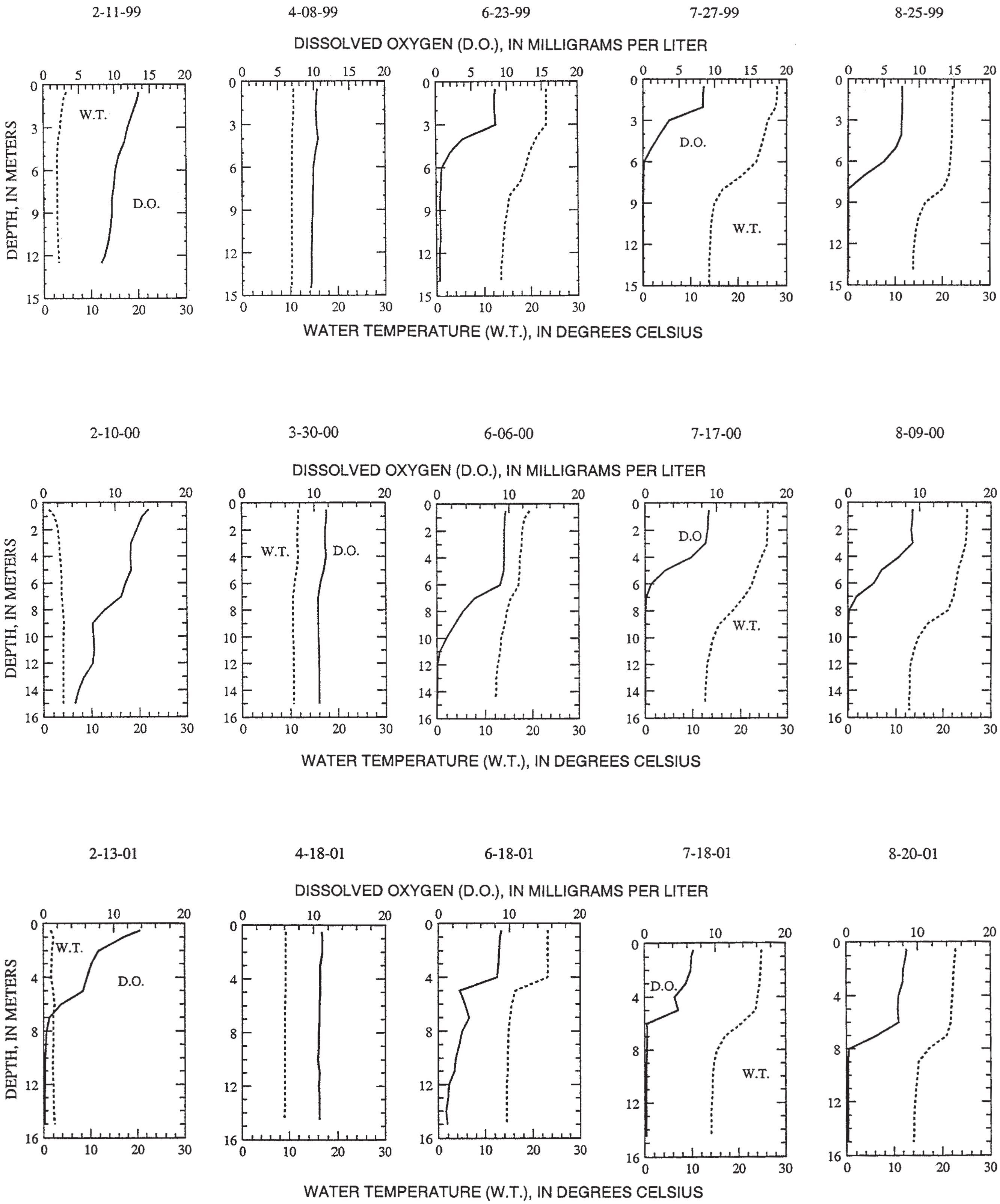


Figure 4 (continued)

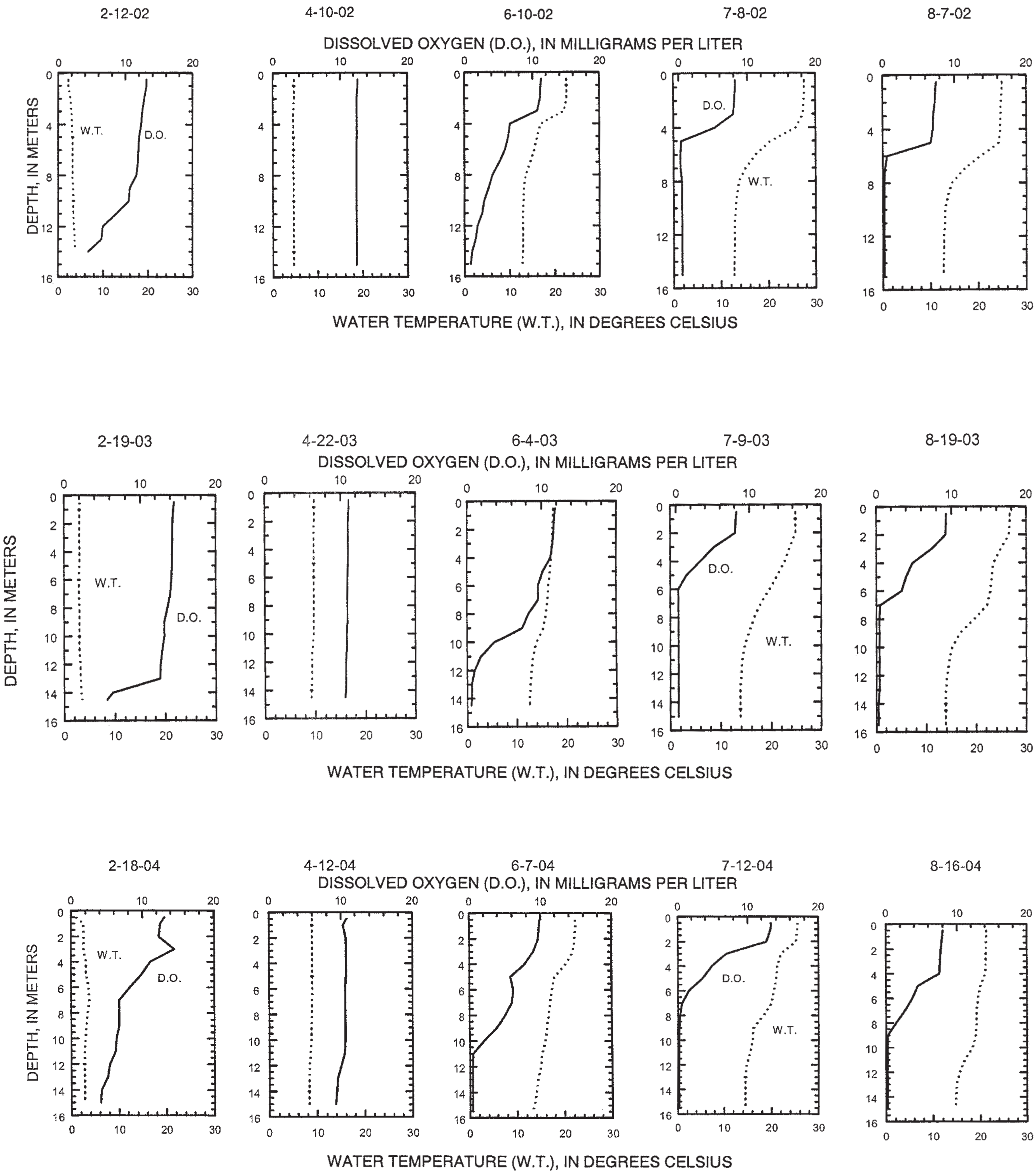
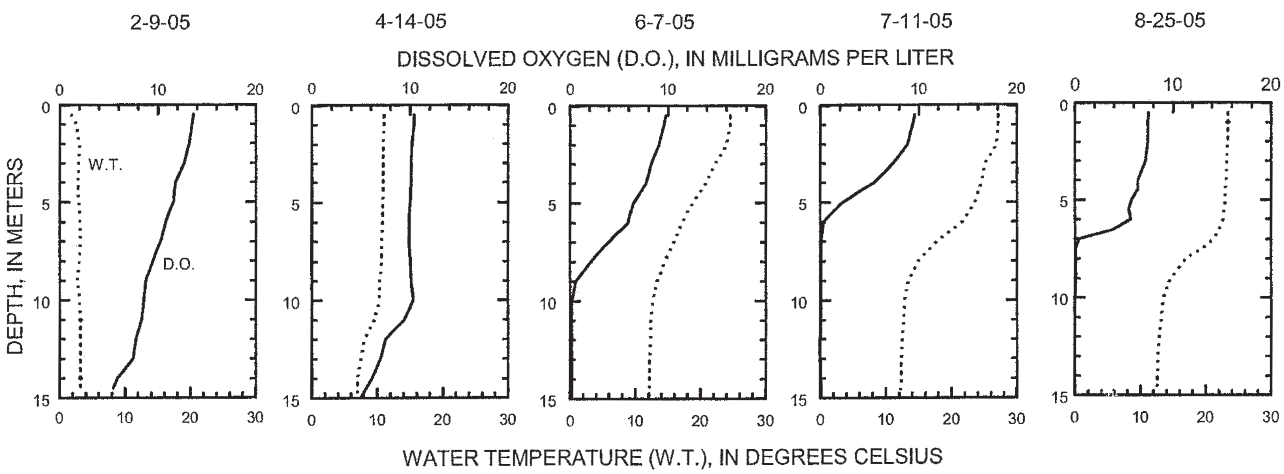


Figure 4 (continued)



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

temperature gradient observed in the Lake during the months of June, July, and August. Stratification usually occurred at a depth of about 15 feet to 20 feet during this period of record, as had been observed during the previous studies. In most years, the Lake was stratified with respect to temperature during the months of July and August.

The autumnal mixing period occurs when air temperatures cool the surface water and wind action results in the erosion of the thermocline: as the surface water cools, it becomes heavier, sinking and displacing the now relatively warmer water below. The colder water sinks and mixes under wind action until the entire column of water is of uniform temperature, as shown in Figure 2. This action, which follows summer stratification, is known as “fall turnover.”

From fall turnover until freeze-up, surface waters continue to cool in response to the continued decline in ambient air temperatures. Water is unique among liquids because it reaches its maximum density, or mass per unit of volume, at about 39°F (4°C). Once the temperature of the water at the surface drops to this point of maximum water density, these waters will now have become denser than the warmer waters below them. As a consequence of this density difference, the surface waters begin to “sink” to the bottom. Eventually, the entire water column is cooled to the point of maximum density at. The surface waters continue to cool until they reach about 32°F, and are, once again, less dense than the waters below which remain at about 39°F. At 32°F, the lake surface may then become ice covered, isolating the lake water from the atmosphere for a period of up to four months. As shown in Figure 2, winter stratification occurs as the colder, lighter water and ice remains at the surface, separated from the relatively warmer, heavier water near the bottom of the lake. The ice shuts the water column off from the atmospheric source of oxygen. Temperature profiles of Wind Lake during the winter months, typically obtained during the month of February as shown in Figure 4, typically suggest that Wind Lake rarely exhibits significant thermal stratification during the winter, although oxygen depletion can be seen in the hypolimnion during this period.

Spring brings a reversal of the process of lake stratification. Once the surface ice has melted, the upper layer of water continues to warm until it reaches 39°F, the maximum density point of water and, coincidentally, the temperature of the deeper waters below it. At this point, the entire water column is, once again, the same temperature (and density) from surface to bottom and wind action results in a mixing of the entire lake. This is referred to as “spring turnover” and usually occurs within weeks after the ice goes out, as shown in Figure 2 and in the spring temperature and oxygen profiles for Wind Lake shown in Figure 4, typically obtained during April.

After spring turnover, the water at the surface continues to warm and become less dense, causing it to float above the colder, deeper water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus begins the formation of the thermocline and another period of summer thermal stratification.

Thermal profiles for Wind Lake during the current study period, as shown in Figure 4, indicate that the Lake is subject to thermal stratification during summer and winter and is, therefore, dimictic, which means that it mixes completely two times per year. During the current study period, water temperatures in Wind Lake ranged from a minimum of 32°F during the winter to a maximum of about 82.5°F during the summer, as shown in Table 11. This range on water temperatures was approximately the same as that measured during the initial SEWRPC study.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem, since most organisms require oxygen to survive. As shown in Figure 4, dissolved oxygen levels were generally higher at the surface of Wind Lake, where there was an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels were lowest on the bottom of the Lake, where decomposer organisms and chemical oxidation processes utilized oxygen in the decay process. When any lake becomes thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion is cut off. Gradually, if there is not enough dissolved oxygen to meet the total demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced, even to zero, a condition known as anoxia or anaerobiasis, as shown in Figure 3.

As reported in the aforementioned WDNR report, during August of 1966, dissolved oxygen concentrations ranged from about 7.5 milligrams per liter (mg/l) at the surface to zero at a depth of about 25 feet. During the initial SEWRPC study period, dissolved oxygen concentrations ranged from about 17.7 mg/l during winter to about 6.9 mg/l during summer, near the surface waters of Wind Lake. Hypolimnetic dissolved oxygen concentrations were reported to drop to zero during winter and during late summer, with the anoxic zone reaching a maximum during July, when dissolved oxygen levels were at or near zero at water depths greater than 15 feet.

This pattern continued to be observed during the current study period, with the hypolimnion of Wind Lake becoming anoxic during summer stratification. Winter anoxia was less frequently observed, but was recorded during February of 2001; during February of 1996 and 1997, extremely low dissolved oxygen concentrations in the bottom waters of Wind Lake, approaching anoxia, also were recorded. Dissolved oxygen concentrations at the bottom of the Lake frequently fell to zero by mid- to late-June, as shown in Figure 4. Even at a depth of approximately 20 feet, oxygen concentrations were at or below the recommended concentration of 5.0 mg/l, the minimum level necessary to support many species of fish during most years studied.

Fall turnover, between September and October in most years, naturally restores the supply of oxygen to the bottom water, although hypolimnetic anoxia can be reestablished during the period of winter thermal stratification. Winter anoxia is more common during the years of heavy snowfall, when snow covers the ice, reducing the degree of light penetration and reducing algal photosynthesis that takes place under the ice. In Wind Lake during the initial study period, hypolimnetic anoxia did occur during winter stratification in some years, such as is shown for February 2001, and was closely approached in other years, such as is shown for February 1996 and February 1997. Under these conditions, anoxia can contribute to the winter-kill of fish, although there are few recorded instances of winterkill reported from Wind Lake. The initial plan notes that limited fish mortality during winter was observed in the shallow bays of the Lake during winters of 1987-1988 and 1988-1989. At the end of winter, dissolved oxygen concentrations in the bottom waters of the Lake were restored during the period of spring turnover, which generally occurs between March and May.

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 concentration 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

Table 11

SEASONAL WATER QUALITY CONDITIONS IN WIND LAKE: 1973-2005

Parameter[a]	Fall (mid-September to mid-December)		Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Physical Properties								
Alkalinity, as $CaCO_3$								
Range	- -	- -	- -	- -	150-191	150-194	- -	- -
Mean	- -	- -	- -	- -	176	179	- -	- -
Standard Deviation	- -	- -	- -	- -	11.6	15.2	- -	- -
Number of Samples	- -	- -	- -	- -	16	7	- -	- -
Color								
Range	- -	- -	- -	- -	15-40	30-50	- -	- -
Mean	- -	- -	- -	- -	29	35	- -	- -
Standard Deviation	- -	- -	- -	- -	6.2	8.0	- -	- -
Number of Samples	- -	- -	- -	- -	15	8	- -	- -
Dissolved Oxygen								
Range	10.4-13.8	6.2-12.6	8.2-17.1	0-9.4	7.5-14	0-12.8	6.0-13.3	0.0-0.8
Mean	12.1	9.4	12.5	2.7	10.9	5.6	8.6	0.25
Standard Deviation	2.4	4.5	2.6	3.4	1.4	5.3	1.2	0.29
Number of Samples	2	2	21	8	38	15	47	15
pH (units)								
Range	8.2-8.5	8.1-8.5	7.3-9.2	7-7.6	7.1-8.7	7.2-8.5	7.8-8.7	6.8-7.4
Mean	8.3	8.3	8.0	7.3	8.2	7.9	8.3	7.14
Standard Deviation	0.2	0.2	0.4	0.2	1.3	0.4	0.2	0.15
Number of Samples	2	2	21	8	38	15	47	15
Secchi Depth (feet)								
Range	3.3-3.6	- -	1.9-2.6	- -	1.6-10.8	- -	1.3-6.8	- -
Mean	3.4	- -	2.3	- -	4.5		4.0	- -
Standard Deviation	0.2	- -	0.4	- -	2.0		1.3	- -
Number of Samples	2	- -	2	- -	39		43	- -
Specific Conductance (µS/cm)								
Range	512-548	522-545	462-814	637-908	457-872	455-652	461-711	502-664
Mean	530	533	641	778.2	613	566	590	606
Standard Deviation	25.4	16.2	80.6	96.4	77.5	58.4	58.4	42.2
Number of Samples	2	2	20	8	36	15	47	15
Temperature (°F)								
Range	34.7-59.9	35.6-57.2	33.8-40.8	35.9-39.2	40.4-76.2	41.3-58.1	65.3-83.3	53.0-59.9
Mean	47.3	46.4	36.6	37.6	56.5	48.6	76.1	55.5
Standard Deviation	17.8	15.2	2.0	1.3	10.8	4.9	4.1	2.2
Number of Samples	2	2	21	8	38	15	47	15
Turbidity (NTU)								
Range	- -	- -	- -	- -	1-8	2.7-6.5	- -	- -
Mean	- -	- -	- -	- -	3.2	3.9	- -	- -
Standard Deviation	- -	- -	- -	- -	1.5	1.4	- -	- -
Number of Samples	- -	- -	- -	- -	16	7	- -	- -
Metals/Salts								
Dissolved Calcium								
Range	- -	- -	- -	- -	41.4-54.0	44.0-50.0	- -	- -
Mean	- -	- -	- -	- -	48.3	47.8	- -	- -
Standard Deviation	- -	- -	- -	- -	3.7	2.4	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -

Table 11 (continued)

Parameter[a]	Fall (mid-September to mid-December)		Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Metals/Salts (continued)								
Dissolved Chloride								
Range	- -	- -	- -	- -	0.2-110	0.2-62	- -	- -
Mean	- -	- -	- -	- -	54.5	42.4	- -	- -
Standard Deviation	- -	- -	- -	- -	25.9	20.2	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -
Dissolved Iron (µg/l)								
Range	- -	- -	- -	- -	5-50	5-25	- -	- -
Mean	- -	- -	- -	- -	24	19.2	- -	- -
Standard Deviation	- -	- -	- -	- -	18.3	9.7	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -
Dissolved Magnesium								
Range	- -	- -	- -	- -	23.0-32.1	23-31	- -	- -
Mean	- -	- -	- -	- -	28.0	27.4	- -	- -
Standard Deviation	- -	- -	- -	- -	2.4	3.6	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -
Dissolved Manganese (µg/l)								
Range	- -	- -	- -	- -	0.2-20	0.8-20	- -	- -
Mean	- -	- -	- -	- -	8.0	14.8	- -	- -
Standard Deviation	- -	- -	- -	- -	9.8	8.8	- -	- -
Number of Samples	- -	- -	- -	- -	13	7	- -	- -
Dissolved Potassium								
Range	- -	- -	- -	- -	3.0-3.5	3.0-3.4	- -	- -
Mean	- -	- -	- -	- -	3.1	3.1	- -	- -
Standard Deviation	- -	- -	- -	- -	0.2	0.1	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -
Dissolved Silica								
Range	- -	- -	- -	- -	0.00-0.57	0.1-0.1	- -	- -
Mean	- -	- -	- -	- -	0.09	0.1	- -	- -
Standard Deviation	- -	- -	- -	- -	0.13	0.0	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -
Dissolved Sodium								
Range	- -	- -	- -	- -	20.0-54.3	20.0-31.0	- -	- -
Mean	- -	- -	- -	- -	33.5	24.8	- -	- -
Standard Deviation	- -	- -	- -	- -	10.3	3.7	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -
Dissolved Sulfate SO_4								
Range	- -	- -	- -	- -	30-51	30-51	- -	- -
Mean	- -	- -	- -	- -	39.9	39.4	- -	- -
Standard Deviation	- -	- -	- -	- -	7.1	8.4	- -	- -
Number of Samples	- -	- -	- -	- -	15	7	- -	- -
Nutrients								
Dissolved Nitrogen, Ammonia								
Range	- -	- -	- -	- -	0.07-0.35	0.11-0.39	0.006-0.037	- -
Mean	- -	- -	- -	- -	0.16	0.24	0.014	- -
Standard Deviation	- -	- -	- -	- -	0.08	0.12	0.011	- -
Number of Samples	- -	- -	- -	- -	15	7	7	- -

Table 11 (continued)

Parameter[a]	Fall (mid-September to mid-December)		Winter (mid-December to mid-March)		Spring (mid-March to mid-June)		Summer (mid-June to mid-September)	
	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]	Shallow[b]	Deep[c]
Nutrients (continued)								
Dissolved Nitrogen, NO_2+NO_3								
Range	- -	- -	- -	- -	0.07-0.51	0.12-0.39	0.005-0.05	- -
Mean	- -	- -	- -	- -	0.24	0.25	0.028	- -
Standard Deviation	- -	- -	- -	- -	0.10	0.09	0.020	- -
Number of Samples	- -	- -	- -	- -	16	7	5	- -
Total Nitrogen, Organic								
Range	- -	- -	- -	- -	0.97-1.70	0.98-1.4	- -	- -
Mean	- -	- -	- -	- -	1.39	1.19	- -	- -
Standard Deviation	- -	- -	- -	- -	0.37	0.21	- -	- -
Number of Samples	- -	- -	- -	- -	3	3	- -	- -
Dissolved Orthophosphorus								
Range	- -	- -	- -	0.38	0.001-0.005	0.001-0.101	0.001-0.003	- -
Mean	- -	- -	- -	0.38	0.001	0.015	0.001	- -
Standard Deviation	- -	- -	- -	- -	0.001	0.032	0.001	- -
Number of Samples	- -	- -	- -	1	12	9	6	- -
Total Phosphorus								
Range	0.039-0.056	0.046-0.113	0.01-0.09	0.03-0.60	0.009-0.144	0.015-0.470	0.017-0.132	0.045-0.620
Mean	0.047	0.083	0.04	0.18	0.046	0.116	0.037	0.39
Standard Deviation	0.012	0.03	0.02	0.27	0.025	0.124	0.021	0.13
Number of Samples	2	3	15	4	37	19	55	19
Biological								
Chlorophyll-*a* (μg/l)								
Range	- -	- -	65	- -	1.41-130	- -	0.02-59	- -
Mean	- -	- -	65	- -	21.5	- -	14.5	- -
Standard Deviation	- -	- -	- -	- -	22.5	- -	10.4	- -
Number of Samples	- -	- -	1	- -	36	- -	47	- -

[a]*Milligrams per liter (mg/l) unless otherwise indicated.*

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

[c]*Depth of sample greater than 45 feet.*

Source: U.S. Geological Survey and SEWRPC.

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. Summer fish kills have not been reported from Wind Lake.

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 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 Wind Lake is discussed further below.

Specific Conductance

Specific conductance, the ability of water to conduct an electric current, is an indicator of the concentration of dissolved solids in the water; as the amount of dissolved solids increases, the specific conductance increases. As such, specific conductance is often useful as an indication of possible pollution in a lake’s waters. Freshwater lakes commonly have a specific conductance range of from 10 to 1,000 microSiemens per centimeter (µS/cm), although measurements in polluted waters or in lakes receiving large amounts of land runoff can sometimes exceed 1,000 µS/cm.[6] Additionally, during periods of thermal stratification, specific conductance can increase at the lake bottom due to an accumulation of dissolved materials in the hypolimnion. This is a consequence of the “internal loading” phenomenon noted above.

In the earlier WDNR study, specific conductivity near the surface during spring was 48 µS/cm at 25°C; during late summer, measurements ranged from 498 µS/cm at a depth of nine feet, to 512 µS/cm at a depth of 30 feet. As reported in the initial SEWRPC planning study, surface to bottom conductivity gradients also were observed, especially during the summer period when specific conductance increased with depth from between 522 µS/cm and 565 µS/cm near the surface to between 591 µS/cm and 648 µS/cm at depth. During the spring turnover events observed between 1985 through 1989, the specific conductance of Wind Lake ranged from 529 µS/cm to 591 µS/cm, values considered within the normal range for lakes in the Southeastern Wisconsin Region.[7]

During the current study period, the specific conductance of the surface waters of Wind Lake during summer ranged from 563 to 712 µS/cm at 25°C, as shown in Table 11. Surface to bottom gradients in specific conductance were observed during most years, with hypolimnetic conductance values ranging from 609 to 774 µS/cm. Similar gradients were observed during the period of winter ice-cover, when specific conductance values ranged from 547 µS/cm at the surface to 916 µS/cm in the hypolimnion. Surface to bottom gradients in specific conductance during both summer and winter were more pronounced during certain years, compared to others, as shown in Figure 4. These ranges were generally more extensive than those measured during the initial study, with the upper extreme values being significantly higher that previously reported. Areawide increases in specific conductance over the years appear to be associated with the increasing chloride concentrations observed in area lakes. Such increases in specific conductance, when continued over the longer term, can serve as an indicator of increasing mineralization in the Region’s lakes, with concomitant and potentially deleterious effects on the plants and animals inhabiting these environments.

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[6]*Deborah Chapman,* Water Quality Assessments, second edition, *E&FN Spon, 1996.*

[7]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983.*

Chloride

At high concentrations, chloride can directly affect aquatic plant growth and pose a threat to aquatic organisms. The effects of chloride contamination begin to manifest themselves at about 250 mg/l, and become severe at concentrations in excess of 1,000 mg/l.[8] Natural chloride concentrations in lake water are directly affected by leaching from underlying bedrock and soils, and by deposition from precipitation events. Higher concentrations can reflect pollution. Lakes in southeastern Wisconsin typically have very low natural chloride concentrations due to the limestone bedrock found in the Region. Limestone is primarily composed of calcium carbonate and magnesium carbonate, and, as such, is rich in carbonates rather than chlorides. Hence, the sources of chloride in southeastern Wisconsin are largely anthropogenic, including sources, such as salts used on streets and highways for winter snow and ice control, salts discharged from water softeners, and salts from sewage and animal wastes. The significance of human-originated chlorides is reflected in the chloride concentrations found in lakes in the different regions of Wisconsin, where geological sources of the element are rare. Chloride concentrations in the more populated and urban southeastern region average about 19 mg/l as contrasted with about 2.0 mg/l in the northeastern and northwestern regions of the State, about 4.0 mg/l in the central region, and about 7.0 mg/l in the southwestern region.[9]

In the earlier WDNR study, chloride concentrations were measured at a depth of about three feet. During spring, the typical chloride concentration was reported to be 19.5 mg/l; during late summer, chloride concentrations were reported to be 21.6 mg/l at the nine-foot depth and 21.3 mg/l at the 30-foot depth. These measurements were considered to be indicative of excessive fertility and representative of a high pollution hazard based on mean chloride content of lakes in the Region at that time. During the initial planning study, chloride concentrations during spring overturn ranged from 40 to 49 mg/l, with an average of 47 mg/l. Chloride concentrations have continued to increase, with chloride concentrations in Wind Lake reported during the current study ranging from 47 to 110 mg/l, as shown in Table 11. The most important anthropogenic sources of chlorides to Wind Lake are believed to be water softener salts, and the salts used on streets and highways for winter snow and ice control.[10] These values are somewhat higher than the concentrations found in many other lakes in southeastern Wisconsin,[11] although an increasing trend in chloride concentrations has been observed throughout the Southeastern Wisconsin Region, as shown in Figure 5.

The WDNR, as part of the National Atmospheric Deposition Program (NADP)/National Trends Network, has operated a precipitation monitoring station for the Southeastern Wisconsin Region at Geneva Lake in the City of Lake Geneva since 1984, the purpose of which is to collect precipitation chemistry data in order to develop geographical and temporal long-term trends. A trend plot for samples collected at the Lake Geneva monitoring station indicates a gradually decreasing trend in chloride concentrations in precipitation from 1984 through 2005,[12] in contrast to the increasing concentrations of the element observed in the surface water of the Region. This observation would tend to further support the in-Region origin of the chlorides being observed in the Region's surface waters.

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[8]*Frits van der Leeden, Fred L. Troise and David Keith Todd,* The Water Encyclopedia, Second Edition, *Lewis Publishers 1990.*

[9]*R.A. Lillie and J.W. Mason,* op. cit.

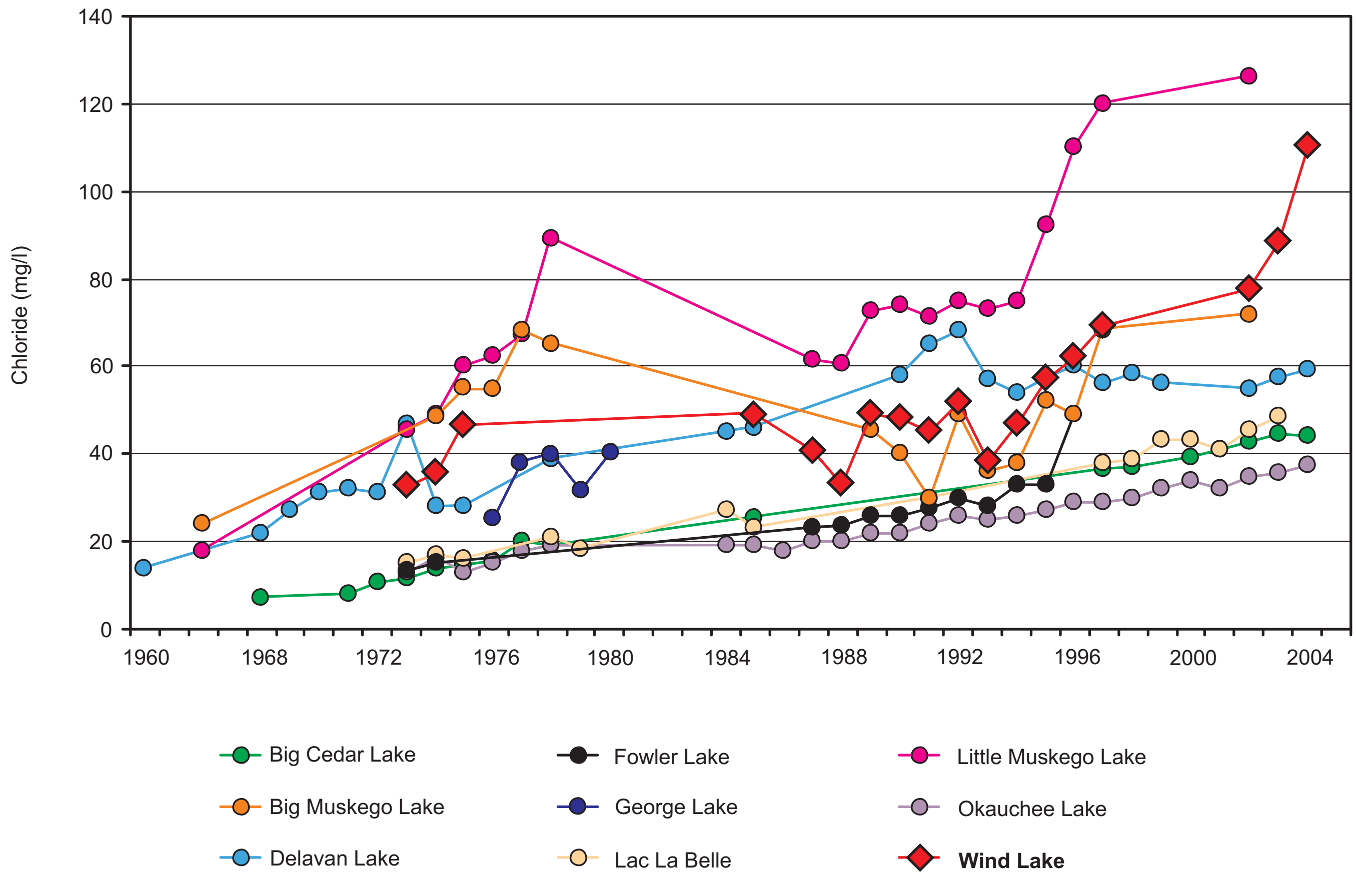
[10]*The major sources of chlorides to lakes in the Southeastern Wisconsin Region include both road salt applications during winter months and salts discharged from water softeners. This latter is of lesser importance to Wind Lake, as such waters are conveyed to the public sewage treatment facility and the effluent therefrom is discharged to the Fox River downstream of the lake.*

[11]*R.A. Lillie and J.W. Mason,* op. cit.

[12]*See National Atmospheric Deposition Program, http://nadp.sws.uiuc.edu.*

Figure 5

CHLORIDE CONCENTRATION TRENDS FOR SELECTED LAKES IN SOUTHEASTERN WISCONSIN: 1960-2004



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

Alkalinity and Hardness

Alkalinity is an index of the buffering capacity of a lake, or the ability of a lake to absorb and neutralize acids. Lakes having a low alkalinity and, therefore, a low buffering capacity, may be more susceptible to the effects of acidic atmospheric deposition. The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and hydroxide ions present in the water. Due, in large part, to the deposits of limestone and dolomite that make up much of the bedrock underlying many of the lakes and their associated tributary areas, lakes in southeastern Wisconsin typically have a high alkalinity, with an average concentration of about 173 mg/l expressed as calcium carbonate.[13] In the earlier WDNR study, Wind Lake was deemed to have below average total alkalinity for lakes in the Fox River watershed at that time, with a spring concentration of 172 mg/l and an average autumn concentration of 145 mg/l. During the initial SEWRPC study period, Wind Lake alkalinity was found to range from 158 mg/l to 191 mg/l. These values were within the normal range of lakes in southeastern Wisconsin at that time.[14] During the current study period, alkalinity ranged from 165 mg/l to 191 mg/l, as shown in Table 11.

In contrast to alkalinity, water hardness is a measure of the multivalent metallic ion concentrations, such as calcium and magnesium, present in a lake. Generally, lakes with high levels of hardness produce more fish and

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[13]*R.A. Lillie and J.W. Mason,* op. cit.

[14]Ibid.

aquatic plants than lakes whose water is "soft."[15] Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). During the initial study period, hardness was found to range from 220 to 250 mg/l; hardness measurements during spring turnover averaged 239 mg/l. During the current study period, hardness values ranged from 220 mg/l to 251 mg/l.

Applying these measures to the study lake, Wind Lake may be classified as a hard-water alkaline lake, which is typical of most lakes in southeastern Wisconsin.

Hydrogen Ion Concentration (pH)
The pH is a logarithmic measure of hydrogen ion concentration on a scale of 0 to 14 standard units, with 7 indicating neutrality. A pH above 7 indicates basic (or alkaline) water, and a pH below 7 indicates acidic water. The pH of lake water influences many of the chemical and biological processes that occur there. Even though moderately low or high pH values may not directly harm fish or other organisms, pH values nearer the ends of the scale can have adverse effects on the organisms living in a lake. Additionally, under conditions of very low (acidic) pH, certain metals, such as aluminum, zinc, and mercury, can become soluble if present in a lake's bedrock or tributary area soils, leading to an increase in concentrations of such metals in the lake water, with subsequent potentially harmful effects to not only the fish but also to those organisms, including humans, who eat the fish.[16]

As in the case of alkalinity, the chemical makeup of the underlying bedrock has a great influence on the pH of lake waters. In the case of lakes in the Southeastern Wisconsin Region, where the bedrock is comprised largely of limestone and dolomite, the pH typically is in the alkaline range, above a pH of 7. In general, the pH for most natural waterbodies is within the range of about 6.0 to about 8.5.[17] Measurements of pH from lakes in the Southeastern Wisconsin Region averaged about 8.1, which, due to the underlying geology of the Region, was the highest recorded from any region in the State. By contrast, lakes in the northeast are slightly acidic, with an average pH of about 6.9.[18] Other factors influencing pH include precipitation, as well as biological (algal) activity within the lake.

In the earlier WDNR study, pH values averaged about 8.2 pH units. In the initial SEWRPC study, spring overturn pH values between 1985 and 1989 averaged about 8.3, within a range of 7.2 to 9.2 units. Seasonal measurements of pH from fall of 1987 through summer of 1989 averaged 8.1 in shallow waters and 7.4 at depth. During the current study period, as shown in Table 11, pH values ranged from 7.0 to 8.7. pH values were typically highest at the surface, as a result of the pH changes in the water column brought about by the activity of aquatic plants whose excretory products typically result in higher pH values being reported from surface waters, and decreased slightly in the hypolimnion. Hypolimnetic pH values were typically closer to a pH of 7.0, as shown in Table 11.

Since Wind Lake has a high alkalinity or buffering capacity, and because the pH does not fluctuate below 7, the Lake is not considered to be susceptible to the harmful effects of acidic deposition. In this respect, the natural buffering of rainfall by carbon dioxide in the atmosphere and the carbonate system in the Lake, its tributary streams and drainage area, all tend to moderate the pH level in Wind Lake and other lakes in the Region.

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[15]*Byron Shaw, Lowell Klessig, Christine Mechenich,* Understanding Lake Data, *University of Wisconsin-Extension Publication No. G3582, 2004.*

[16]Ibid.

[17]*Deborah Chapman,* op. cit.

[18]*R.A. Lillie and J.W. Mason,* op. cit.

The pH of rain in the Southeastern Wisconsin Region is typically in the 4.4 range.[19] Data collected as part of the aforementioned NADP indicate that there has been a gradual upward trend in the pH observed in precipitation, at the City of Lake Geneva monitoring station, from about 4.4 in 1984 to about 5.0 in 2005.[20]

Water Clarity

Water clarity, or transparency, provides an indication of overall water quality. Two important characteristics affecting water transparency are color and turbidity. Clarity may decrease because of turbidity caused by high concentrations of organic suspended materials, such as algae and zooplankton and/or organic (humic) coloration caused by high concentrations of dissolved organic substances, and inorganic suspended materials, such as suspended sediment. The perceived color of lakes is often described as "green" or "brown," or some combination of these colors, and is influenced by dissolved and suspended materials in the water, phytoplankton population levels, as well as various physical factors. Actual, or true, color of lake waters is the result of substances that are dissolved in the water. For example, the brown-stained color of lakes in the northern part of the State is the result of organic acids from certain dissolved humic materials present in those waters.

Secchi-Disc Transparency

Water clarity commonly is measured with a Secchi-disc, a black-and-white, eight-inch-diameter disc, which is lowered into the water until a depth is reached at which the disc is no longer visible. This depth is known as the "Secchi-disc reading." Such measurements comprise an important part of the WDNR Self-Help Monitoring Program in which citizen volunteers assist in lake water quality monitoring efforts.[21] These data provide an important ongoing measure of water quality in the Southeastern Wisconsin Region.[22]

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. Water clarity can also vary from region to region in the State as a reflection of regional differences in lake biogeochemistry. Lakes in the northeastern region of Wisconsin generally have low levels of turbidity, as indicated by the region's average Secchi-disc reading of 8.9 feet, compared to the average transparency in the Southeastern Wisconsin Region of 4.9 feet.[23]

During the earlier WDNR study, Secchi-disc depth was reported to be about 5.5 feet. Based upon this level of transparency, Wind Lake was considered fairly turbid at that time. Secchi-disc depth measurements taken in Wind Lake during spring overturn averaged 3.3 feet during the initial SEWRPC study period, with a maximum reading of 8.9 feet recorded during early May of 1989. Compared to other lakes in southeastern Wisconsin, these values do indicate rather poor water clarity.[24]

During the current study period, Secchi-disc readings for Wind Lake ranged between 2.5 feet and 8.5 feet, as noted in Table 11. The most turbid water was observed during mid-summer (July and August), while the clearer

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[19]Ibid.

[20]*National Atmospheric Deposition Program,* op. cit.

[21]*This program is administered by the University of Wisconsin-Extension (UWEX) as the Citizen Lake Monitoring Program.*

[22]*See SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

[23]*R.A. Lillie and J.W. Mason,* op. cit.

[24]Ibid.

water was observed during late-spring and early-summer (May and June). As shown in Figure 6, during recent years, these values indicate very poor to good water quality compared to other lakes in southeastern Wisconsin.[25]

Seasonal variations in Secchi-disc measurements, as shown in Table 11, indicate a trend of gradually diminishing Secchi-disc depths as the seasons progress from winter, when Secchi-disc readings are typically highest, through spring and summer. Lower Secchi-disc readings in spring are not unusual for lakes in the Region, and reflect the growths of algae and zooplankton during the warmer months, as well as the effects of surface runoff from the tributary area and inflows into the lakes. While some lakes in southeastern Wisconsin have experienced improved water clarity in recent years that may be related to the presence of the zebra mussel, *Dreissena polymorpha,* an invasive, nonnative filter feeding mollusk known to impact water clarity in inland lakes, water clarity of Wind Lake has remained largely stable.

Turbidity and Color

Turbidity, in contrast to water clarity, is measured in Nephalometric Turbidity Units (NTUs). During the current study period, Wind Lake consistently had relatively low turbidity measurements with values generally below 10, ranging from 1.0 to 8.0 NTUs. Water color, on the other hand, is measured against a platinum-cobalt scale (Pt-Co scale). Water color in Wind Lake was close to the Regional average of 46 reported for lakes in the southeastern Wisconsin.[26] During the current planning period, water color measurements in Wind Lake ranged from 15 to 40 units.

Remote Sensing Data

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, was able to gather water clarity measurements as Secchi disc readings for about 800 lakes, or about 10 percent of the Wisconsin's largest lakes. Based upon a review of the satellite data and observer data, it was determined that the satellite remote sensing technology utilized by ERSC was able to accurately estimate water clarity in lakes. In the case of Wind Lake, the ERSC remote sensing data for Wind Lake suggested an average water clarity value of 2.7 feet.

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic or "green" pigment in algae. Consequently, the amount of chlorophyll-*a* present in the water is an indication of the biomass or amount of algae in the water. The median chlorophyll-*a* concentration for lakes in the Southeastern Wisconsin Region is about 9.9 micrograms per liter (μg/l).[27]

During the initial study period, spring and summer chlorophyll-*a* concentrations in Wind Lake ranged from a low of 1.8 μg/l in April 1985, to a high of 58 μg/l in April 1986; in mid-February 1988, a maximum reading of 65 μg/l suggested an algal bloom under ice cover. The average chlorophyll-*a* reading during the initial study period was 21 μg/l, which was within the range of other eutrophic lakes in the Region.[28]

[25]Ibid.

[26]Ibid.

[27]Ibid.

[28]Ibid.

Figure 6

PRIMARY WATER QUALITY INDICATORS FOR WIND LAKE: 1990-2005

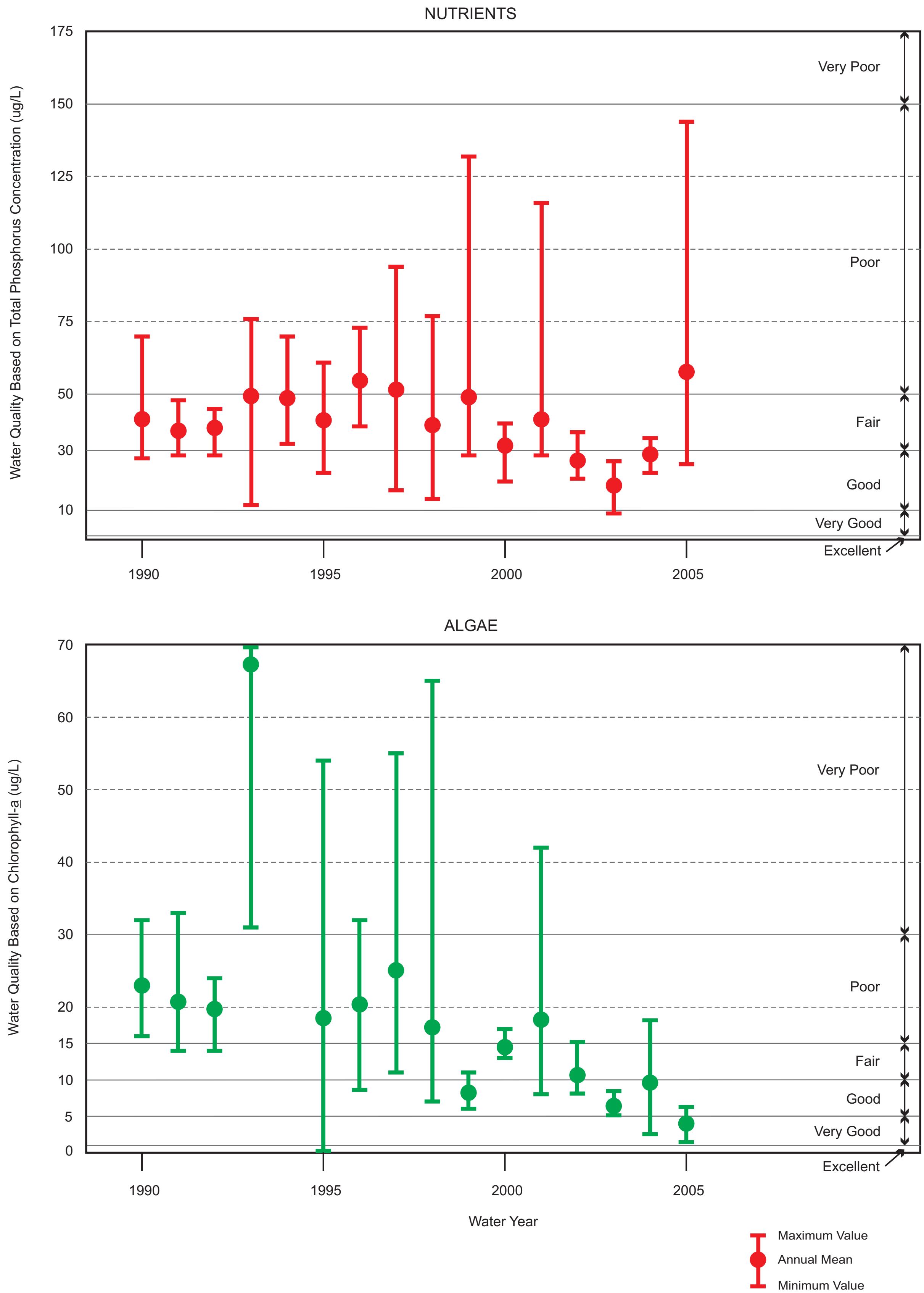
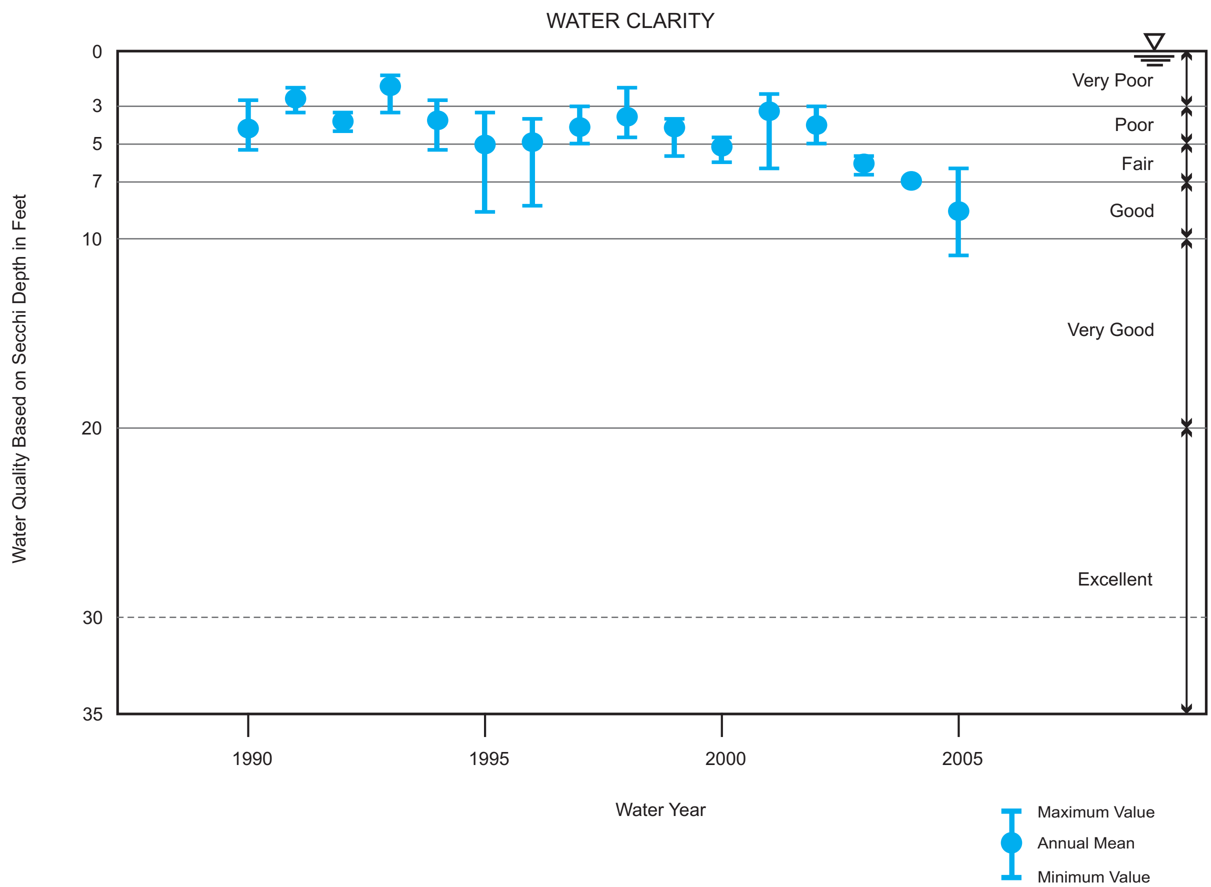


Figure 6 (continued)



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

During the current study period, chlorophyll-*a* concentrations in Wind Lake ranged from 2.5 µg/l to 55.0 µg/l, the latter value being recorded in October 1996 and in June 1997. A value of 42 µg/l was reported during April 2001. Generally, mean chlorophyll-*a* concentrations in Wind Lake were at or below 20 µg/l, with values generally below 10 µg/l commonly being reported in recent years. All of these values are within the range of chlorophyll-*a* concentrations recorded in other lakes in the Southeastern Wisconsin Region[29] and indicate fair to very good water quality, as illustrated in Figure 6. Chlorophyll-*a* levels above about 10 µg/l range result in a green coloration of the water that may be severe enough to impair recreational activities such as swimming and skiing,[30] while chlorophyll-*a* values in excess of 20 µg/l are commonly regarded as indicative of poor water quality.[31]

Nutrient Characteristics

Algal Growth-Limiting Nutrients

Aquatic plants and algae require such nutrients as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants.

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[29]Ibid.

[30]*J.R. Vallentyne, 1969 "The Process of Eutrophication and Criteria for Trophic State Determination." in* Modeling the Eutrophication Process—Proceedings of a Workshop at St. Petersburg, Florida*, November 19-21, 1969, pp. 57-67.*

[31]*R.A. Lillie and J.W. Mason,* op. cit.

However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of that nutrient available. The ratio of total nitrogen (N) to total phosphorus (P) in lake water indicates which nutrient is the factor most likely to be limiting aquatic plant growth in a lake.[32] Where the N:P ratio is greater than 14:1, phosphorus is most likely to be the limiting nutrient. If the ratio is less than 10:1, nitrogen is most likely to be the limiting nutrient. During the initial study, the nitrogen-to-phosphorus ratios in samples collected from Wind Lake following spring turnover for April 1985 through April 1989 were always greater than 15:1. This indicated that plant production was most likely consistently limited by phosphorus. This continued to be the case during the current planning period, during which the N:P ratio was typically in the range of 30- to 40- to 1.

Phosphorus

Phosphorus in a lake can exist in several forms. Soluble phosphorus, being dissolved in the water column, is readily available for plant growth. However, its concentration can vary widely over short periods of time as plants take up and release this nutrient. Therefore, total phosphorus is usually considered a better indicator of nutrient status. Total phosphorus includes the phosphorus contained in plant and animal fragments suspended in the lake water, phosphorus bound to sediment particles, and phosphorus dissolved in the water column. Both total phosphorus and soluble phosphorus concentrations were measured for Wind Lake.

The recommended water quality standard for total phosphorus, which is set forth in the Commission's adopted regional water quality management plan for lakes, is 0.02 mg/l, or 20µg/l, or less during spring turnover. This is the level considered in the regional plan as necessary to limit algal and aquatic plant growth to levels consistent with the recreational and warmwater fishery and other aquatic life water use objectives. Total phosphorus concentrations in Wind Lake have been found to exceed the levels necessary to support periodic nuisance algal blooms.

In the WDNR study, surface water total phosphorus levels in late summer averaged 0.065 mg/l. During the initial SEWRPC study period, spring turnover total phosphorus concentrations from April 1985 through April 1989 ranged from 0.037 mg/l to 0.087 mg/l, indicating eutrophic conditions and poor water quality. Surface water total phosphorus concentrations during the summers of 1985 through 1987 averaged 0.049 mg/l, while average surface water total phosphorus levels for the summers of 1988 and 1989 decreased to about 0.020 mg/l, most likely reflecting the below-average precipitation conditions observed during those years and resultant reduced phosphorus loadings. During the current planning period, dissolved phosphorus concentrations ranged from less than 2.0 µg/l to 3.0 µg/l (<0.002 mg/l to 0.003 mg/l), while total phosphorus concentrations ranged from 0.009 mg/l to 0.067 mg/l in surface waters.

During both the earlier WDNR study and the initial SEWRPC study, total phosphorus concentrations were found to be significantly higher in the bottom waters of Wind Lake during the period of summer stratification. This is most likely to be the result of the release of phosphorus from the anoxic bottom sediments, or "internal loading." Internal loading can reflect a legacy of long-term phosphorus loading to a lake and subsequent deposition of phosphorus through the chemical and biological processes described further below. The total phosphorus levels in the hypolimnion at the end of the summer stratification during the initial study averaged 0.672 mg/l. During the current study, hypolimnetic total phosphorus concentrations ranged from 17 µg/l to 674 µg/l, as shown in Table 11.[33]

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[32]*M.O. Allum, R.E. Gessner, and T.H. Gakstatter, U.S. Environmental Protection Agency Working Paper No. 900,* An Evaluation of the National Eutrophication Data*, 1976.*

[33]*Aluminum sulfate was applied to the deeper water areas (depths of 5 feet or deeper) of Wind Lake during 1997 to reduce the mass of phosphorus being released into the lake from the bottom sediments. This application, reported in Aron & Associates,* Wind Lake Internal Loading Management Strategy—1998 Alum Treatment*, dated February 1998, reduced typical hypolimnetic total phosphorus concentrations to between 52 µg/l and about 110 µg/l during the period 1998 through 2002, although a few concentrations approaching 150 µg/l were recorded*
(Footnote Continued on Next Page)

Seasonal gradients of phosphorus concentrations between the epilimnion and hypolimnion reflect the biogeochemistry of this element. During the growing season, nutrients become depleted in the upper waters as plants utilize them for growth. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed resulting in an accumulation of nutrients. Phosphorus from these organisms is then either stored in the bottom sediments or rereleased into the water column, particularly under conditions of oxygen depletion, a phenomenon mentioned above as "internal loading". Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly, in the lake sediments. If the bottom waters become depleted of oxygen during stratification, however, certain chemical changes occur, especially in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that the phosphorus becomes soluble again and is released from the sediments. This internal loading process also occurs under aerobic conditions, but generally at a slower rate than under anaerobic conditions.

As the waters mix, this phosphorus may be widely dispersed throughout the lake waterbody and become available for algal growth. When the mixing process is relatively slow, on the order of days to weeks, minerals and nutrients released from the sediments into the hypolimnion of the lake tend to recombine with the multivalent cations in the lake sediments and precipitate out of the water column; if the mixing process is relatively rapid, on the order of hours to days, as may occur due to the passage of an intense storm, the minerals and nutrients may be mixed upward into the epilimnion or surface waters where they are available for plant growth.[34] While the magnitude of this release and its concomitant effects in contributing to algal growth in the surface waters of the lake may be moderated by a number of circumstance, including the rate of mixing during the spring and fall overturn events, the contribution of phosphorus from the bottom waters of Wind Lake should be considered in terms of the total phosphorus load.

Nitrogen

While phosphorus is likely to be the nutrient in least supply, and, therefore, the plant growth limiting nutrient in Wind Lake, the various forms of nitrogen that occur in the Lake are also important determinants of aquatic plant growth. Nitrogen occurs in lakes primarily in the forms of nitrate (NO_3) and ammonia (NH_3, sometimes reported as ammonium, NH_4^+), and can undergo significant transformation as a result of biological and geochemical processes that occur in the water column and sediments. These transformations involve the processes of nitrification and denitrification which can result in detectable concentrations of nitrite (NO_2) in the water column as nitrogen is transformed to or from its gaseous form. In addition, there are numerous forms of organic nitrogen, which are frequently reported on the basis of the analytical method used to describe these forms, one of the most common analyses being the Kjeldahl analysis that is reported as Kjeldahl nitrogen. Organic and inorganic nitrogen fractions together form the total nitrogen values used in the determination of the N:P ratios described above.

Total nitrogen concentrations in Wind Lake were reported in the initial SEWRPC plan to range from 1.2 mg/l to 1.9 mg/l. Nitrate- plus nitrite-nitrogen concentrations ranged from 0.09 mg/l to 0.40 mg/l; ammonia-nitrogen concentrations ranged from 0.09 mg/l to 0.10 mg/l; and, organic nitrogen concentrations ranged from 0.59 mg/l to 1.60 mg/l.

(Footnote Continued from Previous Page)
during this period. During 2003, hypolimnetic total phosphorus concentrations during the summer months again approached and exceeded the 200 μg/l level and have remained high, with the maximum reported hypolimnetic total phosphorus values of 674 μg/l and 436 μg/l being recorded in August of 1997 and August of 2004, respectively.

[34]*See, 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.*

During the current study, total nitrogen concentrations ranged from 1.10 mg/l to 2.30 mg/l. Nitrate- plus nitrite-nitrogen concentrations ranged from less than 0.019 mg/l to 0.513 mg/l; ammonia-nitrogen ranged from less than 0.013 mg/l to 0.189 mg/l; and organic nitrogen ranged from 0.50 mg/l to 1.69 mg/l, during the spring and summer months.

The current nutrient status of Wind Lake reflects the positive impacts of, *inter alia*, the implementation of the sewer service area recommendations set forth in the adopted regional water quality management plan and in the initial Wind Lake management plan.

CHARACTERISTICS OF BOTTOM SEDIMENT

Sediment composition has an important effect on the biogeochemistry of a lake. Sediment particles serve as transport mechanisms for nutrients, especially phosphorus, as well as for a variety of other potential pollutants, and play a key role in establishing benthic habitat and macrophyte substrate. As reported in the initial study, sediment samples collected from Wind Lake during 1990 were comprised primarily of a combination of organic "muck" and marl, calcium carbonate precipitate that is deposited in the lake basin as a result of the effect of changing partial pressures of dissolved carbon dioxide gas in groundwater. These sediments were determined to contain levels of total phosphorus which indicated moderate to heavy pollution in the sediments found at the inlet from Big Muskego Lake; the total phosphorus concentrations in the sediments located at the outlet of Wind Lake were considerably lower.

While the nutrient source that was the City of Muskego wastewater treatment plant located upstream of Big Muskego Lake was decommissioned in 1984 as recommended in the regional water quality management plan, and some selective sediment removal was undertaken primarily in the area of the Muskego Canal as recommended in the initial lake management plan for Wind Lake, the legacy of nutrients contained within the lake bottom sediments remains. Consequently, the Wind Lake Management District undertook an alum (aluminum sulfate) application to better contain phosphorus within the lake sediments and limit the sediment to water transfer of phosphorus within the lake basin. The positive impact of this treatment on the in-lake hypolimnetic phosphorus concentrations has been noted. It also has been noted that the expected lifetime of this treatment is close to expiration, and note has been made of the increasing phosphorus concentrations that have been observed in the hypolimnion of Wind Lake since 2002. Consequently, further action to continue to contain this legacy of contamination within the lake sediments is considered to be viable.

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 through-flow lakes, like Wind Lake, pollutant loadings transported across land surfaces and inflowing streams, in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, comprise the principal routes by which contaminants enter a waterbody.[35] Currently, there are no significant point source discharges of pollutants to Wind Lake or to the surface waters tributary to Wind Lake. For this reason, the discussion that follows is based upon nonpoint source pollutant loadings to Wind Lake.

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[35]*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.*

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 initial report, unit-area loading rates were applied to 1985 and planned year 2010 land use conditions to estimate pollutant loadings from both urban and rural nonpoint sources using the WDNR Source Loading and Management Model (SLAMM) results and information from literature sources. For the current study, nonpoint-source phosphorus, suspended solids, and urban-derived metals input to and output from Wind 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 estimates are contrasted with the initial nutrient and sediment load estimates set forth in the initial report in the discussion below.

Phosphorus Loadings

Phosphorus has been identified as the factor generally limiting aquatic plant growth in Wind Lake. Thus, excessive levels of phosphorus in the Lake are likely to result in conditions that interfere with the desired use of the Lake. As part of the initial report, phosphorus budgets for 1988 and 1989 were developed for Wind Lake by the USGS, based upon measured flows and phosphorus concentrations obtained from various points within the drainage area. The Muskego Canal was the primary pathway for phosphorus entering Wind Lake during both study years, accounting for about 70 percent of the total input of about 3,165 pounds of phosphorus during 1988 water year, and for about 65 percent of the total input of about 3,159 pounds of phosphorus during 1989 water year.[36] Phosphorus outputs from Wind Lake varied substantially in response to the drought conditions experienced in 1988 and early 1989 and in response to the attendant impacts of the drought on water levels, decreasing from a total outflow of phosphorus of about 2,376 pounds during the 1988 water year to about 1,322 pounds of phosphorus during the 1989 water year . This decrease coincided with the period of decreased outflow from the lake during the latter period.

During the initial study, existing 1985 and forecast year 2010 phosphorus sources to the lake were identified and quantified. It was estimated that, under existing 1985 conditions, the total phosphorus load to Wind Lake was 14,890 pounds of phosphorus per year.[37] Of this total, 10,670 pounds, or 72 percent, were estimated to be contributed by runoff from agricultural and other rural lands; 1,960 pounds, or 13 percent, from residential lands; and 2,260 pounds, or the remaining 15 percent, from the combination of construction site, commercial, industrial, governmental and institutional, transportation and utilities, recreational, landfill, woodland, and wetland land uses, and atmospheric deposition. Without the implementation of remedial measures, the SLAMM model estimated that, under year 2010 conditions, the total phosphorus loading to the Lake would decrease slightly, to 14,500 pounds per year, or by about 3 percent below the estimated 1985 loadings. This decline in the mass of phosphorus loading was due to the expected decrease in urban land under construction and reduced phosphorus

[36]*The lowest likely annual total phosphorus load hindcast using the WILMS model for then-existing 1985 land use conditions would suggest that approximately 5,700 pounds of phosphorus would have entered Wind Lake; based upon existing year 2000 land use conditions, the WILMS model suggests a lowest likely annual total phosphorus loading of 5,900 pounds of phosphorus, while, under forecast year 2020 conditions, the equivalent load would be approximately 6,000 pounds of phosphorus, reflecting the role of the major transportation corridors, commercial, and industrial activity in the drainage area tributary to Wind Lake.*

[37]*See U. S. Geological Survey,* Hydrology and Water Quality of Wind Lake in Southeastern Wisconsin, op. cit*. The measured phosphorus loads to Wind Lake are lower than those forecast using the various loading models employed during the initial study and current study. However, the phosphorus loads generated using the various models are internally consistent, resulting in forecast in-lake phosphorus concentrations that are not dissimilar to those observed in Wind Lake. In part, this difference between forecast and observed loads may reflect the fact that the models do not account for phosphorus retention in the upstream waterbodies. Consequently, given the agreement between predicted and observed in-lake phosphorus concentrations, the forecast values are used for planning purposes.*

loading from lower-density urban development when compared with that from agricultural land. As described earlier in this report, these estimated land use changes appear to be somewhat conservative, with larger-than-anticipated increases in urban lands and greater-than-anticipated decreases in rural acreage, especially in the categories of agricultural and wetland uses. Subsequently, changes in the nutrient, sediment, and metal loadings to Wind Lake for the current study period are somewhat different from those predicted.

For the current study period, the resulting estimated phosphorus budget for Wind Lake under existing 2000 land use conditions is shown in Table 12. An annual total phosphorus loading of between 5,900 and 20,755 pounds was estimated to be contributed to Wind Lake, with a most likely total phosphorus loading of about 12,000 pounds of phosphorus.[38] Of the most likely annual total phosphorus load, it was estimated that 68 percent of the total loading, was contributed by runoff from rural, primarily agricultural lands; 30 percent was contributed by runoff from urban lands; and 2 percent by direct precipitation onto the lake surface.

Of the annual total phosphorus load, it is estimated that 45 percent, or 5,125 pounds, of the total phosphorus loading will remain in the Lake by conversion to biomass or through sedimentation, resulting in a net transfer of about 6,900 pounds of phosphorus downstream.[39]

Phosphorus release from the lake bottom sediments—internal loading—also contributed phosphorus to the Lake. In the initial report, during water year 1988 the portion of the total load contributed to the Lake from internal recycling was estimated at 50 percent of the external phosphorus load. Figure 7 suggests that the potential for internal loading has been significant in recent years. As shown in Figure 7, hypolimnetic phosphorus concentrations during the period from 1986 through 1997 were significantly higher than measured during the period from 1973 through 1979, despite a substantial reduction in surface water phosphorus concentrations. While it is likely that overturn events generally occurred at such rates that little of this hypolimnetic phosphorus was mixed into the epilimnion of the Lake—i.e., at rates on the order of days,[40] the elevated surface water phosphorus concentrations shown in the figure for specific dates during 1991, 1992, and 1994, indicate that portions of this internal load, at times, can be mixed into the surface waters of the Lake, especially during high-intensity storm events—i.e., when mixing occurs at rates on the order of hours.[41] More recent data, obtained during 2001, do not indicate a continuation of this trend, but continued monitoring would be indicated, as it is likely that the lack of internal loading reported during 2001 is related to the application of alum into the Lake during 1997.

Under 2020 conditions, as set forth in the adopted regional land use plan, agricultural activities within the area tributary to Wind Lake are expected to continue to be replaced by urban residential land uses. Consequently, the phosphorus loadings to Wind Lake can be expected to decrease further as a result of the conversion of agricultural lands. The most likely annual total phosphorus load to the Lake under year 2020 conditions is estimated to be 10,000 pounds of phosphorus. Under the forecast year 2020 land use conditions, the phosphorus loadings from urban lands is expected to approximately equal that from rural, agricultural lands, each land use category contributing about 40 percent of the total annual phosphorus load to the Lake. The forecast ongoing decreasing

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[38]*The forecast year 2000 in-lake total phosphorus concentration of approximately 0.049 mg/l compares fairly well with the observed spring overturn phosphorus level of 0.040 mg/l in the lake. The slightly lower observed value is consistent with the retention of some of the phosphorus, approximately 20 percent of the forecast load, being delivered from the drainage area tributary to Wind Lake being retained in the upstream waterbodies.*

[39]*G.K. Nurnberg, "The Prediction of Internal Phosphorus Load in Lakes with Anoxic Hypolimnia,"* Limnology and Oceanography*, Volume 29, 1984, pp. 111-124.*

[40]*Werner Stumm and James J. Morgan,* Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters*, Wiley-Interscience, New York, 1970.*

[41]*See, for example, R.D. Robarts, P.J. Ashton, J.A. Thornton, H.J. Taussig, and L.M. Sephton,* op. cit.

Table 12

ESTIMATED TOTAL PHOSPHORUS LOADS TO WIND LAKE: 2000 AND 2020

Source	2000			2020		
	Area (acres)	Total Loading (pounds per year)	Percent Distribution	Area (acres)	Total Loading (pounds per year)	Percent Distribution
Urban						
Residential Land	4,227	845	7.0	6,592	1,318	13.3
Commercial Land	225	270	2.2	445	534	5.4
Industrial Land	220	257	2.2	467	546	5.5
Communications and Utilities	1,873	206	1.7	2,620	288	2.9
Government and Institutional Land	192	259	2.2	268	362	3.6
Recreational Land	390	105	0.9	632	171	1.7
Subtotal	7,127	1,942	16.2	11,024	3,219	32.4
Rural						
Agricultural Land	10,262	8,825	73.6	6,404	5,507	55.4
Extractive	369	317	2.6	302	260	2.6
Landfill	300	258	2.2	359	309	3.1
Atmospheric Contribution (area of receiving surface water)	3,567	464	3.9	3,572	464	4.7
Woodlands	1,333	53	0.4	1,297	52	0.5
Wetlands	3,358	134	1.1	3,358	134	1.3
Subtotal	19,189	10,051	83.9	15,292	6,726	67.4
Total	26,316	11,993	100.0	26,316	9,945	100.0

Source: SEWRPC.

trend in phosphorus loading may be offset by the increased utilization of agro-chemicals in urban landscaping.[42] 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.[43] With respect to forecast in-lake phosphorus concentrations, it is anticipated that the in-lake total phosphorus concentration under year 2020 land use conditions will be similar to that currently observed in Wind Lake. The OECD phosphorus budget model would suggest a slight decrease from the in-lake concentration of 0.049 mg/l phosphorus forecast under year 2000 conditions to an in-lake concentration of about 0.045 mg/l in the year 2020.[44]

Sediment Loadings

To estimate sediment loadings during the initial study, agricultural croplands within the direct tributary area to Wind Lake and the Muskego Canal were surveyed by the Waukesha and Racine County Land Conservation Departments. Sediment yields from each of 109 agricultural fields were estimated using the WDNR Wisconsin Nonpoint Source (WIN) model. The mean sediment yield was calculated to be about 525 pounds per acre per year. Based upon this estimated yield, it was estimated that 4,275 tons of sediment were delivered to Wind Lake under 1985 land use conditions, as shown in Table 13. With the land use changes noted above, this sediment load was forecast to decrease to about 4,200 tons under year 2010 conditions. About two-thirds of the year 1985 sediment load was estimated to be derived from agricultural activities within the watershed, with this percentage

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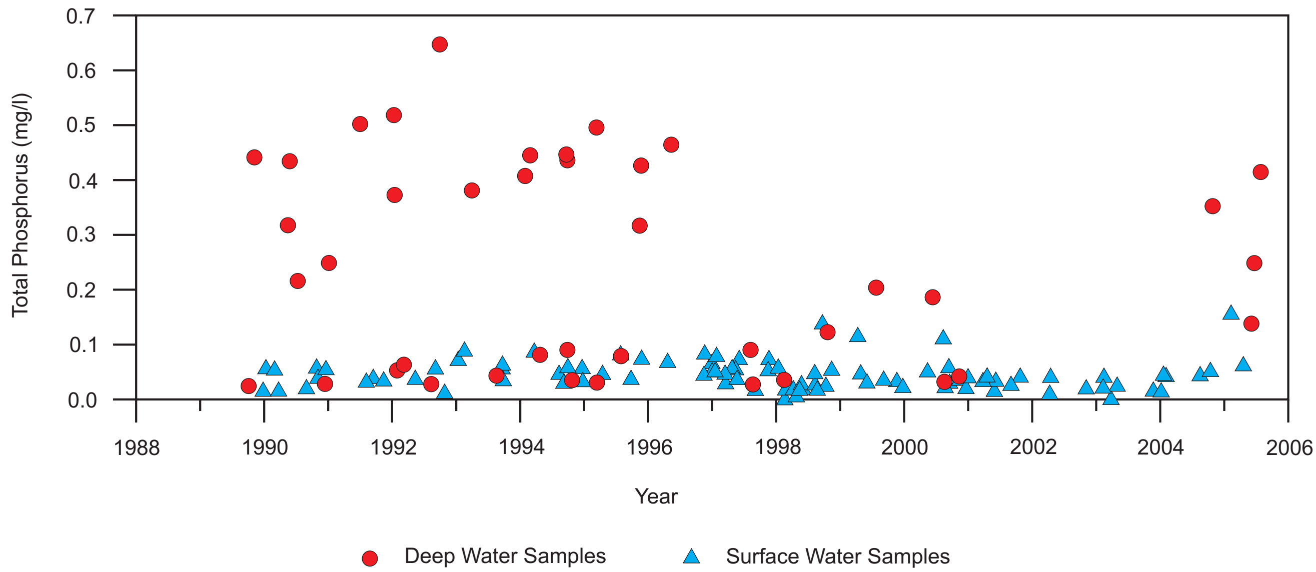
[42]*U.S. Geological Survey Water-Resources Investigations Report No. 02-4130,* Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Lakeshore Lawns, Lauderdale Lakes, Wisconsin*, July 2002.*

[43]Ibid.

[44]*OECD,* Eutrophication of Waters: Monitoring, Assessment and Control*, Organization for Economic Cooperation and Development, Paris, 1982.*

Figure 7

TOTAL PHOSPHORUS CONCENTRATIONS AMONG SURFACE VERSUS DEEP WATER SAMPLES WITHIN WIND LAKE: 1988-2006



Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 13

ESTIMATED TOTAL SEDIMENT AND HEAVY METAL LOADS TO WIND LAKE: 2000 AND 2020

Source	2000				2020			
	Area (acres)	Sediment Loading (tons per year)	Copper Loading (pounds per year)	Zinc Loading (pounds per year)	Area (acres)	Sediment Loading (tons per year)	Copper Loading (pounds per year)	Zinc Loading (pounds per year)
Urban								
Residential Land	4,227	41	0.0	42.3	6,592	64	0.0	65.9
Commercial Land	225	88	49.5	335.2	445	174	97.9	663.1
Industrial Land	220	83	48.4	327.8	467	176	102.7	695.8
Communications and Utilities	1,873	9	0.0	0.0	2,620	12	0.0	0.0
Government and Institutional Land	192	49	13.4	153.6	268	68	18.8	214.4
Recreational Land	390	4	0.0	0.0	632	8	0.0	0.0
Subtotal	7,127	274	111.3	858.9	11,024	502	219.4	1,639.2
Rural								
Agricultural Land	10,262	2,309	- -	- -	6,404	1,441	- -	- -
Extractive	369	83	- -	- -	302	68	- -	- -
Landfill	300	68	- -	- -	359	81	- -	- -
Atmospheric Contribution (area of receiving surface water)	3,567	335	- -	- -	3,572	336	- -	- -
Woodlands	1,333	2	- -	- -	1,297	2	- -	- -
Wetlands	3,358	6	- -	- -	3,358	6	- -	- -
Subtotal	19,189	2,803	- -	- -	15,292	1,934	- -	- -
Total	26,316	3,077	111.3	858.9	26,316	2,436	219.4	1,639.2

Source: SEWRPC.

of sediment contribution remaining relatively constant under year 2010 conditions, the reduction in sediment load being related to the conversion of agricultural lands to other land uses within the drainage area.

The estimated sediment budget for Wind Lake under year 2000 land use conditions is shown in Table 13. A total annual sediment loading of 3,100 tons of sediment was estimated to be contributed to Wind Lake. Of this forecast sediment load, it was estimated that 2,300 tons per year, or 75 percent of the total loading, was contributed by runoff from rural agricultural land.

Under 2020 conditions, as set forth in the Waukesha County development plan and adopted regional land use plan,[45] the annual sediment load to the Lake is anticipated to continue to decrease. The forecast annual sediment load to the Lake under year 2020 conditions is estimated to be 2,400 tons. The mass of sediment being contributed from agricultural sources are expected to further decrease, to about 60 percent of the total annual sediment load.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[46] The majority of these metals become associated with sediment particles,[47] and are likely to be encapsulated into the bottom sediments of the Lake.

In the initial report, lead was used as an indicator of urban heavy metals. The largest sources of lead were runoff from residential lands, and runoff from the combination of transportation, communications, and utilities lands, both categories each accounting for about 26 percent of the total heavy metals load or almost two-thirds of the total loadings. Since the use of lead in, among others, motor fuels and paints was discontinued, the use of lead as a surrogate for urban heavy metals is obviated. Nevertheless, the forecast increase in lead loadings to the Lake, indicated in the initial plan, can be considered to be indicative of this class of contaminants as a whole. Thus, the approximately 25 percent increase in urban sourced heavy metals may be a reasonable representation of the expected increase in the loadings of other metals.

During the current study, urban-sourced heavy metal inputs to Wind Lake were estimated using copper, zinc, and cadmium. The likely year 2000 heavy metals loads expected to be contributed to Wind Lake are shown in Table 13. It is estimated that 110 pounds of copper, 860 pounds of zinc, and 4.5 pounds of cadmium were contributed annually to Wind Lake from urban lands.

Under 2020 conditions, as set forth in the aforereferenced Waukesha County development and regional land use plans, an approximately two-fold increase in heavy metals loadings can be anticipated. The most likely annual loads to the lake under year 2020 conditions are estimated to be 220 pounds of copper, 1,640 pounds of zinc, and 9.0 pounds of cadmium.

In-Lake Sinks

As part of the initial planning program, the USGS measured the phosphorus loads into and out of Wind Lake.[48] Their estimates suggest that, of the approximately 3,160 pounds of phosphorus observed to enter the Lake, between about 25 percent and 60 percent is retained in the Lake, depending upon the volume of outflow from Wind Lake. As a consequence of the drought reported during the 1989 water year, a greater proportion of the

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

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

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

[48]*U.S. Geological Survey Water-Resources Investigations Report No. 91-4107,* op. cit.

phosphorus load to Wind Lake was retained in the Lake, whereas during the more normal 1988 water year, a greater percentage of the load was washed out of the Lake through the Wind Lake Canal. Given the relatively short long-term water residence time of Wind Lake, estimated to be 0.68 year, as noted in Chapter II, it can be anticipated that a significant proportion of the external phosphorus load would be washed out of the Lake[49]

RATING OF TROPHIC CONDITION

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.

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 such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries.

Several numeric "scales," based on one or more water quality indicators, have been developed to define the trophic condition of a lake. 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 applied. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary trophic classification system,[50] and the Wisconsin Trophic State Index value (WTSI) is presented.[51] The WTSI is a refinement of the Carlson TSI,[52] designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes. The WTSI has been adopted by the WDNR for use in lake management investigations.

Vollenweider Trophic State Classification

The Vollenweider trophic state classification system assigns a trophic condition rating based on the ratio of mean lake depth to hydraulic residence time and phosphorus loading per unit of lake surface. The 1988 and 1989 phosphorus loadings to Wind Lake, based on the USGS study results, indicated that Wind Lake was eutrophic.

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[49]*D.P. Larsen and H.T. Mercier, "Phosphorus Retention Capacity of Lakes,"* Journal of the Fisheries Research Board of Canada*, Volume 33, 1976, pp. 1742-1750.*

[50]*See OECD,* op. cit.

[51]*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.*

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

Subsequent to the initial study, the Vollenweider trophic system was further refined into a probabilistic system that recognizes that lake trophic status is part of a continuum of conditions.[53] This continuum could result in an observer classifying specific lakes somewhat differently that might be the case with a closed-ended classification system, such as that initially developed by Vollenweider during the 1970s. Applying the current data in Table 11 to this probabilistic trophic state classification system, Wind Lake would be classified as having about a 60 percent probability of being eutrophic based upon phosphorus levels, as shown in Figure 8. The Lake would have about a 30 percent probability of being mesotrophic, and 10 percent probability of being hypertrophic, based upon mean annual phosphorus concentrations for the 2005 water year. Based upon chlorophyll-*a* levels, the Lake would be classified as having about a 60 percent probability of being mesotrophic, with about a 30 percent probability of being oligotrophic and about a 10 percent probability of being eutrophic, as shown in Figure 8. Based upon Secchi-disc readings, the Lake would be classified as having a 50 percent probability of being eutrophic, and a 25 percent probability of being either mesotrophic or hypertrophic, as shown in Figure 8. While these indicators result in slightly differing lake trophic state classifications, it may be concluded that Wind Lake should be classified as a eutrophic lake, or a productive lake with a water quality poorly suited for many uses.

Trophic State Index

The Trophic State Index (TSI) assigns a numerical trophic condition rating based on Secchi-disc transparency, total phosphorus, and chlorophyll-*a* concentrations. The original Trophic State Index developed by Carlson has been modified for Wisconsin lakes by the WDNR using data on 184 lakes throughout the State.[54] Based on the Trophic State Index ratings during the initial study,[55] Wind Lake was classified as eutrophic. Remote sensing data gathered as part of the aforementioned ERSC program, estimated a TSI rating of 63 for Wind Lake, which places Wind Lake in the eutrophic category with poor water clarity. The WTSI ratings for Wind Lake based on current, year 2005 data are shown in Figure 9 as a function of sampling date. Based on the WTSI rating of between 39 and 54, Wind Lake may be classified as meso-eutrophic. Figure 10 shows an improvement in lake trophic status between 1985 and 2005, with the Carlson TSI calculated by the USGS decreasing from about 65 in 1985 to a mean of about 50 as of 2005, based upon the logarithmic scale. This improvement in water quality is likely to be the result of a combination of factors, including the construction of the sewerage system and diversion of treated wastewater treatment plant effluent to a discharge point downstream of Wind Lake, lake rehabilitation activities in Big Muskego Lake immediately upstream of Wind Lake, and various lake management activities undertaken by the WLMD such as the 1997 alum treatment. Nonetheless, slightly increased total phosphorus-based WTSI values in recent years may indicate some cause for concern during this period.

SUMMARY

Wind Lake represents a typical hard-water, alkaline lake that is considered to have fair water quality. Total phosphorus levels were found to be generally at the level considered to cause nuisance algal and macrophytic growths. Summer stratification was commonly observed in Wind Lake. Nevertheless, the surface waters of the Lake remained well oxygenated and supported a healthy fish population. Winterkill was not a problem in Wind Lake because of the substantial volume of the Lake that provided adequate oxygenated water volume for the support of fish throughout the winter. Internal releases of phosphorus from the bottom sediments were considered to be a potential problem in Wind Lake.

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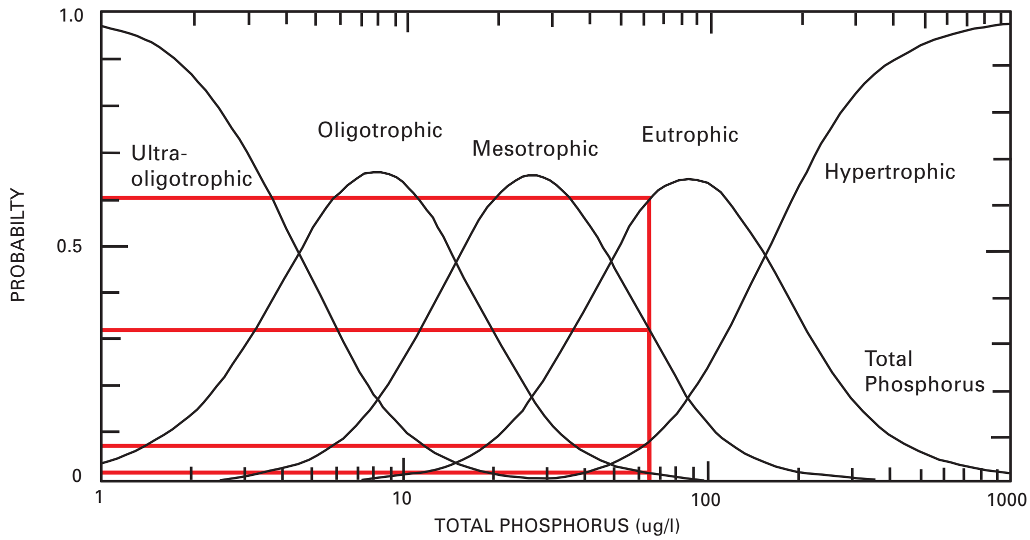
[53]*See OECD,* op. cit.

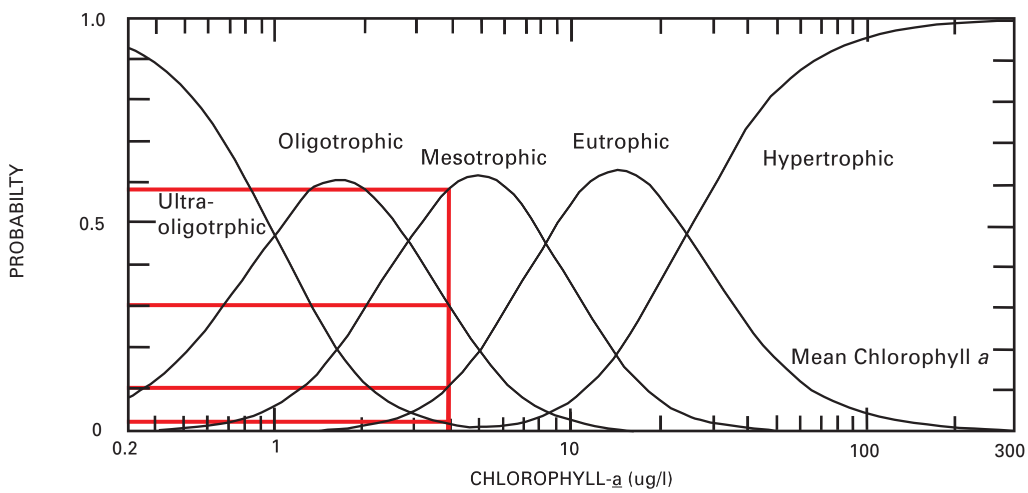
[54]*R.A. Lillie, S. Graham, and P. Rasmussen*, op. cit.

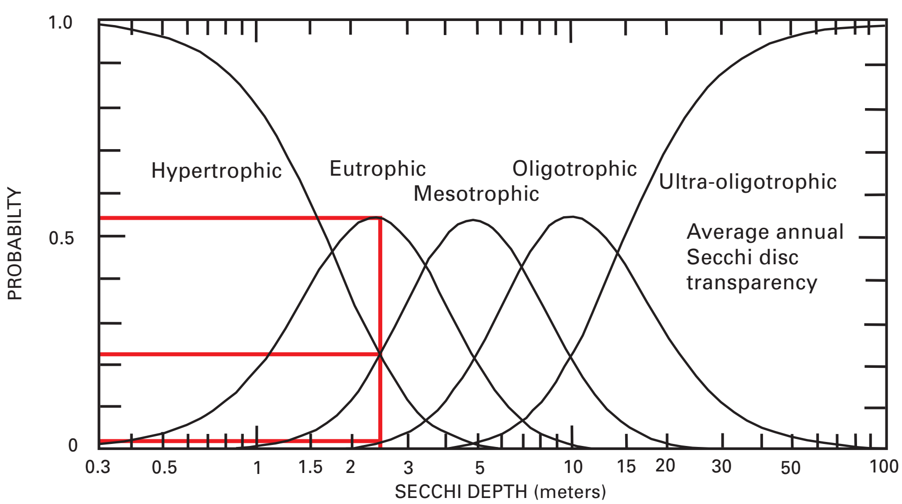
[55]*Wisconsin Department of Natural Resources, Publication No. WR-375-94,* op. cit.*; TSI ratings for Wind Lake were reported to be about 55 during 1988 and 1989, increasing to about 69 in 1990, and decreasing to about 62 in 1991 and 1992.*

Figure 8

TROPHIC STATE CLASSIFICATION OF WIND LAKE BASED UPON THE VOLLENWEIDER MODEL: 2005



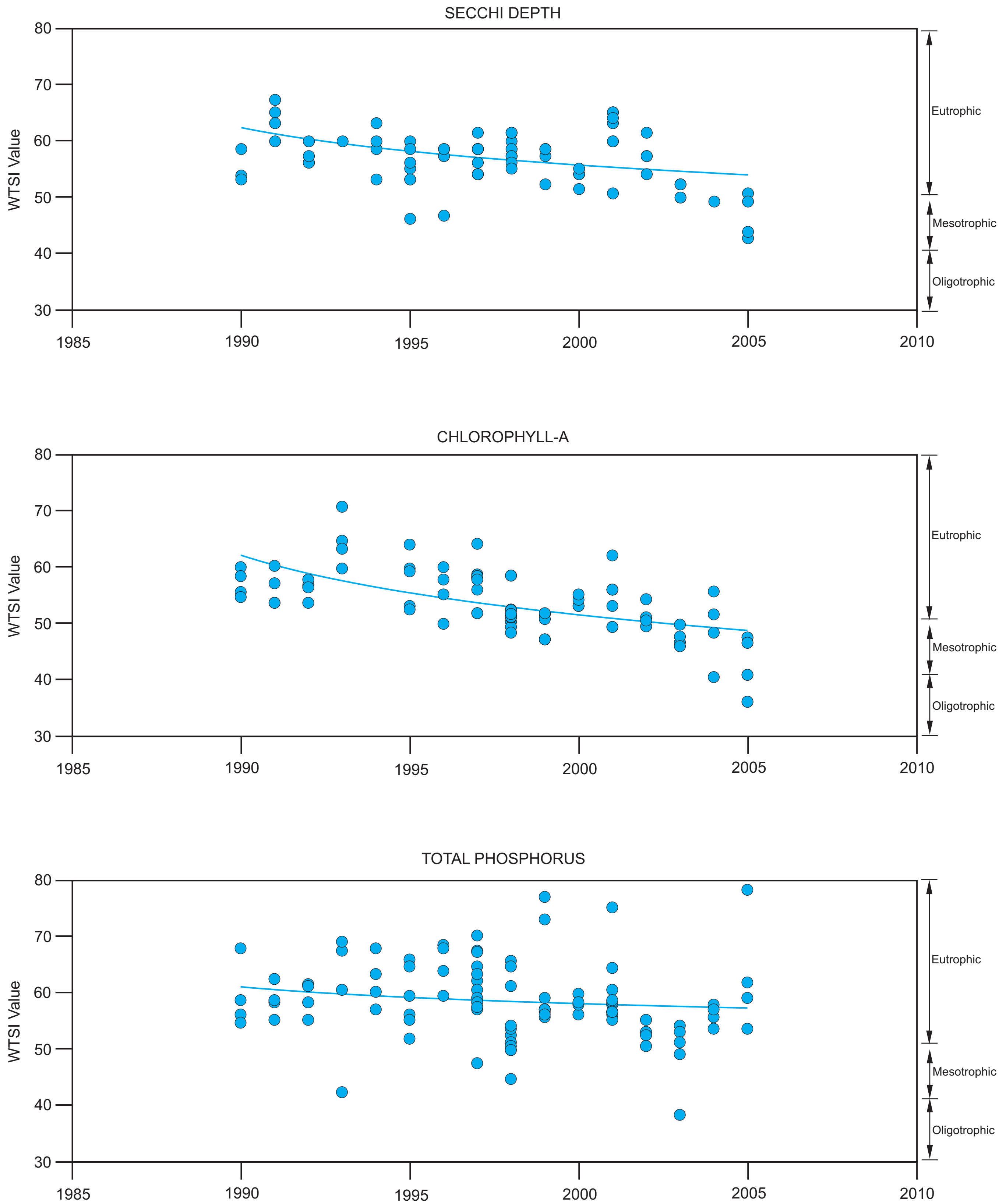




Source: U.S. Geological Survey and SEWRPC.

Figure 9

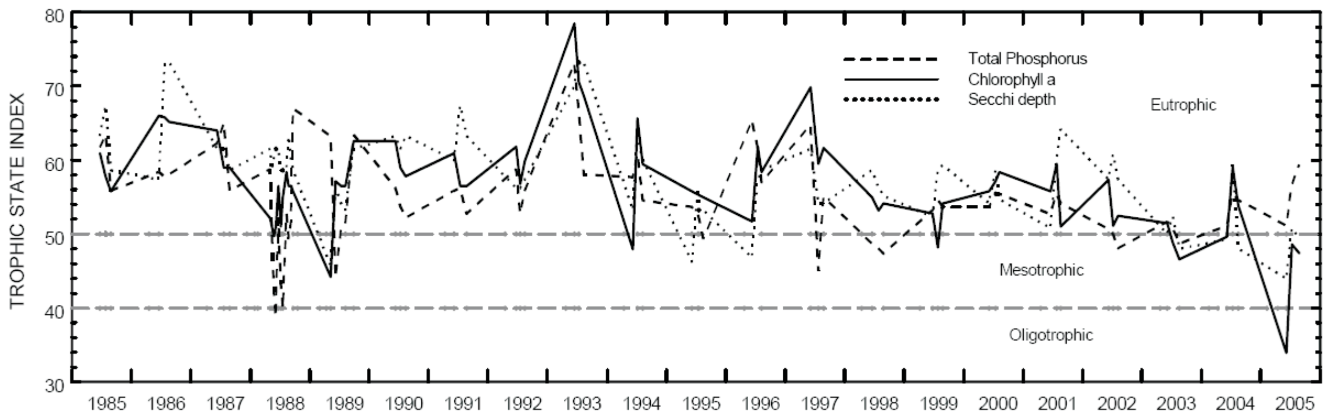
TROPHIC STATE INDICES FOR WIND LAKE: 1990-2005



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

Figure 10

CARLSON TROPHIC STATE INDICES FOR WIND LAKE: 1985-2005



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

There were no significant point sources of pollutants in the Wind Lake tributary area. Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. In 2000, the total annual phosphorus load to Wind Lake was estimated to be 12,000 pounds. Runoff from the rural lands contributed the largest amount of phosphorus, about 80 percent of the total phosphorus load, with the runoff from urban lands contributing about 16 percent of the total phosphorus load. In addition, direct precipitation onto the Lake surface contributed about 4 percent of the total phosphorus load, or relatively minor amounts of phosphorus, to the Lake. Agricultural lands constituted the primary source of phosphorus to the Lake under current land use conditions within the area tributary to the Lake. Under forecast year 2020 conditions, the total annual phosphorus load to Wind Lake is expected to decrease slightly, to about 9,950 pounds annually, with rural lands being anticipated to contribute approximately 65 percent of the total annual load. Urban lands are expected to contribute about 30 percent of the annual phosphorus load, and direct precipitation onto the lake surface to remaining approximately 5 percent.

Approximately 45 percent, or 5,125 pounds, of the total phosphorus loading is estimated to remain in the Lake by conversion to biomass or through sedimentation, resulting in a net transfer of about 6,900 pounds of phosphorus downstream.

Based on the Vollenweider phosphorus loading model and the Wisconsin Trophic State Index ratings calculated from Wind Lake data, Wind Lake may be classified as a meso-eutrophic lake.

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Wind Lake is an important element of the natural resource base, providing a valuable ecological resource for the northwestern portion of Racine County. The Lake, its biota, its parks, and its residential lands combine to contribute to the quality of life in the area.

When located in urban settings, resource features, such as lakes and wetlands, are typically subject to extensive recreational use pressure and high levels of pollutant discharges, common forms of stress to aquatic systems, and these may result in the deterioration of the natural resource features. For this reason, the formulation of sound management strategies must be based on a thorough knowledge of: the pertinent characteristics of the individual resource features, as well as the urban development in the area concerned. Accordingly, this chapter provides information concerning the natural resource features of the Wind Lake tributary area, including data on aquatic macrophytes, fish, wildlife, wetlands, woodlands, and environmental corridors. Recreational activities are described and quantified in Chapter VI.

AQUATIC PLANTS

Aquatic plants include larger plants, or macrophytes, and microscopic algae, or phytoplankton. These plants form an integral part of the aquatic food web, converting inorganic nutrients present in the water and sediments into organic compounds that are directly available as food to other aquatic organisms. In this process, known as photosynthesis, plants utilize energy from sunlight and release oxygen required by other aquatic life forms.

To document the types, distribution, and relative abundance of aquatic macrophytes in Wind Lake, the initial planning report compiled by the Southeastern Wisconsin Regional Planning Commission (SEWRPC)[1] presented data from surveys conducted in 1967 by the Wisconsin Department of Natural Resources (WDNR), in 1988 by a private company from Minnesota, and in 1990 by SEWRPC staff. In addition to the 1990 survey, staff of SEWRPC and WDNR recorded macrophyte species observed during the sediment collection undertaken during August 1990. As part of the current planning effort, an aquatic plant survey was conducted by Commission staff during the summer of 2005. Phytoplankton populations were sampled only during a survey conducted primarily

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[1]*SEWRPC Community Assistance Planning Report No. 198,* A Management Plan for Wind Lake, Racine County, Wisconsin, *December 1991.*

from fall of 1987 through late summer of 1989 by the U.S. Geological Survey (USGS),[2] the results of which were presented in the initial SEWRPC planning report. Data from the various phytoplankton and aquatic macrophytes surveys are summarized below.

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 aquatic food webs. As primary producers, they utilize the process of photosynthesis to 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. In lakes with high nutrient levels, heavy growths of phytoplankton, or algal blooms, may occur, especially during the summer months. Algal blooms have occasionally been perceived as a problem in Wind Lake.

Algae are generally classified according to their dominant pigment, for example, green, blue-green, yellow-brown, and golden brown. 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, or "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. Diatoms, also referred to as yellow-brown algae, and golden-brown algae are adapted to growth under low-light conditions and cooler water temperatures. In temperate lakes, there is a typical seasonal succession of algae from chrysophytes or golden-brown algae during the winter, to diatoms in the spring, to blue-green algae or cyanophytes during the summer,[3] to green algae during the fall.

Algal blooms may reach nuisance proportions in fertile, or eutrophic-lakes, resulting in the accumulation of surface scums or slime. In some cases, heavy concentrations of wind-blown algae accumulate on shorelines, where they die and decompose, causing noxious odors and unsightly conditions. The decaying algae consume oxygen, sometimes depleting available supplies and resulting in fish kills. Also, certain species of decomposing blue-green algae may release toxic materials into the water.

Algae species in Wind Lake were identified and enumerated as part of the aforementioned study conducted by USGS in 1987 through 1989.[4] At that time, the blue-green algae dominated the algal population on all sample dates, comprising about 90 percent of the total algal population. During winter, cooler water temperatures and low-light conditions favored the diatoms and golden-brown algae whose populations peaked during this time of year, comprising as much as 40 percent of the total algal population. As temperatures warmed, faster-growing green algae became more common, reaching their maximum growth in late May and early June, when they made up about 15 percent of the algal population. By July, the blue-green algae had reached their maximum growth, remaining abundant until late September, the result of a combination of slow growth rates and low loss rates. Low loss rates can be attributed, in part, to special adaptations of some blue-green species. Some blue-green algae, for example, possess specialized bodies (vacuoles) within their cells which allow them to regulate their buoyancy, minimizing loss of cells by sedimentation and maximizing growth by allowing them to control their vertical

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[2]*U.S. Geological Survey,* Hydrology and Water Quality of Wind Lake in Southeastern Wisconsin*,* Water-Resources Investigations Report 91-4107, *1993.*

[3]*Cyanophytes or blue-green algae are also known as cyanobacteria.*

[4]*U.S. Geological Survey Water-Resources Investigations Report 91-4107,* op. cit.

position in the water in order to obtain optimal levels of light and nutrients. The blue-green alga, *Coelosphaerium naegelianum,* present in Wind Lake, forms hollow spheres of this numerous coccoid alga and may, during bloom periods and the ensuing decomposition period, be deposited as wind-concentrated accumulations along shorelines with resultant odor problems thereby having a negative impact on recreational and esthetic qualities of the Lake.

Data concerning the types and densities of algal species found in Wind Lake during the current study period were not collected. However, the mean annual chlorophyll-*a* concentrations of less than 10 mg/m^3, reported in Table 11 in Chapter IV of this report, generally indicate fair to very good water quality, as illustrated in Figure 6, also in Chapter IV of this report. This concentration is significantly less than the 20 μg/l chlorophyll-*a* threshold level, above which algal populations generally are at densities which result in a green coloration of the water and which may be severe enough to discourage recreational activities such as swimming and skiing.[5] The average chlorophyll-*a* concentrations during the initial study period exceeded this threshold level—averaging 21 μg/l chlorophyll-*a* during 1987 and 1988—suggesting that water quality in Wind Lake has improved considerably during the period between the initial study and current planning project.

Aquatic Macrophytes

Aquatic macrophytes, play an important role in the ecology of southeastern Wisconsin lakes. Depending on their type, distribution, and abundance, they can be either beneficial or a nuisance. Macrophytes growing in the locations and in densities that do not significantly interfere with human access to the water and recreational uses, such as boating and swimming, are beneficial in maintaining lake fisheries and wildlife populations. Macrophytes provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise could contribute to excessive algal growth. When their densities become so great as to interfere with swimming and boating activities, when their growth forms limit habitat diversity, and when the plants reduce the aesthetic appeal of the resource, some form of control may be required to ensure the ongoing multiple purpose use of the Region's lakes. 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.

To document the types, distribution, and relative abundance of aquatic macrophytes in Wind Lake, aquatic plant surveys were conducted on the lake in 1967, 1988, 1990, and 2005, as described above. For purposes of the current study, the vegetation was identified by species, and the frequency of occurrence, relative density, and importance value was recorded for each species, along the entire shoreline of the Lake. Comparisons of the relative abundance of aquatic plant species during the 1967, 1988, and 1990 surveys were presented in the initial SEWRPC report. Survey results during the current study are presented in Table 14.

Results of the surveys presented in the initial report indicated that Eurasian water milfoil (*Myriophyllum spicatum*) had increased in abundance since the WDNR survey of 1967 and had become the dominant submergent macrophytes species by the time of the 1988 survey, accounting for 72 percent of the total submerged plants in the Lake. Eurasian water milfoil is a nonnative, invasive species and is a plant of concern in the system. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can control the potentially explosive growth which the plant typically exhibits in lakes with organic-rich sediments, or where the lake bottom has been disturbed. In such cases, the Eurasian water milfoil populations can displace native plant species, leading to the loss of plant diversity, degradation of water quality, and reduction in habitat value for fish, invertebrates, and wildlife. In addition, the plant has been known to cause severe aesthetic and recreational use problems in lakes in southeastern Wisconsin. Other species present during the earlier surveys, although in relatively small numbers compared to Eurasian water milfoil, were muskgrass (*Chara* spp.), Sago pondweed (*Potamogeton pectinatus*), curly-leaf pondweed (*Potamogeton crispus)*, water celery or eel grass (*Vallisneria americana*), and coontail (*Ceratophyllum demersum*).

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[5]*J.R. Vallentyne, "The Process of Eutrophication and Criteria for Trophic State Determination." in* Modeling the Eutrophication Process—Proceedings of a Workshop at St. Petersburg, Florida*, November 19-21, 1969, pp. 5767.*

Table 14

FREQUENCY OF OCCURRENCE AND DENSITY RATINGS OF SUBMERGENT PLANT SPECIES IN WIND LAKE: JULY 2005

Aquatic Plant Species Present	Sites Found	Frequency of Occurrence[a] (percent)	Relative Density[b]	Importance Value[c]
Bladderwort *(Utricularia vulgaris)*……………………..	1	0.9	1.0	0.9
Bushy Pondweed *(Najas flexilis)*…………………………......	8	7.2	1.1	8.1
Clasping-Leaf Pondweed *(Potamogeton richardsonii)*	3	2.7	1.3	3.6
Coontail (*Ceratophyllum demersum*)	49	44.1	2.0	90.1
Curly-Leaf Pondweed *(Potamogeton crispus)*..................	22	19.8	1.5	29.7
Eel-Grass/Wild Celery *(Vallisneria americana)*	35	31.5	2.3	0.1
Elodea *(Elodea Canadensis)*	8	7.2	1.5	10.8
Eurasian Water Milfoil *(Myriophyllum spicatum)*	19	17.1	1.8	30.6
Flatstem Pondweed *(Potamogeton zosteriformis)*	2	1.8	1.5	2.7
Illinois Pondweed *(Potamogeton illinoensis)*....................	9	8.1	2.0	16.2
Leafy Pondweed (*Potamogeton foliosis)*..........................	13	11.7	1.5	18.0
Long-Leaf Pondweed (*Potamogeton nodosus)*................	1	0.9	2.0	1.8
Muskgrass *(Chara vulgaris)*	58	52.3	2.7	138.7
Northern Water Milfoil *(Myriophyllum sibiricum)*...............	31	27.9	1.4	39.6
Sago Pondweed (*Potamogeton pectinatus)*.....................	40	36.0	2.2	77.5
Small Pondweed (*Potamogeton pusillus)*	7	6.3	1.6	9.9
Spiny Naiad *(Najas marina)*	5	4.5	1.0	4.5
Variable Pondweed *(Potamogeton gramineus)*................	1	0.9	1.0	0.9
White-Stem Pondweed (*Potamogeton praelongus)*	9	8.1	1.2	9.9

NOTE: There were 111 sites sampled during the July 2005 survey.

[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 or relative 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.*

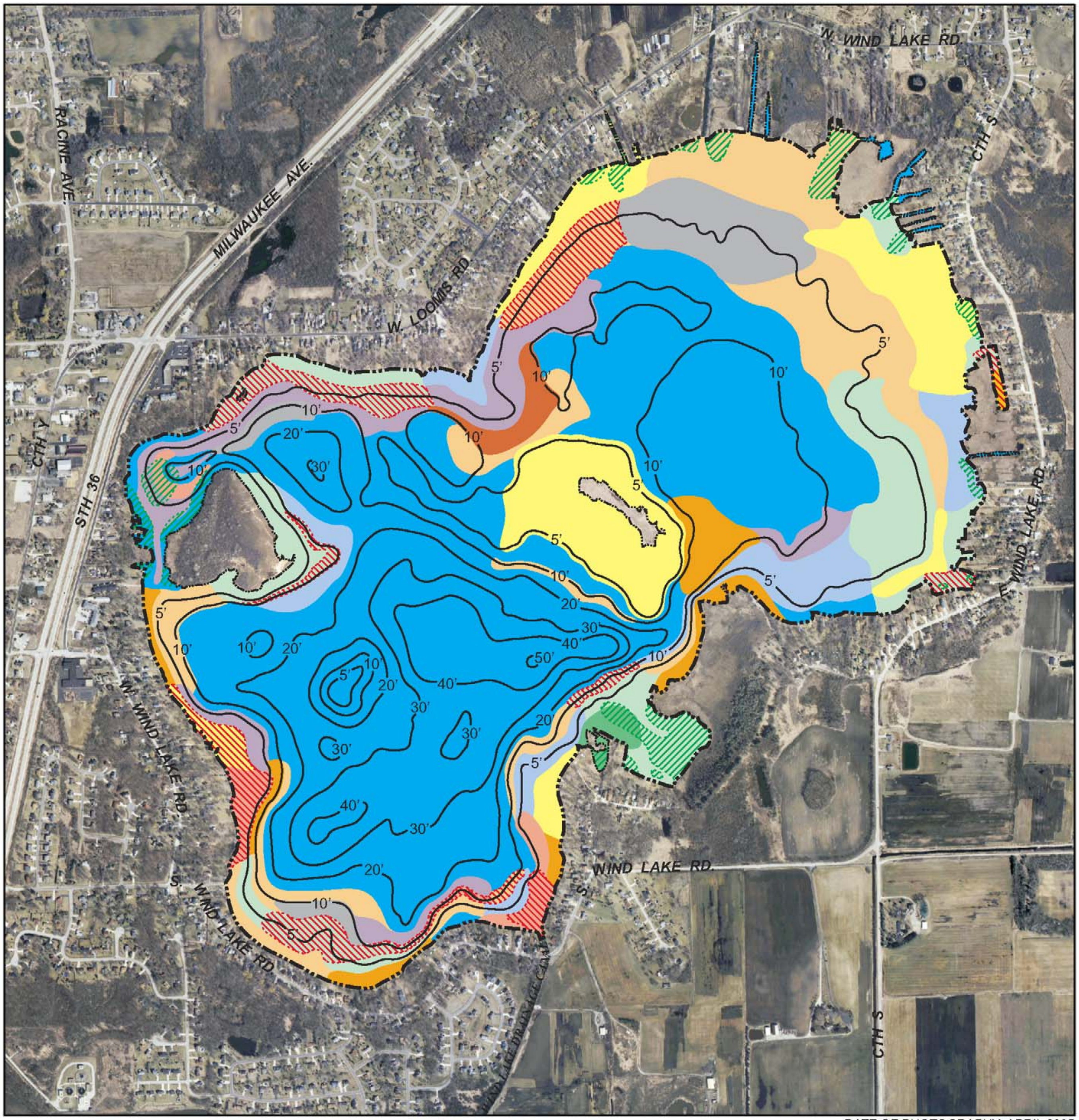
Source: SEWRPC.

In 2005, SEWRPC staff conducted an aquatic plant survey of Wind Lake, the results of which are shown in Table 14. Illustrations of representative macrophyte species identified in Wind Lake at that time are set forth in Appendix A. Of the 19 submergent aquatic plants observed in Wind Lake during July of 2005, the dominant species was muskgrass (*Chara* spp.). Also present in significant numbers were coontail *(Ceratophyllum demersum)*, Sago pondweed (*Potamogeton pectinatus*), northern water milfoil (*Myriophyllum sibiricum*), and curly-leaf pondweed (*Potamogeton crispus)*. Eurasian water milfoil (*Myriophyllum spicatum*) was still present in fairly significant numbers, but to a much lesser extent than in the previous surveys. The distribution of aquatic plant communities in Wind Lake is shown on Map 16.

In general, Wind Lake supports a healthy and diverse aquatic macrophyte community. The beneficial nature of the aquatic plant community in Wind Lake, as well as the importance of this community in maintaining the ecological balance in the Lake, is generally recognized by the lakeshore residents, although some residents report difficulties with navigation in portions of the Lake. Generally, the diversity of the plant community in and adjacent to the Lake contributes to the wildlife habitat value of the area, as set forth below. Fish, waterfowl, pheasants, muskrats, and other wetland wildlife species dependent on aquatic vegetation for feeding and nesting, brooding, or resting

Map 16

AQUATIC PLANT COMMUNITY DISTRIBUTION IN WIND LAKE: 2005



DATE OF PHOTOGRAPHY: APRIL 2005

- 20' — WATER DEPTH CONTOUR IN FEET
- OPEN WATER
- WATER LILIES
- EURASIAN WATER MILFOIL
- COONTAIL
- MUSKGRASS
- COONTAIL, MUSKGRASS, WILD CELERY, AND SAGO PONDWEED
- COONTAIL AND FLOATING LEAF PONDWEED
- COONTAIL, MUSKGRASS, WATERWEED, SAGO PONDWEED, NATIVE WATER MILFOIL, LEAFY PONDWEED, BLADDERWORT AND WILD CELERY
- COONTAIL, MUSKGRASS, WATER STAR GRASS, NATIVE WATER MILFOIL, BUSHY PONDWEED, SAGO PONDWEED, LONG LEAF PONDWEED, AND WILD CELERY
- COONTAIL, MUSKGRASS, SAGO PONDWEED, VARIABLE PONDWEED, ILLINOIS PONDWEED, AND WHITESTEM PONDWEED
- COONTAIL, MUSKGRASS, CURLY LEAF PONDWEED, SAGO PONDWEED, FLAT STEM PONDWEED, AND WILD CELERY
- COONTAIL, MUSKGRASS, WILD CELERY, NATIVE WATER MILFOIL, CURLY LEAF PONDWEED, SAGO PONDWEED, LEAFY PONDWEED, AND SMALL PONDWEED
- COONTAIL, MUSKGRASS, WATERWEED, NATIVE WATER MILFOIL, WILD CELERY, CURLY LEAF PONDWEED, SAGO PONDWEED, AND LEAFY PONDWEED
- COONTAIL, MUSKGRASS, WATER STAR GRASS, NATIVE WATER MILFOIL, BUSHY PONDWEED, SPINY NAIAD, CURLY PONDWEED, CLASPING LEAF PONDWEED, WILD CELERY, ILLINOIS PONDWEED, LEAFY PONDWEED, AND SMALL PONDWEED

GRAPHIC SCALE

0 750 1500 FEET

Source: SEWRPC.

areas are known to make use of the Lake. The positive ecological values of the aquatic plants reported from Wind Lake are set forth in Table 15.

Aquatic Plant Management

Records of aquatic plant management efforts on Wisconsin lakes were not maintained by the WDNR prior to 1950. Thus, while previous interventions were likely, the first recorded efforts to manage the aquatic plants in Wind Lake have taken place since 1950. Aquatic plant management activities in Wind Lake can be categorized as primarily chemical control, although some limited mechanical macrophyte harvesting has occurred sporadically since 1990. 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*.

Chemical Controls

Perceived excessive macrophytes growths in Wind Lake have generally resulted in the application of a chemical control program. Recorded herbicide treatments that have been applied to Wind Lake are set forth in Table 16. 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.

In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in the Madison area, and, by the 1930s, sodium arsenite was widely used throughout the State for aquatic plant control. No other chemicals were applied in significant amounts to control macrophytes until recent years, when a number of organic chemical herbicides came into general use. The amounts of sodium arsenite applied to Wind Lake, and years of application during the period 1950 through 1967, are listed in Table 16. The total amount of sodium arsenite applied over this 17-year period was about 880 pounds.

Sodium arsenite was typically sprayed onto the surface of Wind Lake within an area up to 200 feet from the shoreline. Treatments typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 milligrams per liter (mg/l) of sodium arsenite (or about five mg/l of arsenic) in the treated lake water. The sodium arsenite typically remained in the water column for less than 120 days. Although the arsenic residue was naturally converted from a highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments.

When it became apparent that arsenic was accumulating in the sediments of treated lakes and that the accumulations of arsenic were found to present potential health hazards to both humans and aquatic life, the use of sodium arsenite was discontinued in the State in 1969. Draft sediment quality criteria, including limits for arsenic and copper, proposed by the WDNR are shown in Table 17.

As shown in Table 16, the aquatic herbicides diquat, endothall, and 2,4-D have also been applied to Wind Lake to control aquatic macrophyte growth. Diquat and endothall (Aquathol) 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 primarily kills pondweeds, and provides limited control of such nuisance species as Eurasian water milfoil (*Myriophyllum spicatum*) when used as an early-season central agent. The herbicide 2,4-D is a systemic herbicide that is absorbed by the leaves and translocated to other parts of the plant; it is more selective than the other herbicides listed above and is generally used to control Eurasian water milfoil. However, it will also kill species such as water lilies (*Nymphaea* sp. and *Nuphar* sp.). The present restrictions on water use after application of these herbicides are given in Table 18.

In addition to the chemical herbicides used to control large aquatic plants, algicides also have been applied to Wind Lake. As shown in Table 16, copper sulfate (Cutrine Plus) has been applied to Wind Lake on occasion. Like arsenic, copper, the active ingredient in many algicides, including Cutrine Plus, may accumulate in the bottom sediments. Excessive levels of copper may be toxic to fish and benthic organisms, but, generally, have not been

Table 15

POSITIVE ECOLOGICAL SIGNIFICANCE OF AQUATIC PLANT SPECIES PRESENT IN WIND LAKE

Aquatic Plant Species Present	Ecological Significance
Ceratophyllum demersum (coontail)	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	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 (waterweed)	Provides shelter and support for insects which are valuable as fish food
Myriophyllum sibiricum (northern water milfoil)	Provides food for waterfowl, insect habitat and foraging opportunities for fish
Myriophyllum spicatum (Eurasian water milfoil)	None known
Najas flexilis (bushy pondweed)	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Important food source for ducks
Potamogeton crispus (curly-leaf pondweed)	Provides food, shelter and shade for some fish and food for wildfowl
Potamogeton foliosis (leafy pondweed)	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)	Provides habitat for fish and food for waterfowl, muskrat, beaver and deer
Potamogeton illinoensis (Illinois pondweed)	Provides shade and shelter for fish; harbor for insects; seeds are eaten by wildfowl
Potamogeton nodosus (long-leaf pondweed)	Provides food for ducks, geese, muskrat, beaver, and deer, and provides food and shelter for fish
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton praelongus (white-stem pondweed)	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)	Provides food for ducks, geese, muskrat, beaver, and deer, and provides food and shelter for fish
Potamogeton richardsonii (clasping-leaf pondweed)	Provides food, shelter and shade for some fish, food for some wildfowl, and food for muskrat. Provides shelter and support for insects, which are valuable as fish food
Potamogeton zosteriformis (flat-stem pondweed)	Provides some food for ducks
Utricularia spp. (bladderwort)	Provides cover and foraging for fish
Vallisneria americana (water celery/eelgrass)	Provides good shade and shelter, supports insects, and is valuable fish food

NOTE: Information obtained from *A Manual of Aquatic Plants* by Norman C. Fassett, University of Wisconsin Press; *Guide to Wisconsin Aquatic Plants*, Wisconsin Department of Natural Resources; and, *Through the Looking Glass...A Field Guide to Aquatic Plants*, Wisconsin Lakes Partnership, University of Wisconsin-Extension.

Source: SEWRPC.

Table 16

CHEMICAL CONTROL OF AQUATIC PLANTS IN WIND LAKE: 1958-2005

		Algae Control			Macrophyte Control				
Year	Total Acres Treated	Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine-+ (pounds)	Sodium Arsenite (pounds)	2, 4-D (gallons)	Diquat (gallons)	Endothall (gallons)	Aquathol (gallons)
1958-1972	N/A	- -	- -	100	880	- -	- -	- -	- -
1973	N/A	- -	- -	23	- -	- -	- -	370 lbs.	- -.
1974	N/A	- -	- -	120	- -	- -	- -	- -	54.9
1975-1976	N/A	- -	- -	66 + 22 gal.	- -	5.0	- -	- -	30.0
1977	N/A	- -	- -	14.8 gal.	- -	2.0	- -	- -	1.7
1978	N/A	- -	- -	17.0 gal.	- -	- -	0.5	- -	21.0
1979[a]	N/A	- -	- -	18.0 gal.	- -	- -	- -	- -	19.5
1980	N/A	- -	- -	10.5 gal.	- -	0.25	- -	- -	13.0
1981	N/A	- -	- -	2.8 gal.	- -	6.6	- -	- -	2.5
1982-1983	N/A	- -	- -	185 + 9.25 gal.	- -	- -	- -	- -	- -
1984	N/A	- -	- -	5.1 gal.	- -	2.6	- -	- -	- -
1985	N/A	- -	- -	27.0 gal.	- -	44.0	- -	- -	6.0
1986	N/A	- -	- -	35.0 gal.	- -	15.0	- -	- -	15.0
1987[b]	N/A	- -	- -	79.5 gal.	- -	8.0	- -	- -	16.0
1988[b]	N/A	- -	- -	64.0	- -	30.0	- -	- -	- -
1989	N/A	- -	- -	52.0	- -	14.9	- -	- -	- -
1990-1991	N/A	- -	- -	48.0	- -	1.25	- -	- -	- -
1992	10.1	- -	- -	1.0	- -	50	- -	- -	- -
1993-1994	N/A	- -	- -	- -	- -	- -	- -	- -	- -
1995	1.81	- -	- -	- -	- -	7.5	- -	- -	- -
1996	2.40	- -	- -	0.25	- -	13.05	- -	- -	- -
1997	0.75	- -	- -	- -	- -	100 lbs.	- -	- -	- -
1998	2.0	- -	- -	- -	- -	200 lbs.	- -	- -	- -
1999	1.4	- -	- -	0.75 gal.	- -	130 lbs.	- -	- -	- -
2000	5.75	- -	- -	505 + 1.0 gal	- -	- -	1.0	1.0	- -
2001	81.1	- -	- -	- -	- -	397	- -	- -	- -
2002	15.62	- -	- -	2.75 gal.	- -	51	1.25	- -	- -
2003[c]	21.0	- -	- -	1 gal.	- -	100	1.0	2.5	- -
2004	25.1	- -	- -	22.75 gal.	- -	44.0	2.75	- -	- -
2005	54.7	- -	- -	52.5 gal.	- -	45.75	6	3.75	- -
Total	221.73	- -	- -	1,164.25 + 321.7 gal	880	837.90 + 430 lbs.	12.5	7.25 + 370 lbs.	179.6

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

[a] *1979, unknown number of acres were treated with 0.83 pound of Dalapon to manage emergent vegetation.*

[b] *1987 and 1988, unknown number of acres were treated with 0.8 and 1.0 gallon, respectively, of "Rodeo."*

[c] *In 2003, 0.6 acre were treated with 0.03 gallon of glyphosate.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

found to be harmful to humans.[6] Restrictions on water uses after application of Cutrine Plus and other copper-containing compounds also are given in Table 18.

Macrophyte Harvesting

Although excessive macrophyte growth on Wind Lake has resulted in a control program primarily utilizing chemical treatments, some limited mechanical harvesting has been used to complement the chemical control program. The harvesting program emphasizes removal of nuisance plants necessary to facilitate recreational use by opening up channels and clearing off topped-out beds of milfoil, rather than 100 percent plant removal. Under

[6] *Jeffrey A. Thornton and Walter 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 17

WISCONSIN DEPARTMENT OF NATURAL RESOURCES DRAFT SEDIMENT QUALITY SCREENING CRITERIA[a]

Chemical	Lowest Effect Level (LEL)	Medium Effect Level (MEL)	Severe Effect Level (SEL)
Arsenic	6.00	33.0	85.0
Copper	25.00	110.0	390.0
Lead	31.00	110.0	250.0
Mercury	0.15	0.2	1.3
Ammonia-Nitrogen	75.00	- -	- -

[a]*Units are in mg/kg of dry sediment.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 18

PRESENT RESTRICTIONS ON WATER USES AFTER APPLICATION OF AQUATIC HERBICIDES[a]

Use	Days after Application					
	Copper Sulfate	Diquat	Glyphosate	Endothall	2,4-D	Fluridone
Drinking	- -[b]	14	- -[c]	7-14	- -[d]	- -[e]
Fishing	0	14	0	3	0	0
Swimming	0	1	0	- -	0	0
Irrigation	0	14	0	7-14	- -[d]	7-30

[a]*The U.S. Environmental Protection Agency has indicated that, if these restrictions are observed, pesticide residues in water, irrigated crops, or fish will not pose an unacceptable risk to humans and other organisms using or living in the treatment zone.*

[b]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the residual copper content cannot exceed one part per million (ppm).*

[c]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the drinking water tolerance of glyphosate (Rodeo®) is one part per million (ppm).*

[d]*2,4-D products are not to be applied to waters used for irrigation, animal consumption, drinking, or domestic uses, such as cooking and watering vegetation.*

[e]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the drinking water tolerance of fluridone (Sonar®) is 0.15 parts per million (ppm).*

Source: Wisconsin Department of Natural Resources and SEWRPC.

this program, harvesting operations are carried out utilizing the services of a private contractor. A shore conveyor is used for off-loading and the harvested material is trucked to a nearby site for disposal. Harvesting operations occurred in 1987 through 1989, for two weeks each in 1990 and 1991, and again from 2003 through 2006. Table 19 contains data showing the reports from the harvesting episodes for the time period 2003 through 2006. Permits are required pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* to cut vegetation in lakes. The harvested material must be removed from the water.

Manual Controls

Manual harvesting of aquatic plants around piers and docks is not quantified, as permits governing the conduct of shoreland aquatic plant management programs have only recently been required by the Wisconsin Department of Natural Resources. As of 2003, manual removal of aquatic plants from lakes outside of a 30-foot-wide linear shoreland corridor is governed by Chapter NR 109 of the *Wisconsin Administrative Code*. No data on permits

Table 19

AQUATIC PLANT HARVESTING RESULTS ON WIND LAKE: 2003-2006

Harvesting Data	2003	2004	2005	2006	
Start Date	July 14	June 14	June 27	June 8	July 17
End Date	July 18	June 18	June 28	June 14	July 20
Primary Harvested Species	Eurasian Water Milfoil	Eurasian Water Milfoil	Eurasian Water Milfoil	Eurasian Water Milfoil	Eurasian Water Milfoil
Number of Acres Harvested	22	25	2	80	50
Amount of Plant Material Removed (pounds wet weight)	441,000	168,000	2,000	228,000	200,000
Cost	$12,310	$8,500[a]	$8,500[a]	$8,200	$5,990

[a]*Contract minimum.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

issued to Wind Lake residents are available, although riparian property owners and residents report periodic application of manual harvesting techniques along portions of the shoreline of the Lake.

AQUATIC ANIMALS

Aquatic animals include microscopic zooplankton; benthic, or bottom-dwelling, invertebrates; fish and reptiles; amphibians; mammals; and waterfowl and other birds that inhabit the Lake and its shorelands. These make up the primary and secondary consumers of the Lake's food web.

Zooplankton

Zooplankton are microscopic animals which inhabit the same environment as phytoplankton, the microscopic plants. An important link in the food chain, crustacean zooplankton feed mostly on algae and, in turn, are good food sources for fish. Zooplankton populations were surveyed as part of the initial SEWRPC study. At that time, the diversity of zooplankton species was considered to be typical of a Wisconsin eutrophic lake, with major groups including rotifers, copepods, and cladocerans. *Daphnia* spp., or water fleas, were the dominant cladoceran throughout most of the year. There are no records available concerning surveys of zooplankton populations in Wind Lake during the current study period.

Benthic Invertebrates

The benthic, or bottom dwelling, macroinvertebrate communities of lakes include such organisms as sludge worms, midges, and caddis fly larvae. These organisms are frequently used to assess the existing and recent past water quality of a lake. In addition, these organisms form an important part of the food web, acting as processors of the organic material that accumulates on the lake bottom. Subsequently, the organisms frequently are grazed, in turn, by bottom feeding fishes. Some benthic macroinvertebrate organisms are opportunistic in their feeding habits, while others are openly predaceous. The diversity of the benthic community reflects the trophic status of a lake, with less enriched lakes typically having a greater diversity. Nevertheless, there is no single "indicator organism" that determines the trophic status, or level of enrichment of a lake; rather the entire community must be assessed. The time of year for this assessment consequently becomes an important consideration since these populations fluctuate widely during the summer months as a result of the life stages of the organisms, climatic variability, and localized water quality changes, among other factors. An early-spring or winter sampling is considered to be the best opportunity for making an overall assessment of the benthic community composition. That said, however, there are no current records available concerning benthic populations in Wind Lake.

Zebra mussels, *Dreissenia polymorpha*, are a nonnative species of shellfish having known negative impacts on native benthic populations. This animal currently is spreading into inland lakes from the Laurentian Great Lakes system, where it is considered an invasive species originally introduced into the Great Lakes by ballast water carried by ships from Europe. According to WDNR records, zebra mussels have had an established population in Wind Lake since 2002. Zebra mussels are having a varied impact on inland lakes in the Upper Midwest. They disrupt the food chain by removing significant amounts of phytoplankton which serve as food, not only for themselves, but also for larval and juvenile fish and many forms of zooplankton. However, many lakes experience improved water clarity and greater depths of light penetration as a result of the filter feeding proclivities of these animals. This improved clarity has led 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. 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, so do the environmental, aesthetic, and economic costs to water users.

Fishes of Wind Lake

Wind Lake supports a relatively large and diverse fish community. In the earlier WDNR report,[7] Wind Lake was considered to have good populations of game fish and panfish, and was one of only a few lakes in southeastern Wisconsin to have a fishable white bass population. Most of the panfish were of a generally small size and consisted primarily of bluegills, warmouth, pumpkinseed, rock bass, black crappies, brown bullheads, and perch; bluegills, rock bass, pumpkinseed, and perch being the dominant varieties. Game fish were comprised mainly of largemouth bass, northern pike, and walleye, but an established smallmouth bass population existed as well. Carp and white suckers were common roughfish, but did not appear to be a problem at the time of the surveys. The WDNR has conducted seven fish surveys on Wind Lake since 1981, with the most recent survey having been conducted during 2006. As reported in the initial SEWRPC study, results of the 1990 survey showed the Wind Lake fish population was comprised of about 82 percent panfish, 9 percent gamefish, 6 percent roughfish, and 3 percent minnows.

A baseline survey, undertaken through the use of mini-fyke nets and electrofishing, was conducted by the WDNR in 2006. Utilizing fyke nets, thirteen species of fish were sampled: largemouth bass, walleye, northern pike, bluegill, pumpkinseed, black crappie, white crappie, yellow perch, rock bass, warmouth, longnose gar, black bullhead, and bluntnose minnow. Bluegill was the most abundant fish, comprising about 65 percent of the sample. During the electrofishing survey, eleven species of fish were sampled: largemouth bass, walleye, northern pike, bluegill, yellow bass, bowfin, lake chubsucker, yellow perch, grass pickerel, black bullhead, and brown bullhead. Again, bluegills were the most abundant fish, ranging in size from 2.7 inches to 8.5 inches with an average length of 5.9 inches; the seven-inch group occurred most frequently. The second most abundant fish was walleye, ranging in length from 6.6 inches to 19.3 inches, with a mean length of 8.9 inches. The seven-inch size class occurred most frequently in the sample. Largemouth bass ranged in size from 7.6 inches to 15.7 inches with an average length of 11.6 inches and most bass were in the nine-inch group. Additionally, SEWRPC reports the presence of the striped shiner, a State-designated endangered species, and the pugnose minnow, a State-designated special concern species.[8]

"Panfish" is a common term applied to a broad group of smaller fish with a relatively short and usually broad shape that makes them a perfect size for the frying pan. A wide range of panfish is present in the Lake, as discussed above. Panfish species known to exist in Wind Lake include yellow perch (*Perca flavescens*),

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[7]*Wisconsin Department of Natural Resources Lake Use Report No. FX-5,* Wind Lake, Racine County, Wisconsin, *1969.*

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

pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), and warmouth (*Lepomis gulous*). Additionally, in the initial SEWRPC report, white crappie (*Pomoxis annularis*) and black and brown bullheads (*Ictalurus* spp.) were reported as present in the Lake. The habitats of panfish vary widely among the different species, but their cropping of the plentiful supply of insects and plants, coupled with prolific breeding rates, leads to large populations with a rapid turnover. Some lakes within southeastern Wisconsin have stunted, or slow-growing, panfish populations because their numbers are not controlled by predatory fishes. Panfish frequently feed on the fry of predatory fishes and, if the panfish population is overabundant, they may quickly deplete the predator fry population. Figure 11 illustrates the importance of a balanced predator-prey relationship, using walleyed pike and perch as an example.

"Roughfish" is a broad term applied to species, such as carp, that do not readily bite on hook and line, but feed on gamefish, destroy habitat needed by more-desirable species, and are commonly considered in Southeastern Wisconsin as undesirable for human consumption. Roughfish species which have been found in Wind Lake include the common carp (*Cyprinus carpio*), longnose gar (*Lepisosteus osseus*), quillback (*Carpiodes cyrinus*), bowfin (*Amia calva*), and white sucker (*Catostomos commersoni*).

"Gamefish" is the term applied to those fishes that are typically sought by anglers, and which are generally considered to be desirable species. Gamefish that have been found in Wind Lake include northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), walleye (*Stizostedion vitreum vitreum*), and channel catfish (*Ictalurus punctatus*). At the time of the initial SEWRPC study, the northern pike and walleyed pike populations were relatively small, indicating heavy fishing pressure on these species. The walleyed pike population is dependent on stocking, since little or no natural reproduction of this species occurs in Wind Lake.

Fisheries Management

The Lake is judged to have a good fishery. Currently, the WDNR manages Wind Lake as a bass-panfish warmwater fishery. Fish management efforts have included annual carp removal via a private contractor, which began in 2000. Carp that move up the Muskego Canal from Wind Lake to the Big Muskego Lake dam in the spring and early summer are removed by seining. The amount of carp harvested through this program each year has been between 0 and 16,440 pounds. Additionally, fish management has included passive maintenance through ensuring compliance with WDNR State fishing regulations. The 2006-2007 regulations governing the harvest of fishes from the waters of the State are summarized in Table 20. The Lake is judged to provide adequate spawning, nursery, and feeding habitat for largemouth bass, bluegill, and other native panfish, and, as such, is not considered to require these populations to be supplemented by stocking. However, due largely to the popularity of northern pike and walleye among fishermen, supplemental stocking of these species has been recommended. Stocking data for Wind Lake are shown in Table 21. All stocking of lakes in Wisconsin is regulated by the WDNR. Management measures are recommended to include protection of existing, remnant populations of threatened and endangered species, and species of special concern.[9]

Other Wildlife

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the current Wind Lake study, it is possible, by polling naturalists and wildlife managers familiar with the area, to complete a list of amphibians, reptiles, birds, and mammals which may be expected to be found in the area under existing conditions. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or known to have existed, in the Wind Lake area; associating these lists with the historic and remaining habitat areas in the Wind Lake area as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Wind Lake area. The net result of the application of this technique is a listing of those species, summarized in Tables 22 through 24, for mammals, birds, and amphibians and reptiles, respectively, which were probably once present in the tributary area; those species which may be expected to still be present under currently prevailing conditions; and those species which may be expected to be lost or gained as a result of urbanization within the area.

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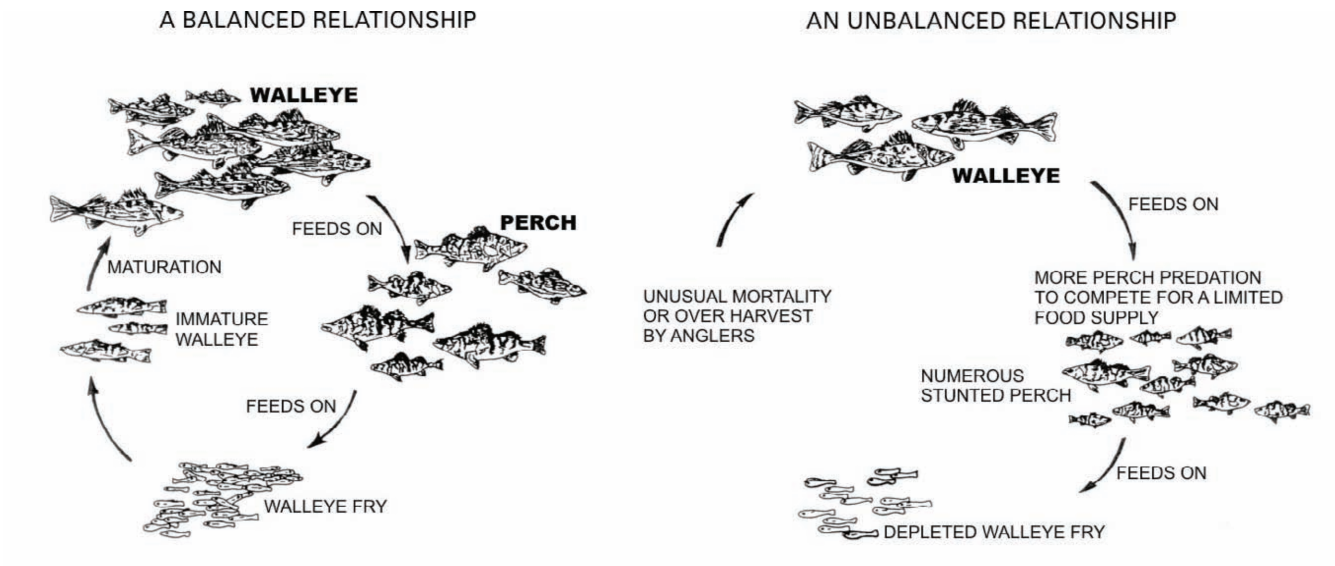
[9]Ibid.

Figure 11

THE PREDATOR-PREY RELATIONSHIP



Source: Wisconsin Department of Natural Resources and SEWRPC.

A variety of mammals, ranging in size from large animals like the northern white-tailed deer to small animals like the least shrew, are expected to be found in the Wind Lake area. Mink, muskrat, beaver, white-tailed deer, red and grey fox, grey and fox squirrel, and cottontail rabbits are mammals reported to frequent the area. Table 22 lists 38 mammals whose ranges are known to extend into the area.

A large number of birds, ranging in size from large gamebirds to small songbirds, also are expected to be found in the Wind Lake area. Table 23 lists those birds that normally occur in the tributary area. Each bird is classified as to whether it breeds within the area, visits the area only during the annual migration periods, or visits the area only on rare occasions. The Wind Lake tributary area supports a significant population of waterfowl, including mallard and teal. Larger numbers of birds move through the tributary area during migrations when most of the regional species may also be present.

Mallards, wood ducks, blue-winged teal, and Canada geese are the most numerous waterfowl and are known to nest in the area. Many game birds, songbirds, waders, and raptors also reside or visit the Lake and its environs. Ospreys and loons are notable migratory visitors.

Because of the mixture of lowland and upland woodlots, wetlands, and agricultural lands still present in the area, along with the favorable summer climate, the area supports many other species of birds. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whippoorwills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as the major insect predators. In addition to their ecological roles, birds such as robins, red-winged blackbirds, orioles, cardinals, kingfishers, and mourning doves serve as subjects for bird watchers and photographers. Threatened species migrating in the vicinity of Wind Lake include the cerulean warblers, the Acadian flycatcher, great egret, and the osprey. Endangered species migrating in the vicinity of Wind Lake include the common tern, Caspian tern, Forster's tern, and loggerhead shrike. A large blue heron rookery exists in a wooded portion of the Wind Lake tributary area upstream of the Lake.

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Wind Lake tributary area. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the Wind Lake area. Table 24 lists the 14 amphibian and 15 reptile

Table 20

FISHING REGULATIONS APPLICABLE TO WIND LAKE: 2006-2007

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 6 to March 4	2	26 inches
Walleyed Pike	May 6 to March 4	5	15 inches
Largemouth and Smallmouth Bass	May 6 to March 4	5 in total	14 inches
Rock, Yellow and White Bass	Open all year	None	None
Bluegill, Pumpkinseed (sunfish), Crappie, and Yellow Perch	Open all year	25 in total	None
Bullhead and Rough Fish	Open all year	None	None

Source: Wisconsin Department of Natural Resources Publication No. PUBL-FH-301 2006, Guide to Wisconsin Hook and Line Fishing Regulations 2006-2007*, January 2006; and SEWRPC.*

Table 21

FISH STOCKED INTO WIND LAKE: 1972-2006

Year	Species Stocked	Number Stocked	Size	Source
1972	Walleye	21,000	5 inches	WDNR
1974	Walleye	20,250	3 inches	WDNR
1976	Walleye	36,500	3 inches	WDNR
1979	Walleye	50,640	4 inches	WDNR
1981	Walleye	41,865	4 inches	WDNR
1983	Northern pike	2,000	9 inches	WDNR
1984	Walleye	50,000	3 inches	WDNR
1985	Northern pike	2,000	8 inches	WDNR
1985	Walleye	34,033	3 inches	WDNR
1987	Walleye	143,520	2 inches	WDNR
1990	Walleye	38,000	2 inches	WDNR
1992	Northern pike	2,800	8 inches	WDNR
1992	Walleye	148,120	2 inches	WDNR
1994	Walleye	23,590	3 inches	WDNR
1994	Northern pike	1,870	7 inches	WDNR
1996	Walleye	2,000	8 inches	WDNR
1996	Northern pike	1,770	9 inches	WDNR
1998	Walleye	82,200	3 inches	WDNR
2000	Walleye	92,375	2 inches	WDNR
2000	Northern pike	1,872	8 inches	WDNR
2002	Walleye	52,180	2 inches	WDNR
2002	Northern pike	1,000	8 inches	WDNR
2004	Northern pike	400	N/A	Private
2006	Walleye	32,760	2 inches	WDNR
2006	Northern pike	2,340	9 inches	WDNR

Source: Wisconsin Department of Natural Resources and SEWRPC.

species normally expected to be present in the Wind Lake area under existing conditions, and identifies those species most sensitive to urbanization.

Most amphibians and reptiles have definite habitat requirements that are adversely affected by advancing urban development, as well as by certain agricultural land management practices. The major detrimental factors affecting the maintenance of amphibians in a changing environment is the destruction of breeding ponds, urban development occurring along migration routes, and changes in food sources brought about by urbanization.

Table 22

MAMMALS OF THE WIND LAKE AREA

Scientific (family) and Common Name	Scientific Name
Didelphidae	
Virginia Opossum	*Didelphis virginiana*
Soricidae	
Cinereous Shrew	*Sorex cinereus*
Short-Tailed Shrew	*Blarina brevicauda*
Least Shrew	*Cryptotis parva*
Vespertilionidae	
Little Brown Bat	*Myotis lucifugus*
Silver-Haired Bat	*Lasisoncteris octivagans*
Big Brown Bat	*Eptesicus fuscus*
Red Bat	*Lasiurus borealus*
Hoary Bat	*Lasiurus cinereus*
Leporidae	
Cottontail Rabbit	*Sylvilgus floridanus*
Sciuridae	
Woodchuck	*Marmota monax*
Thirteen-lined Ground Squirrel (gopher)	*Spermophilus tridencemilineatus*
Eastern Chipmunk	*Tamias striatus*
Grey Squirrel	*Sciurus carolinensis*
Western Fox Squirrel	*Sciurus niger*
Red Squirrel	*Tamiasciurus hudsonicus*
Southern Flying Squirrel	*Glaucomys volans*
Castoridae	
American Beaver	*Castor canadensis*
Cricetidae	
Woodland Deer Mouse	*Peromyscus maniculatus*
Prairie Deer Mouse	*Peromyscus leucopus bairdii*
White-Footed Mouse	*Microtus pennsylvanicus*
Meadow Vole	*Microtus ochrogaster*
Common Muskrat	*Ondatra zibethicus*
Muridae	
Norway Rat (introduced)	*Rattus norvegicus*
House Mouse (introduced)	*Mus musculus*
Zapodidae	
Meadow Jumping Mouse	*Zapas hudonius*
Canidae	
Coyote	*Canis latrans*
Eastern Red Fox	*Vulpes vulpes*
Gray Fox	*Urocyon cinereoargenteus*
Procyonidae	
Raccoon	*Procyon lotor*
Mustelidae	
Least Weasel	*Mustela nivalis*
Short-Tailed Weasel	*Mustela erminea*
Long-Tailed Weasel	*Mustela frenata*
Mink	*Mustela vison*
Badger (occasional visitor)	*Taxidea taxus*
Stiped Skunk	*Mephitis mephitis*
Otter (occasional visitor)	*Lontra canadensis*
Cervidae	
White-Tailed Deer	*Odecoileus virginianus*

Source: H.T. Jackson, Mammals of Wisconsin*, 1961, U.S. Department of Agriculture Integrated Taxonomic Information System, National Museum of Natural History, Smithsonian Institute, and SEWRPC.*

The complete spectrum of wildlife species originally native to Racine County has, along with its habitat, undergone significant change in terms of diversity and population size since the European settlement of the area. This change is a direct result of the conversion of land by the settlers from its natural state to agricultural and urban uses, beginning with the clearing of the forest and prairies, the draining of wetlands, and ending with the development of extensive urban areas. Successive cultural uses and attendant management practices, both rural and urban, have been superimposed on the land use changes and have also affected the wildlife and wildlife habitat. In agricultural areas, these cultural management practices include draining land by ditching and tiling and the expanding use of fertilizers, herbicides, and pesticides. In urban areas, cultural management practices that affect wildlife and their habitat include the use of fertilizers, herbicides, and pesticides; the use of road salt for snow and ice control; the presence of heavy motor vehicle traffic that produces disruptive noise levels, as well as air pollution and nonpoint source water pollution; and the introduction of domestic pets.

WILDLIFE HABITAT AND RESOURCES

Wildlife habitat areas within southeastern Wisconsin were initially inventoried by the Regional Planning Commission in cooperation with the WDNR during 1985. The five major criteria used to determine the value of these wildlife habitat areas are listed below:

1. Diversity: An area must maintain a high, but balanced, diversity of species for a temperate climate; balanced in that the proper predator-prey (consumer-food) relationships can occur. In addition, a reproductive interdependence must exist.

2. Territorial Requirements: The maintenance of proper spatial relationships among species which allows for a certain minimum population level can occur only if the territorial requirements of each major species within a particular habitat are met.

3. Vegetative Composition and Structure: The composition and structure of vegetation must be such that the required levels for nesting, travel routes, concealment, and protection from weather are met for each of the major species.

4. Location with Respect to Other Wildlife Habitat Areas: It is very desirable that a wildlife habitat maintain proximity to other wildlife habitat areas.

Table 23

BIRDS KNOWN OR LIKELY TO OCCUR IN THE WIND LAKE AREA

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Gaviidae			
Common Loon[a]	- -	- -	X
Podicipedidae			
Pied-Billed Grebe	X	- -	X
Horned Grebe	- -	- -	X
Phalacrocoracidae			
Double-Crested Cormorant	- -	- -	X
Ardeidae			
American Bittern[a]	X	- -	X
Least Bittern[a]	X	- -	X
Great Blue Heron[a]	X	R	X
Great Egret[b]	- -	- -	X
Cattle Egret[a,c]	- -	- -	R
Green Heron	X	- -	X
Black-Crowned Night Heron[a]	- -	- -	X
Anatidae			
Tundra Swan	- -	- -	X
Trumpeter Swan	- -	- -	X
Mute Swan[c]	X	X	X
Snow Goose	- -	- -	X
Canada Goose	X	X	X
Wood Duck	X	- -	X
Green-Winged Teal	- -	- -	X
American Black Duck[a]	- -	X	X
Mallard	X	X	X
Northern Pintail[a]	- -	- -	X
Blue-Winged Teal	X	- -	X
Northern Shoveler	- -	- -	X
Gadwall	- -	- -	X
American Widgeon[a]	- -	- -	X
Canvasback[a]	- -	- -	X
Redhead[a]	- -	- -	X
Ring-Necked Duck	- -	- -	X
Lesser Scaup[a]	- -	- -	X
Greater Scaup	- -	- -	R
Common Goldeneye[a]	- -	X	X
Bufflehead	- -	- -	X
Red-Breasted Merganser	- -	- -	X
Hooded Merganser[a]	R	- -	X
Common Merganser[a]	- -	- -	X
Ruddy Duck	- -	- -	X
Cathartidae			
Turkey Vulture	X	- -	X
Accipitridae			
Osprey[a]	- -	- -	X
Bald Eagle[a,d]	- -	- -	R
Northern Harrier[a]	X	R	X
Sharp-Shinned Hawk	X	X	X
Cooper's Hawk[a]	X	X	X
Northern Goshawk[a]	- -	R	X
Red-Shouldered Hawk[b]	R	- -	X
Broad-Winged Hawk	R	- -	X
Red-Tailed Hawk	X	X	X
Rough-Legged Hawk	- -	X	X
American Kestrel	X	X	X
Merlin[a]	- -	- -	X

Table 23 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Phasianidae			
Grey Partridge[c]	R	R	- -
Ring-Necked Pheasant[c]	X	X	- -
Wild Turkey	X	X	- -
Rallidae			
Virginia Rail	X	- -	X
Sora	X	- -	X
Common Moorhen	X	- -	X
American Coot	X	R	X
Gruidae			
Sandhill Crane	X	- -	X
Charadriidae			
Black-Bellied Plover	- -	- -	X
Semi-Palmated Plover	- -	- -	X
Killdeer	X	- -	X
Scolopacidae			
Greater Yellowlegs	- -	- -	X
Lesser Yellowlegs	- -	- -	X
Solitary Sandpiper	- -	- -	X
Spotted Sandpiper	X	- -	X
Upland Sandpiper[a]	R	- -	X
Semi-Palmated Sandpiper	- -	- -	X
Pectoral Sandpiper	- -	- -	X
Dunlin	- -	- -	X
Common Snipe	R	- -	X
American Woodcock	X	- -	X
Wilson's Phalarope	- -	- -	X
Laridae			
Ring-Billed Gull	- -	- -	X
Herring Gull	- -	X	X
Common Tern[e]	- -	- -	R
Caspian Tern[e]	- -	- -	R
Forster's Tern[e]	- -	- -	R
Black Tern[a]	X	- -	X
Columbidae			
Rock Dove[c]	X	X	- -
Mourning Dove	X	X	X
Cuculidae			
Black-Billed Cuckoo	X	- -	X
Yellow-Billed Cuckoo[a]	X	- -	X
Strigidae			
Eastern Screech Owl	X	X	- -
Great Horned Owl	X	X	- -
Snowy Owl	- -	R	- -
Barred Owl	X	X	- -
Long-Eared Owl[a]	- -	X	X
Short-Eared Owl[a]	- -	R	X
Northern Saw-Whet Owl	- -	- -	X
Caprimulgidae			
Common Nighthawk	X	- -	X
Whippoorwill	- -	- -	X
Apodidae			
Chimney Swift	X	- -	X

Table 23 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Trochilidae			
Ruby-Throated Hummingbird	X	- -	X
Alcedinidae			
Belted Kingfisher	X	X	X
Picidae			
Red-Headed Woodpecker[a]	X	R	X
Red-Bellied Woodpecker	X	X	- -
Yellow-Bellied Sapsucker	- -	R	X
Downy Woodpecker	X	X	- -
Hairy Woodpecker	X	X	- -
Northern Flicker	X	R	X
Tyrannidae			
Olive-Sided Flycatcher	- -	- -	X
Eastern Wood Pewee	X	- -	X
Yellow-Bellied Flycatcher[a]	- -	- -	X
Acadian Flycatcher[b]	R	- -	X
Alder Flycatcher	R	- -	X
Willow Flycatcher	X	- -	X
Least Flycatcher	R	- -	X
Eastern Phoebe	X	- -	X
Great Crested Flycatcher	X	- -	X
Eastern Kingbird	X	- -	X
Alaudidae			
Horned Lark	X	X	X
Hirundinidae			
Purple Martin[a]	X	- -	X
Tree Swallow	X	- -	X
Northern Rough-Winged Swallow	X	- -	X
Bank Swallow	X	- -	X
Cliff Swallow	X	- -	X
Barn Swallow	X	- -	X
Corvidae			
Blue Jay	X	X	X
American Crow	X	X	X
Paridae			
Tufted Titmouse	R	R	- -
Black-Capped Chickadee	X	X	X
Sittidae			
Red-Breasted Nuthatch	R	X	X
White-Breasted Nuthatch	X	X	- -
Certhiidae			
Brown Creeper	- -	X	X
Troglodytidae			
Carolina Wren	- -	- -	R
House Wren	X	- -	X
Winter Wren	- -	- -	X
Sedge Wren[a]	X	- -	X
Marsh Wren	X	- -	X
Regulidae			
Golden-Crowned Kinglet	- -	X	X
Ruby-Crowned Kinglet[a]	- -	- -	X
Blue-Gray Gnatcatcher	X	- -	X
Eastern Bluebird	X	- -	X

Table 23 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Regulidae (continued)			
Veery[a]	X	- -	X
Gray-Cheeked Thrush	- -	- -	X
Swainson's Thrush	- -	- -	X
Hermit Thrush	- -	- -	X
Wood Thrush[a]	X	- -	X
American Robin	X	X	X
Mimidae			
Gray Catbird	X	- -	X
Brown Thrasher	X	- -	X
Bombycillidae			
Bohemian Waxwing	- -	R	- -
Cedar Waxwing	X	X	X
Laniidae			
Northern Shrike	- -	- -	X
Loggerhead Shrike[e]	- -	- -	R
Sturnidae			
European Starling[c]	X	X	X
Vireonidae			
Bell's Vireo	- -	- -	R
Solitary Vireo	- -	- -	X
Yellow-Throated Vireo	X	- -	X
Warbling Vireo	X	- -	X
Philadelphia Vireo	- -	- -	X
Red-Eyed Vireo	X	- -	X
Parulidae			
Blue-Winged Warbler	X	- -	X
Golden-Winged Warbler[a]	R	- -	X
Tennessee Warbler[a]	- -	- -	X
Orange-Crowned Warbler	- -	- -	X
Nashville Warbler[a]	- -	- -	X
Northern Parula	- -	- -	X
Yellow Warbler	X	- -	X
Chestnut-Sided Warbler	- -	- -	X
Magnolia Warbler	- -	- -	X
Cape May Warbler[a]	- -	- -	X
Black-Throated Blue Warbler	- -	- -	X
Yellow-Rumped Warbler	- -	R	X
Black-Throated Green Warbler	- -	- -	X
Cerulean Warbler[b]	R	- -	R
Blackburnian Warbler	- -	- -	X
Palm Warbler	- -	- -	X
Bay-Breasted Warbler	- -	- -	X
Blackpoll Warbler	- -	- -	X
Black-and-White Warbler	- -	- -	X
Prothonotary Warbler[a]	- -	- -	R
American Redstart	X	- -	X
Ovenbird	X	- -	X
Northern Waterthrush	- -	- -	X
Connecticut Warbler[a]	- -	- -	X
Mourning Warbler	R	- -	X
Common Yellowthroat	X	- -	X
Wilson's Warbler	- -	- -	X
Kentucky Warbler[b]	- -	- -	R
Canada Warbler	R	- -	X
Hooded Warbler[b]	R	- -	R

Table 23 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Thraupidae			
Scarlet Tanager	X	- -	X
Cardinalidae			
Northern Cardinal	X	X	- -
Rose-Breasted Grosbeak	X	- -	X
Indigo Bunting	X	- -	X
Emberizidae			
Dickcissel[a]	R	- -	X
Eastern Towhee	X	- -	X
American Tree Sparrow	- -	X	X
Chipping Sparrow	X	- -	X
Clay-Colored Sparrow	R	- -	X
Field Sparrow	X	- -	X
Vesper Sparrow[a]	X	- -	X
Savannah Sparrow	X	- -	X
Grasshopper Sparrow[a]	X	- -	X
Henslow's Sparrow[b]	R	- -	X
Fox Sparrow	- -	R	X
Song Sparrow	X	X	X
Lincoln's Sparrow	- -	- -	X
Swamp Sparrow	X	X	X
White-Throated Sparrow	- -	R	X
White-Crowned Sparrow	- -	- -	X
Dark-Eyed Junco	- -	X	X
Lapland Longspur	- -	R	X
Snow Bunting	- -	R	X
Icteridae			
Bobolink[a]	X	- -	X
Red-Winged Blackbird	X	X	X
Eastern Meadowlark[a]	X	R	X
Western Meadowlark[a]	R	- -	X
Yellow-Headed Blackbird	X	- -	X
Rusty Blackbird	- -	R	X
Common Grackle	X	X	X
Brown-Headed Cowbird	X	R	X
Orchard Oriole[a]	R	- -	R
Baltimore Oriole	X	- -	X
Fringillidae			
Purple Finch	- -	X	X
Common Redpoll	- -	X	X
Pine Siskin[a]	- -	X	X
American Goldfinch	X	X	X
House Finch	X	X	X
Evening Grosbeak	- -	X	X
Passeridae			
House Sparrow[c]	X	X	- -

NOTE: Total number of bird species: 220
Number of alien, or nonnative, bird species: 7 (3 percent)

Breeding: Nesting species
Wintering: Present January through February
Migrant: Spring and/or fall transient

X - Present, not rare
R - Rare

Table 23 Footnotes

[a]*State-designated species of special concern. Fully protected Federal and State laws under the Migratory Bird Act.*

[b]*State-designated threatened species.*

[c]*Alien, or nonnative, bird species.*

[d]*Federally designated threatened species.*

[e]*State-designated endangered species.*

Source: Samuel D. Robbins, Jr., Wisconsin Birdlife, Population & Distribution, Past and Present*, 1991; John E. Bielefeldt, Racine County Naturalist; Zoological Society of Milwaukee County and Birds Without Borders-Aves Sin Fronteras,* Report for Landowners on the Avian Species Using the Pewaukee, Rosendale and Land O'Lakes Study Sites*, April-August, 1998; Wisconsin Department of Natural Resources; and SEWRPC.*

5. Disturbance: Minimum levels of disturbance by human activities are necessary (other than those activities of a wildlife management nature).

On the basis of these five criteria, the wildlife habitat areas in the Wind Lake tributary area were categorized as either Class I, High-Value; Class II, Medium-Value; or Class III, Good-Value, habitat areas. Class I wildlife habitat areas contain a good diversity of wildlife, are adequate in size to meet all of the habitat requirements for the species concerned, are generally located in proximity to other wildlife habitat areas, and meet all five criteria listed above. Class II wildlife habitat areas generally fail to meet one of the five criteria in the preceding list for a high-value wildlife habitat. However, they do retain a good plant and animal diversity. Class III wildlife habitat areas are remnant in nature in that they generally fail to meet two or more of the five criteria for a high-value wildlife habitat. Nevertheless, Class III habitat areas may be important if located in proximity to medium- or high-value habitat areas if they provide corridors linking wildlife habitat areas of higher value or if they provide the only available habitat in an area.

As shown on Map 17, approximately 7,400 acres, or about 28 percent of the total area tributary to Wind Lake, were classified in the 1985 inventory as wildlife habitat, with about 3,775 acres, or about 14 percent of the total tributary area, classified as Class I habitat; about 2,127 acres, or about 8 percent, classified as Class II habitat; and about 1,498 acres, or about 6 percent, classified as Class III habitat. Of the 7,400 acres of wildlife habitat in the total tributary area of Wind Lake, about 51 percent is considered Class I habitat, 29 percent is Class II habitat, and 20 percent is Class III.

In the area directly tributary to Wind Lake, about 570 acres, or about 24 percent, are classified as wildlife habitat. Of the 570 acres identified as wildlife habitat, about 173 acres, or about 30 percent, were classified as Class I habitat; about 228 acres, or about 40 percent, were considered Class II habitat; and about 168 acres, or about 29 percent, were considered Class III habitat.

NATURAL AREAS AND CRITICAL SPECIES HABITAT

The Wind Lake area contains natural areas of local, countywide, and regional importance, due to its richness of natural habitat and biota and, as shown on Map 18, contains four specially designated natural areas as defined in the adopted Regional Natural Areas and Critical Species Habitat plan.[10] These areas are:

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[10]Ibid.

Table 24

AMPHIBIANS AND REPTILES OF THE WIND LAKE AREA

Scientific (family) and Common Name	Scientific Name	Species Reduced or Dispersed with Full Area Urbanization	Species Lost with Full Area Urbanization
Amphibians			
Proteidae			
Mudpuppy	*Necturus maculosus maculosus*	X	- -
Ambystomatidae			
Blue-Spotted Salamander	*Ambystoma laterale*	- -	X
Spotted Salamander	*Ambystoma maculatum*		
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	X	- -
Salamandridae			
Central Newt	*Notophthalmus viridescens louisianensi*	X	- -
Bufonidae			
American Toad	*Bufo americanus americanus*	X	- -
Hylidae			
Western Chorus Frog	*Pseudacris triseriata triseriata*	X	- -
Blanchard's Cricket Frog[a,b]	*Acris crepitans blanchardi*	X	- -
Northern Spring Peeper	*Hyla crucifer crucifer*	- -	X
Gray Tree Frog	*Hyla versicolor*	- -	X
Ranidae			
Bull Frog[c]	*Rana catesbeiana*	- -	X
Green Frog	*Rana clamitans melanota*	X	- -
Northern Leopard Frog	*Rana pipiens*	- -	X
Pickerel Frog[c]	*Rana palustris*	- -	X
Reptiles			
Chelydridae			
Common Snapping Turtle	*Chelydra serpentina serpentina*	X	- -
Kinosternidae			
Musk Turtle (stinkpot)	*Sternotherus odoratus*	X	- -
Emydidae			
Western Painted Turtle	*Chrysemys picta belli*	X	- -
Midland Painted Turtle	*Chrysemys picta marginata*	X	- -
Blanding's Turtle[d]	*Emydoidea blandingii*	- -	X
Trionychidea			
Eastern Spiny Softshell	*Trionyx spiniferus spiniferus*	X	- -
Colubridae			
Northern Water Snake	*Nerodia sipedon sipedon*	X	- -
Midland Brown Snake	*Storeria dekayi wrightorum*	X	- -
Northern Red-Bellied Snake	*Storeria occipitomaculata occipitomaculata*	X	- -
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	X	- -
Chicago Garter Snake	*Thamnophis sirtalis semifasciata*	X	- -
Butler's Garter Snake[d]	*Thamnophis butleri*	X	- -
Eastern Hognose Snake	*Heterodon platyrhinos*	- -	X
Smooth Green Snake	*Opheodrys vernalis vernalis*	- -	X
Eastern Milk Snake	*Lampropeltis triangulum triangulum*	- -	X

[a]*Likely to be extirpated from the watershed.*

[b]*State-designated endangered species.*

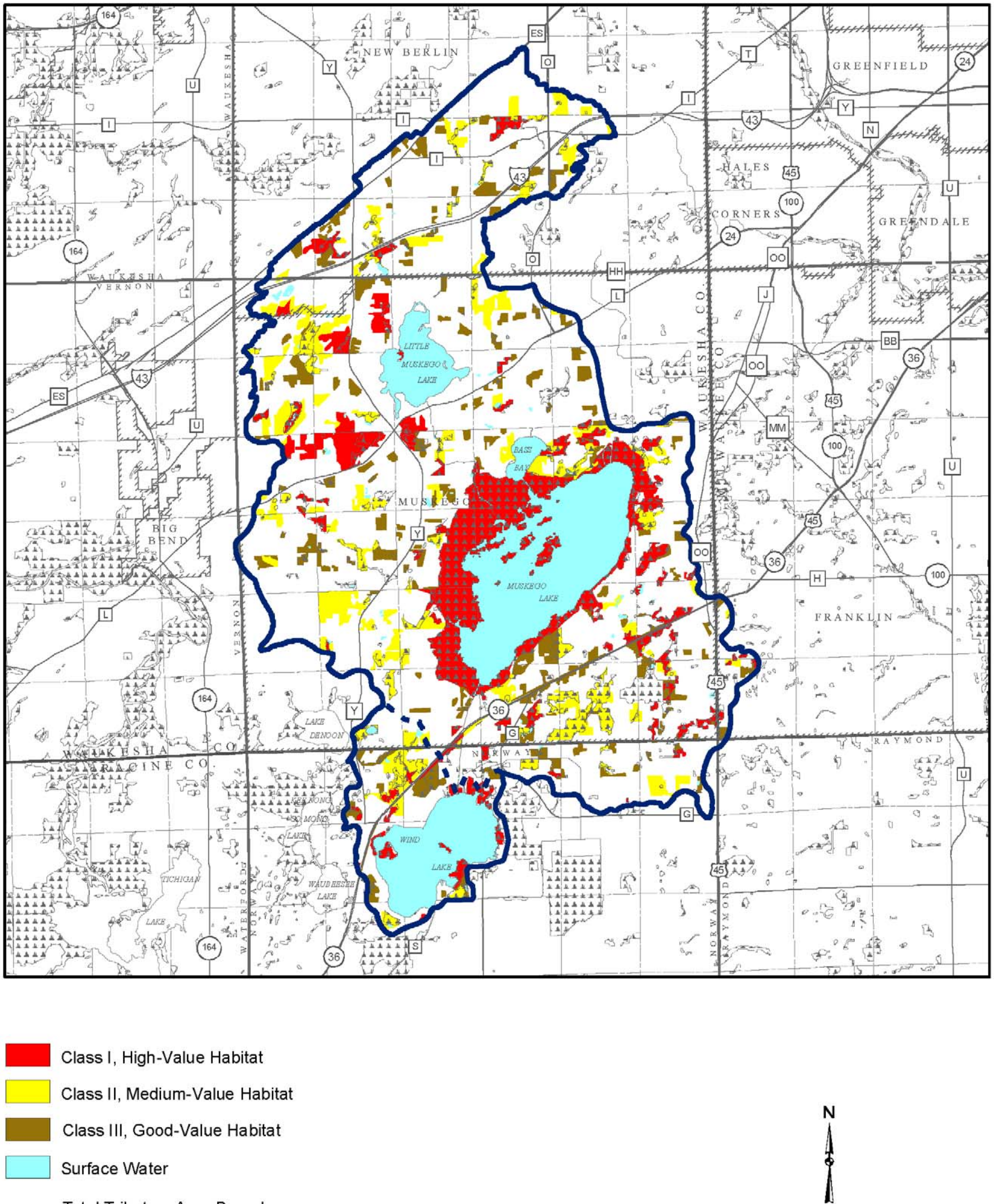
[c]*State-designated special concern species.*

[d]*State-designated threatened species.*

Source: Gary S. Casper, Geographical Distribution of the Amphibians and Reptiles of Wisconsin, *1996, Wisconsin Department of Natural Resources, Kettle Moraine State Forest, Lapham Peak Unit; and SEWRPC.*

Map 17

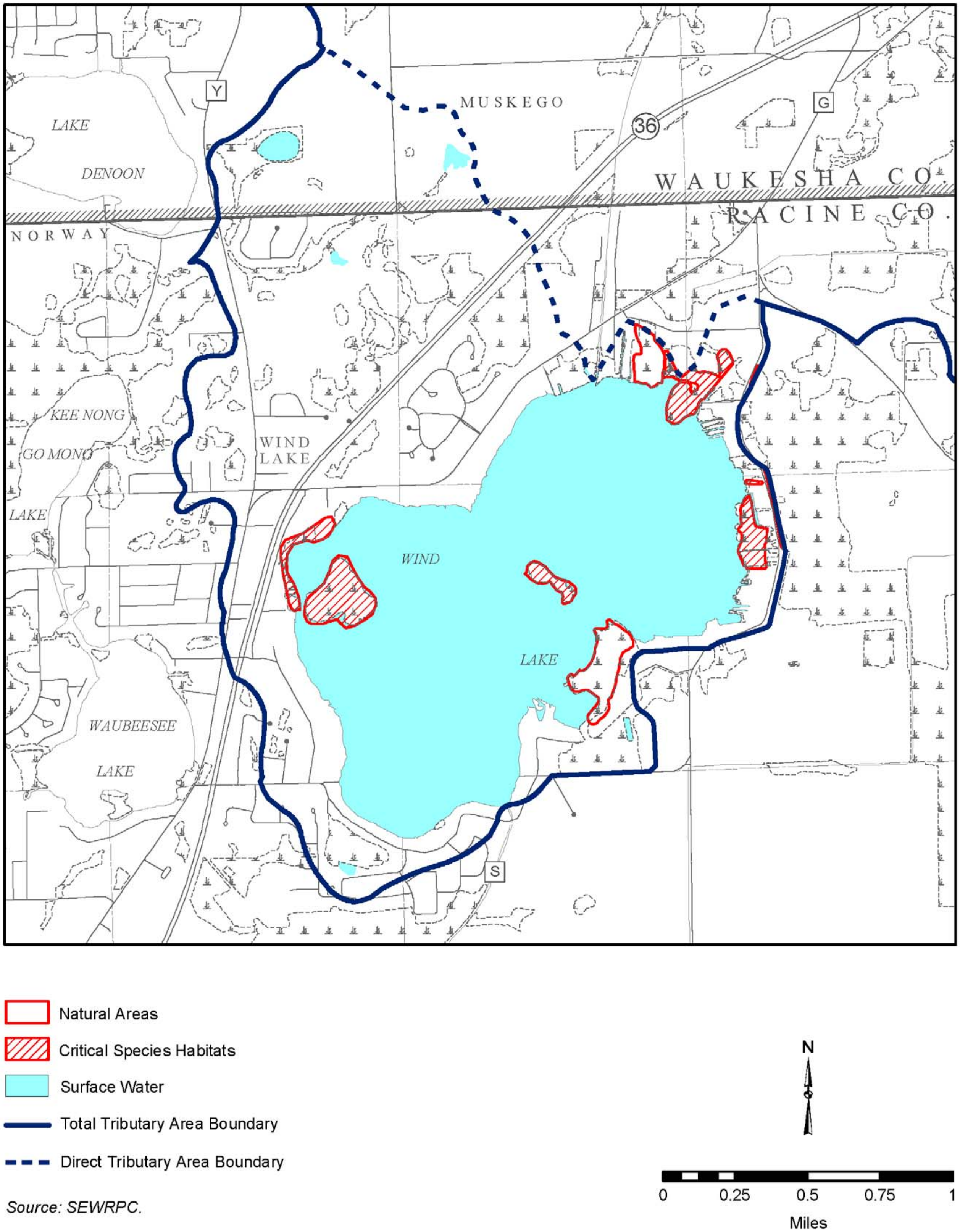
WILDLIFE HABITAT AREAS WITHIN THE AREA TRIBUTARY TO WIND LAKE: 1985



Source: SEWRPC.

Map 18

NATURAL AREAS WITHIN THE AREA DIRECTLY TRIBUTARY TO WIND LAKE



Source: SEWRPC.

1. Wind Lake Wet Meadow—This area is a 12-acre, moderate-quality wetland complex located on the north shore of Wind Lake at the mouth of the Muskego Canal. It is comprised of wet meadow, fen, shallow marsh, and sedge meadow and contains the marsh blazing-star (*Liatris spicata*), a State-designated special concern plant species. It has received an NA-3 designation identifying it as a natural area of local significance.

2. Wind Lake Shrub-Fen—This is a 21-acre, good-quality wetland complex of fen and schrub-carr on the south end of Wind Lake near the entrance to the Wind Lake Drainage Canal and contains a good population of Ohio goldenrod (*Solidago ohioensis*). It is given a rating of NA-2 as a natural area of countywide or regional significance.

3. Wind Lake Tamarack Swamp—This 334-acre block of former tamarack swamp, partly under private ownership, consisting of a woods that is converting to a lowland hardwood forest due to hydrologic changes resulting from the artificial drainage of surrounding agricultural lands. It remains a refugium for many species with more northerly affinities, such as starflower, goldthread, winterberry, dwarf raspberry, yellow birch, bunchberry, and blueberry. It also provides habitat for several State-designated bird species of special concern, including the American woodcock, mourning warbler, ovenbird, wood thrush, and veery. It has received a designation of NA-2 identifying it as a natural area of countywide or regional significance.

4. Wind Lake—Wind Lake itself is designated as a Critical Lake of Southeastern Wisconsin and has been given a rating of AQ-2, identifying it as an aquatic area of countywide or regional significance. The Lake, in addition to providing good waterfowl habitat, provides habitat for critical fish and herptile species. It also provides habitat for a colony of black tern, a State-designated bird species of special concern.

In addition to the abovementioned Natural Areas, there are four Critical Plant Species Habitat sites located around Wind Lake that, although they are not a part of identified Natural Areas, have been found to support State-designated endangered, threatened, or rare plant species. The Erwin Wetlands, Patzke Fen, Krieser Fen, and Landon Wetland are all privately owned areas containing the State-designated species of concern, Ohio goldenrod (*Solidago ohioensis*).

WETLANDS

Wetlands are defined by the Regional Planning Commission (SEWRPC) as, "areas that have a predominance of hydric soils and that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions." This definition, which is also used by the U.S. Army Corps of Engineers (USCOE) and the U.S. Environmental Protection Agency (USEPA), is essentially the same as the definition used by the U.S. Natural Resource Conservation Service (NRCS).[11]

Another definition, set forth in Chapter 23 of the *Wisconsin Statutes* and applied by the WDNR, defines a wetland as "an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions." In practice, the WDNR definition differs from the SEWRPC definition in that the WDNR considers very poorly drained, poorly drained, and some

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[11]*Lands designated as prior converted cropland, that is, lands that were cleared, drained, filled, or otherwise manipulated to make them capable of supporting a commodity crop prior to December 23, 1985, may meet the criteria of the U.S. Natural Resource Conservation Service wetland definition, but they would not be regulated under Federal wetland programs. If such lands are not cropped, managed, or maintained for agricultural production, for five consecutive years, and, in that time, if the land reverts back to wetland, the land would then be subject to Federal wetland regulations.*

of the somewhat poorly drained soils as wetland soils meeting the Department's "wet condition" criterion. The Commission definition only considers the very poorly drained and poorly drained soils as meeting the "hydric soil" criterion. Thus, the State definition as actually applied is more inclusive than the Federal and Commission definitions in that the Department may include some soils that do not show hydric field characteristics as wet soils capable of supporting wetland vegetation, a condition that may occur in some floodlands.[12]

As a practical matter, experience has shown that application of the WDNR, the USEPA and USCOE, and the SEWRPC definitions produce reasonably consistent wetland identifications and delineations in the majority of situations within the Southeastern Wisconsin Region. That consistency is due in large part to the provision in the Federal wetland delineation manual that allows for the application of professional judgment in cases where satisfaction of the three criteria for wetland identification is unclear.

Wetlands in southeastern Wisconsin are classified predominantly as deep marsh, shallow marsh, bog, fen, low prairie, southern sedge meadow, fresh (wet) meadow, shrub carr, southern wet and wet-mesic hardwood forest, and conifer swamp. As of 2000, the major wetland communities located in the total area tributary to Wind Lake encompassed approximately 3,358 acres, or approximately 13 percent of the total tributary area, and about 299 acres, or about 13 percent, of the area directly tributary to the Lake, as shown on Map 19. Wetland types included sedge meadow, shrub carr, fresh (wet) meadow, deep and shallow marsh, and southern wet and wet-mesic hardwood forest.

Sedge meadows are stable wetland plant communities that tend to perpetuate themselves if dredging activities and water level changes are prevented from occurring. Sedge meadows in Southeastern Wisconsin are characterized by the tussock sedge (*Carex stricta*) and, to a lesser extent, by Canada blue-joint grass (*Calamagrostis canadensis*). Sedge meadows that are drained or disturbed to some extent typically succeed to shrub carrs. Shrub carrs, in addition to the sedges and grasses found in the sedge meadows, contain an abundance of shrubs such as willows (*Salix* spp.) and red osier dogwood (*Cornus stolonifera*). In extremely disturbed shrub carrs, the willows, red osier dogwood, and sedges are replaced by such exotic plants as honeysuckle (*Lonicera* sp.), buckthorn (*Rhamnus* sp.), and the very aggressive reed canary grass (*Phalaris arundinacea*).

Fresh (wet) meadows are essentially lowland grass meadows which are dominated by Canada blue-joint grass, and forbes such as marsh (*Aster simplex*), red-stem (*Aster puniceus*) and New England (*Aster novae-angliae*) asters, and giant goldenrod (*Solidago gigantea*). Several disturbed fresh (wet) meadows are located throughout the Wind Lake tributary area, and are largely associated with sedge meadows and shrub carrs. Many of these fresh meadows have been subject to grazing, plowing, and drainage, and consequently, are dominated by reed canary grass.

Areas of deep and shallow marsh also occurred in the Wind Lake tributary area. These deep and shallow marsh areas were dominated by broadleaf cat-tail (*Typha latifolia*), soft-stem bulrush (*Scirpus validus*), and hard-stem bulrush (*Scirpus atrovirens*).

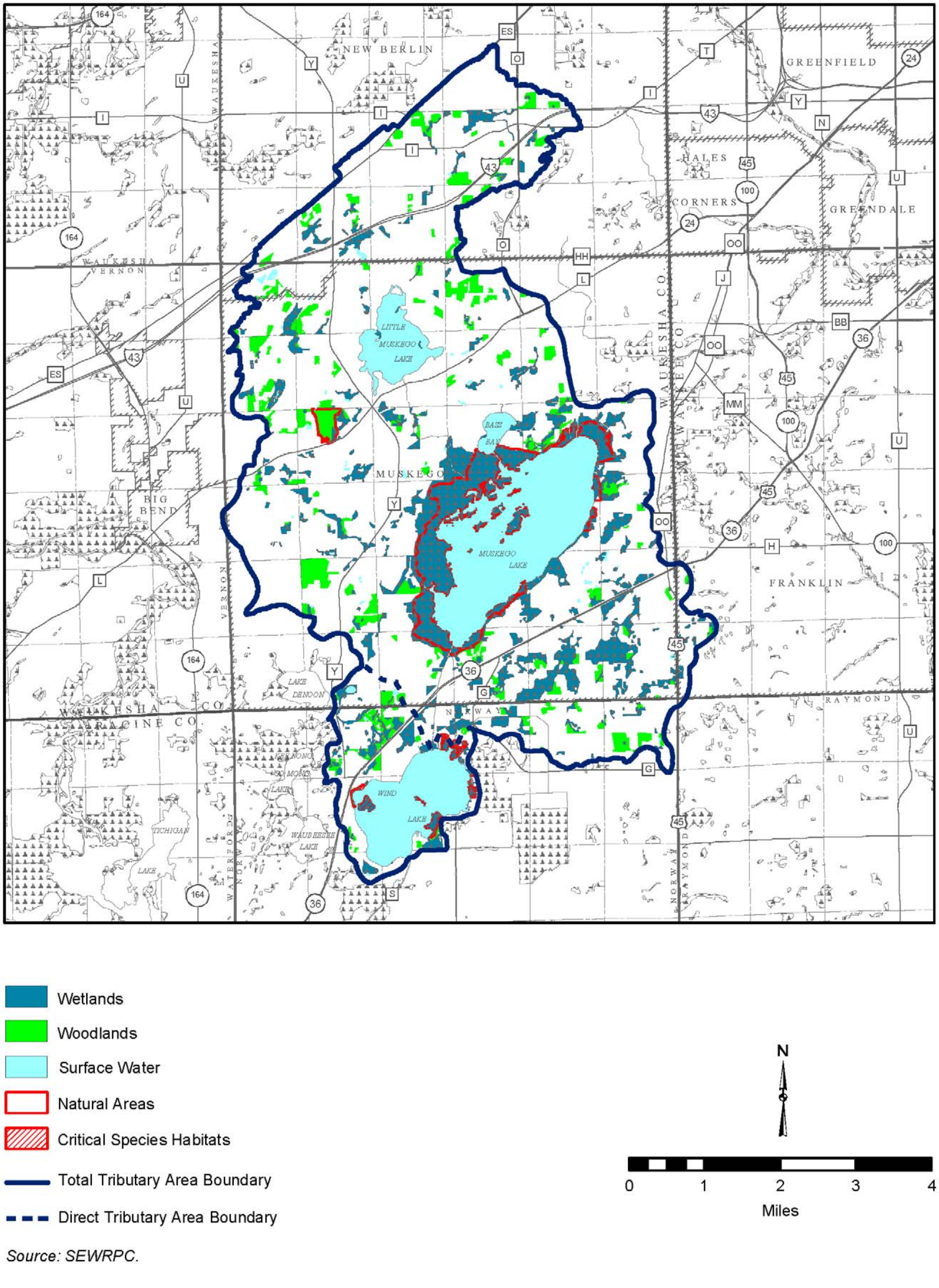
Southern wet and wet-mesic hardwood forest occurred in scattered areas of the tributary area. These lowland forests were characterized by the prevalence of black willow (*Salix nigra*), cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), silver maple (*Acer saccharinum*), and American elm (*Ulmus americana*).

In 1989 and 1990, two wetland areas located to the east of Wind Lake, adjacent to East Wind Lake Road, were identified as containing calcareous fens, the rarest wetland plant community in Wisconsin. These two wetland

[12]*Although prior converted cropland is not subject to Federal wetland regulations unless cropping ceases for five consecutive years and the land reverts to a wetland condition, the State may consider prior converted cropland to be subject to State wetland regulations if the land meets the criteria set forth in the State wetland definition before it has not been cropped for five consecutive years.*

Map 19

WETLANDS, WOODLANDS, NATURAL AREAS AND CRITICAL SPECIES HABITAT WITHIN THE AREA TRIBUTARY TO WIND LAKE: 2000



Source: SEWRPC.

areas together covered about three acres and contained species not found in previous surveys of the Wind Lake shoreline. The Ohio goldenrod (*Solidago ohioensis*), a rare wetland plant species in southeastern Wisconsin, occurred at one of these two sites.

As shown on Map 19, the largest wetlands within the total area tributary to Wind Lake are located north of the Lake, in the vicinity of Big Muskego Lake. Within the area directly tributary to Wind Lake, wetland areas dominate the shorelands along the northeast corner of the Lake, as well as along the southeastern shoreline, the islands in the Lake, and in an area to the northwest of the Lake on either side of STH 36.

WOODLANDS

Woodlands in southeastern Wisconsin are defined as those areas containing 17 or more trees per acre which have at least a four-inch-diameter at breast height, that is, at a height of 4.5 feet above the ground. In addition, native woodlands are classified as dry, dry-mesic, mesic, wet-mesic, and wet hardwoods, and conifer swamp forests. The latter three woodland classifications are also considered to be wetlands. As of 2000, the total area tributary to Wind Lake contained about 1,333 acres of woodlands, covering approximately 5 percent of the total tributary area, and about 136 acres, or 6 percent, of the area directly tributary to the Lake. These woodlands consisted of all of the native upland woodland classifications. Specifically, as shown on Map 19, upland woodlands in the area tributary to Wind Lake included southern dry hardwoods consisting primarily of white oak (*Quercus alba*), burr oak (*Quercus macrocarpa*), shagbark hickory (*Carya ovata*), and black cherry (*Prunus serotina*); southern dry-mesic hardwoods consisting primarily of northern red oak (*Quercus borealis*), paper birch (*Betula papyrifera*), and white ash (*Fraxinus americana*); and mesic hardwoods consisting primarily of sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), and basswood (*Tilia americana*). Woodland tracts in the area tributary to Wind Lake occurred primarily as scattered woodlots, as shown on Map 19.

The amount and distribution of woodlands in the tributary area should remain relatively stable if the recommendations contained in the regional land use plan are followed. However, if urban development continues within the tributary area much of the remaining woodland cover may be expected to be lost.

ENVIRONMENTAL CORRIDORS

The Environmental Corridor Concept

One of the most important tasks undertaken by the Regional Planning Commission as part of its work program was the identification and delineation of those areas of the Region having high concentrations of natural, recreational, historic, aesthetic, and scenic resources which should be preserved and protected in order to maintain the overall quality of the environment. Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and the natural beauty of the Region: 1) lakes, rivers, and streams and the associated undeveloped shorelands and floodlands; 2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained, and organic soils, and 7) rugged terrain and high-relief topography. While the foregoing seven elements constitute integral parts of the natural resource base, there are five additional elements which, although not a part of the natural resource base *per se*, are closely related to or centered on that base and therefore are important considerations in identifying and delineating areas with scenic, recreational, and educational value. These additional elements are: 1) existing outdoor recreation sites; 2) potential outdoor recreation and related open space sites; 3) historic, archaeological, and other cultural sites; 4) significant scenic areas and vistas; and 5) natural and scientific areas. The delineation of these 12 natural resource and natural resource-related elements on a map results in essentially linear patterns of relatively narrow, elongated areas which have been termed “environmental corridors” by the Commission:

- **Primary environmental corridors** include a wide variety of the abovementioned important resource and resource-related elements and are, by definition, at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors identified in the Wind Lake tributary area are, in some cases, contiguous with environmental corridors and isolated natural resource areas lying outside the boundary of the lake tributary area and, consequently, meet these size and natural resource element criteria as a result of these linkages.

- **Secondary environmental corridors** contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive agricultural purposes or urban land uses, and facilitate surface water drainage, maintain “pockets” of natural resource features, and provide for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species.

- **Isolated natural resource areas** may provide the only available wildlife habitat in a localized area, provide good locations for local parks and nature study areas, and lend a desirable aesthetic character and diversity to the area. These concentrations are isolated from the environmental corridors by urban development or agricultural lands and, although separated from the environmental corridor network, have important natural values.

It is important to point out that, because of the many interlocking and interacting relationships between living organisms and their environment, the destruction or deterioration of one element of the total environment may lead to a chain reaction of deterioration and destruction. The drainage of wetlands, for example, may have far-reaching effects, since such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas of interconnecting land, lake, and stream systems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater. Groundwater serves as a source of domestic, municipal, and industrial water supply and provides a basis for low flows in rivers and streams. Similarly, the destruction of woodland cover, which may have taken a century or more to develop, may result in soil erosion and stream siltation, and more rapid runoff and increased flooding, as well as destruction of wildlife habitat. Although the effects of any one of these environmental changes may not be overwhelming, in and of itself, the combined effects eventually may lead to the deterioration of the underlying and supporting natural resource base, and the overall quality of the environment for life. The need to protect and preserve the remaining environmental corridors within the Wind Lake tributary area thus becomes apparent.

In the area tributary to Wind Lake, the streambanks and lakeshores located within the environmental corridors should be candidates for immediate protection through proper zoning or through public ownership. Of the areas not already publicly owned, the remaining areas of natural shoreline, and riparian wetland areas, are perhaps the most sensitive areas in need of greatest protection. In this regard, the regional natural areas and critical species habitat protection and management plan recommends public acquisition of specific lands. Within the area tributary to Wind Lake, the Wind Lake Tamarack Swamp, Wind Lake Shrub-Fen, and Wind Lake Wet Meadow are partly or completely under private ownership and, as such, are recommended for public acquisition in part or in total. [13] Table 25 summarizes the proposed acquisition of the selected natural area sites described above.

Primary Environmental Corridors

The primary environmental corridors in southeastern Wisconsin generally lie along major stream valleys and around major lakes, and contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all of the major bodies of surface water and related undeveloped floodlands and shorelands. As shown on Map 20, primary environmental corridors encompassed about 2,169 acres, or about 8 percent of the Wind Lake total tributary area, as of 2000.

Primary corridors may be subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusions of urban development into these corridors, however, not only tend to destroy the very resources and related amenities sought by the developments, but tend to create severe environmental and development problems, as well. These problems include, among others, water pollution, flooding, wet

[13] *SEWRPC Planning Report No. 42,* op cit.

Table 25

LAND ACQUISITION OF SELECTED NATURAL AREA SITES IN THE WIND LAKE TRIBUTARY AREA

Site	Natural Area Class	Total Acres of Site	Acres Already Under Protective Ownership	Acres Proposed to be Acquired	Proposed Acquisition Agency
Wind Lake Tamarack Swamp	NA-2	334	122	212	Wisconsin Department of Natural Resources
Wind Lake Shrub-Fen[a]	NA-2	21	0	21	Racine County
Wind Lake Wet Meadow[a]	NA-3	12	0	12	Wind Lake Management District

[a]*Acquisition of this Natural Area is recommended in SEWRPC Community Assistance Planning Report No. 215,* An Environmentally Sensitive Lands Preservation Plan for the Town of Norway Sanitary District No. 1, Racine County, Wisconsin*, June 1996, which was approved in early 1996 by the SEWRPC Technical Coordinating and Advisory Committee overseeing preparation of the plan documented therein.*

Source: SEWRPC.

basements, failing foundations for roads and other structures, and excessive infiltration of clear water into sanitary sewerage systems. The preservation of such corridors, thus, is one of the major ways in which the water quality of Wind Lake can be maintained and perhaps improved.

Secondary Environmental Corridors

Secondary environmental corridors are located generally along intermittent streams or serve as links between segments of primary environmental corridors. As shown on Map 20, secondary environmental corridors encompassed about 2,226 acres, or about 8 percent of the total tributary area, as of 2000.

Isolated Natural Resource Areas

In addition to the primary environmental corridors, other small concentrations of natural resource base elements exist within the Wind Lake tributary area. Important isolated natural resource features include a variety of wetlands, woodlands, and wildlife habitat that also should be protected and preserved in a natural state whenever possible. Isolated natural resource areas five or more acres in size within the area tributary to Wind Lake also are shown on Map 20 and total about 853 acres, or about 3 percent of the total tributary area.

Wisconsin Department of Natural Resources-Delineated Sensitive Areas

Pursuant to authorities granted under Paragraph NR 107.05(3)(i) of the *Wisconsin Administrative Code*, the WDNR identifies sites that have special importance biologically, historically, geologically, ecologically, or even archaeologically, within lakes. Areas are identified as sensitive areas after comprehensive examination and study is completed by WDNR staff from many different disciplines and fields of study. Map 21 shows those areas of Wind Lake identified as sensitive areas.

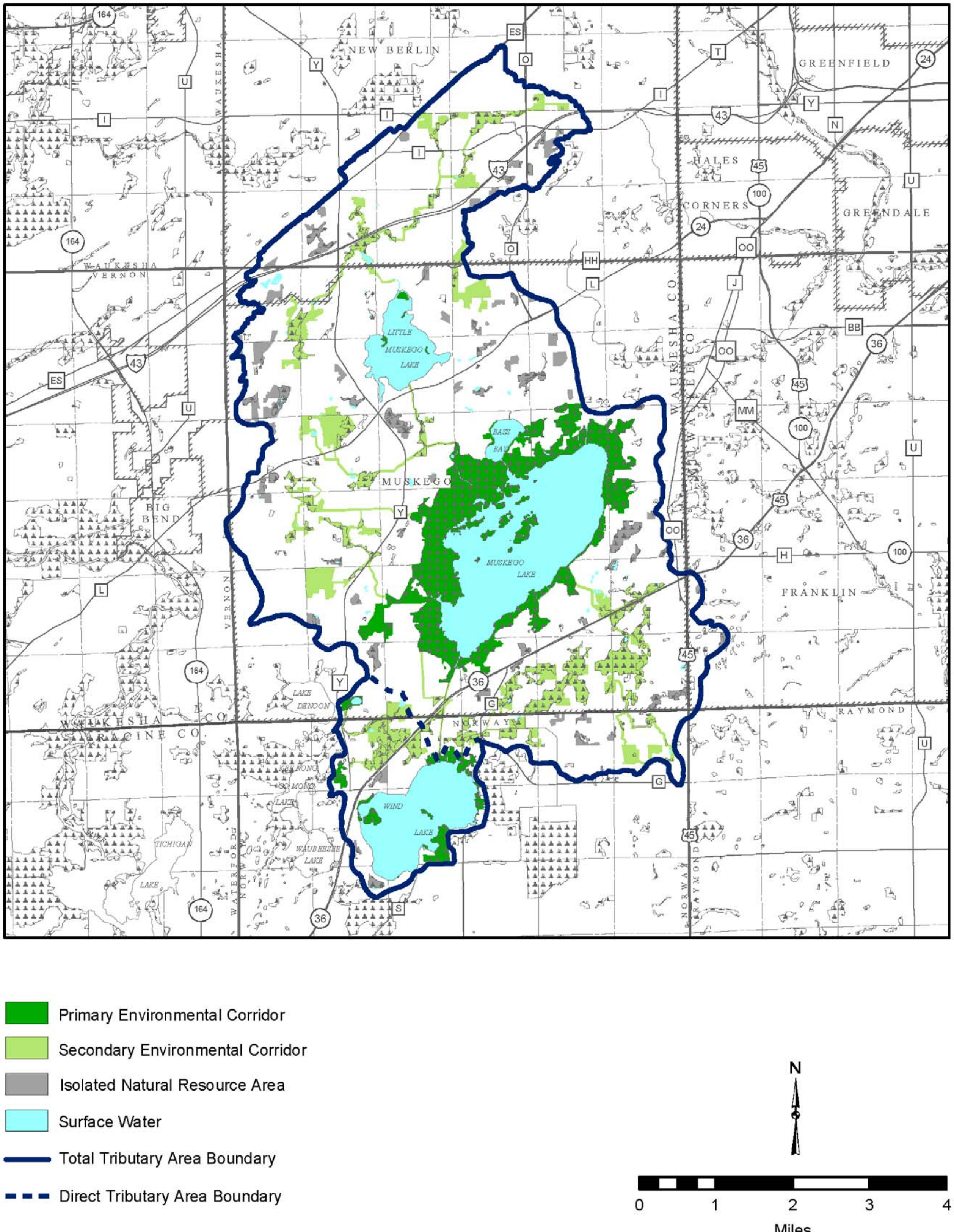
SUMMARY

Wind Lake is a reflection of its tributary area. As noted in Chapter IV, Wind Lake is a typical hard-water, alkaline lake that is considered to have relatively good water quality. While total phosphorus levels were found to be generally at or near the 0.02 mg/l level considered to cause nuisance algal growths, chlorophyll-*a* concentrations were such in recent years as to suggest that algal growth was not an issue in the Lake. In contrast, the increasing abundance of rooted aquatic plants, especially Eurasian water milfoil, was remarked as an issue of concern. Nevertheless, the Lake provides suitable habitat for a self-sustaining gamefish population.

The total area tributary to Wind Lake provides a range of habitats for birds, large and small mammals, and reptiles and amphibians, with about 28 percent of the total tributary area being considered to be valuable wildlife habitat. While the area of wildlife habitat in the total tributary area has declined since the initial delineation of habitat areas in 1985, about one-half of the area delineated as wildlife habitat is considered to be of very high value.

Map 20

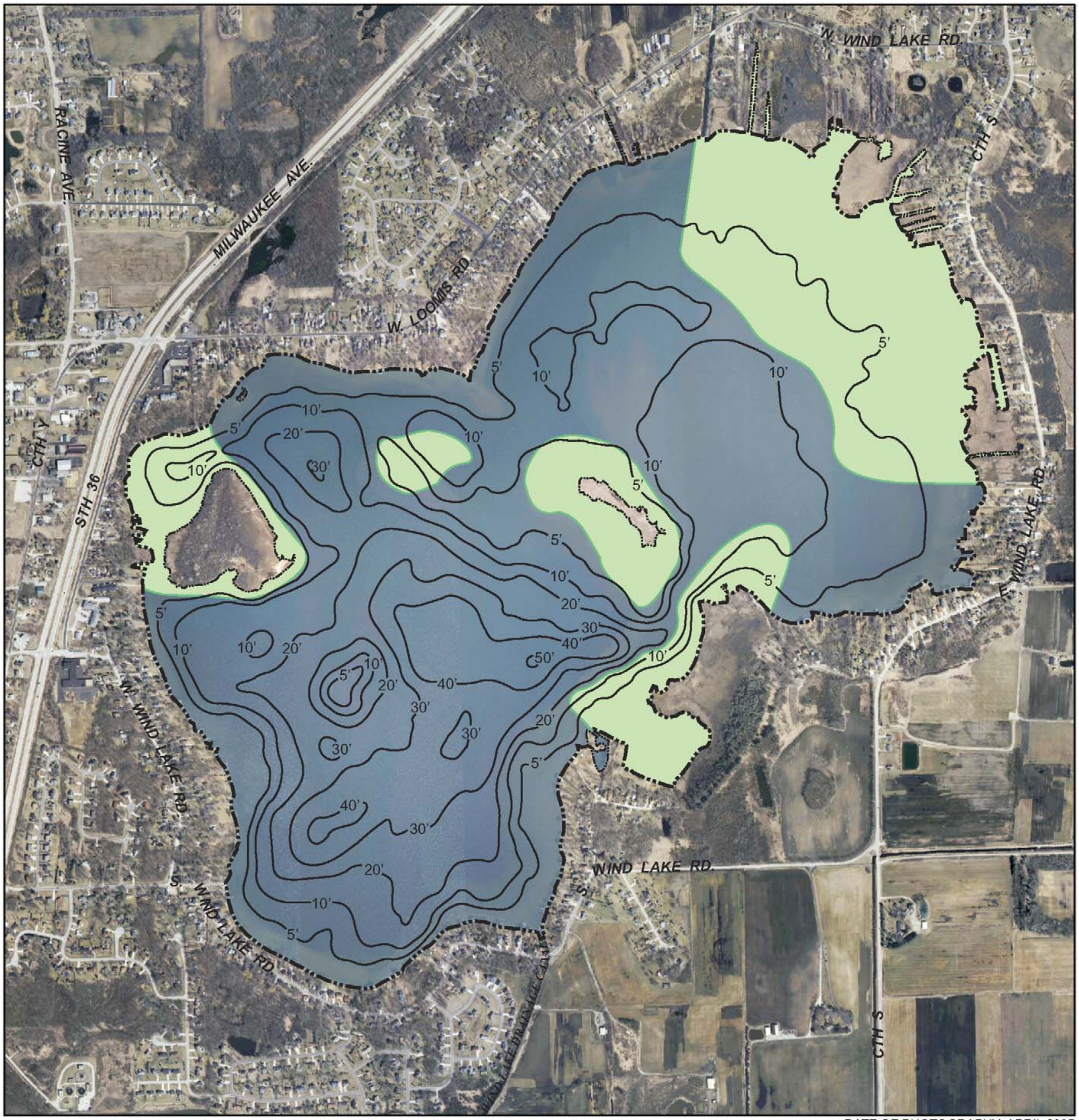
ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS WITHIN THE AREA TRIBUTARY TO WIND LAKE: 2000



Source: SEWRPC.

Map 21

SENSITIVE AREAS WITHIN WIND LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

SENSITIVE AREA

Source: Wisconsin Department of Natural Resources and SEWRPC.

GRAPHIC SCALE
0 750 1500 FEET

The environmental corridors contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, as well as the major surface water resources and related undeveloped floodlands and shorelands. The preservation of such corridors, thus, is one of the major ways in which the water quality of Wind Lake can be maintained and perhaps improved.

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Chapter VI

CURRENT WATER USES AND WATER USE OBJECTIVES

INTRODUCTION

Nearly all major lakes in the Southeastern Wisconsin Region serve multiple purposes, ranging from recreation to receiving waters for stormwater runoff. Recreational uses range from noncontact, passive recreational activities, such as picnicking and walking along the shoreline, to full-contact, active recreational activities, such as swimming, boating, and waterskiing. To accommodate this range of uses, the State of Wisconsin has developed water use objectives for the surface waters of the State, and has promulgated these objectives in Chapters NR 102 and NR 104 of the *Wisconsin Administrative Code*. Complementary water use objectives and supporting water quality guidelines have been adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), as set forth in the adopted regional water quality management plan for all major lakes and streams in the Region.[1] The current water uses, as well as the water use objectives and supporting water quality guidelines for Wind Lake, are discussed in this chapter.

RECREATIONAL USES AND FACILITIES

Wind Lake is located within about a one half-hour drive from much of the metropolitan area of Milwaukee. Its location, accessibility, and degree and type of shoreline development, contribute to a moderate degree of recreational usage by residents and nonresidents alike. In the initial SEWRPC report, Wind Lake was described as being used less intensively for recreation, other than fishing, than many other lakes of similar size in southeastern Wisconsin. This relative lack of use of Wind Lake was ascribed to the Lake's shallow basin, poor water quality, and excessive macrophyte growth. The Lake can support a full range of lake uses, providing opportunities for a variety of water-based outdoor recreational activities, including fishing, boating, swimming, and nature studies. Winter recreational uses include cross-country skiing, ice skating, and snowmobiling. The scope of these recreational uses engaged in on Wind Lake is sufficiently broad to be consistent with the recommended use objectives of full recreational use and the support of a healthy warmwater sport fishery, as set forth in the adopted regional water quality management plan.

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[1]*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.*

Park and Open Space Sites
Wind Lake provides an ideal setting for the provision of parks and open space sites and facilities. As shown on Map 22, there are two public access sites on Wind Lake; both are owned and operated by the Wisconsin Department of Natural Resources (WDNR). The first site is located on STH 36 where a gravel ramp and gravel parking area are provided for access to the Lake via the Muskego Canal; the second site is located at the southwestern corner of Wind Lake where a paved ramp, pier, and paved parking area with regular and handicapped car/trailer parking spaces are provided. Both sites were found to be well maintained and in good condition. Parking at the launch sites was deemed to be adequate, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*. A private launch site with parking is located at the north end of the Lake.

Recreational Activities and Boating
In recent years, lakes in the Region have generally experienced an increase in recreational boating activity. This has, at times, resulted in periods of heavy boating pressure on some of the Region's lakes. There is a range of opinion on the issue of what constitutes optimal boating density. 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.[2] For safe waterskiing and fast boating, an area of 40 acres per boat was suggested as the minimum area necessary for safe operations in the aforementioned Regional guidelines. Subsequently, Chapter NR 1 of the *Wisconsin Administrative Code* utilized an area of between 25 acres and 35 acres per boat as the basis for determining maximum and minimum standards for recreational boating access for inland lakes of between 500 acres and 999 acres, within which category Wind Lake is placed. Pursuant to this administrative code requirement, at 936 acres, Wind Lake would be required to support between 27 and 37 car-trailer unit parking stalls in order for the Lake to be deemed to have adequate public recreational boating access and be eligible for State natural resources enhancement services, such as fish stocking, aquatic plant management funding, and other cost-share programs.

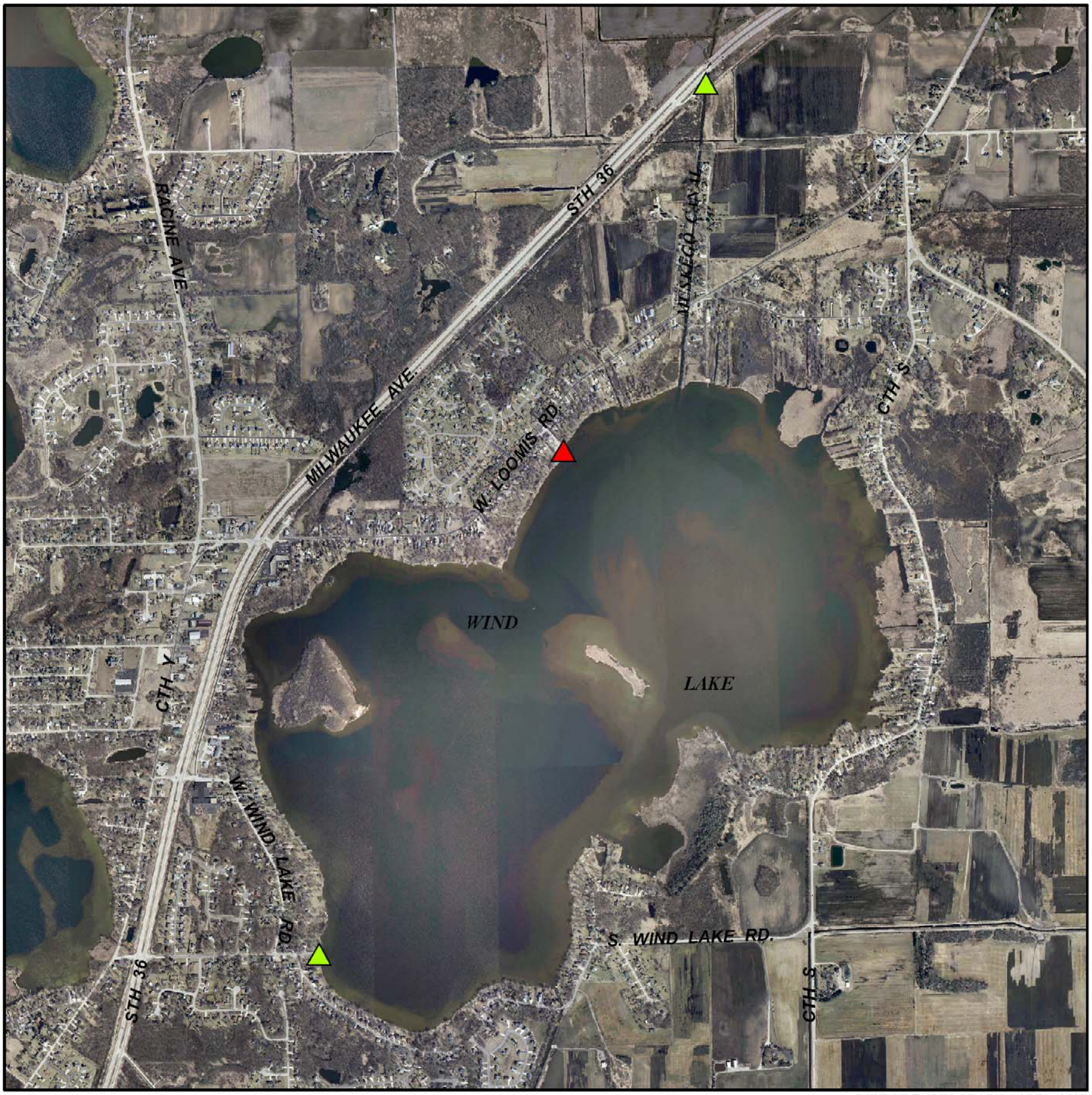
In order to indirectly assess the intensity of recreational boating use on a lake, the numbers of watercraft docked and moored on, or trailered around, a lake can be counted to provide an estimate of the total potential numbers of watercraft likely to use a particular lake. It has been estimated that, in southeastern Wisconsin, the number of watercraft operating at any given time during nonpeak use periods is 2 to 5 percent of the total number of watercraft docked and moored. About 516 watercraft of various descriptions were observed to be docked or moored on Wind Lake, or trailered on land around Wind Lake, during the current study period, as shown in Table 26. Of the motorized watercraft, fishing boats and pontoon boats comprised the largest proportion, with a combined total of 271 watercraft. These watercraft represented about 65 percent of the motorized watercraft on the Lake. Powerboats and personal watercraft (i.e., jetskis®) comprised the remaining portion of the motorized watercraft. Of the nonmotorized watercraft, paddleboats formed the largest proportion, comprising about 60 boats, or about 63 percent of the nonmotorized watercraft on the Lake; canoes and sailboats made up most of the balance. Applying the 2 to 5 percent estimate described above to the number of motorized watercraft given in Table 26, or to the approximately 420 motorized watercraft observed, it can be assumed that between eight and 21 watercraft would typically be in operation on the Lake. These numbers result in motorized boating densities that range from 45 acres per boat to 117 acres per boat. Such estimated densities are within the range considered appropriate for the conduct of safe high-speed boating activities, as recommended in the regional guidelines.

Another way to assess the degree of recreational boating use on a lake is through direct observation of boats in operation on a lake at given times. These counts also can be used to calculate the typical boating density, or the numbers of acres of open water available in which to operate a boat. Direct observations provide a better indication of the intensity of recreational boating occurring on a lake. Table 27 shows the numbers of watercraft observed by Commission staff to be in use during a typical, off-peak weekday and a weekend day during June 2005. As shown in Table 27, fishing boats represented the majority of watercraft operating on both the weekday

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

Map 22

BOAT ACCESS SITES WITHIN THE VICINITY OF WIND LAKE: 2005



DATE OF PHOTOGRAPHY: APRIL 2005

Source: Wisconsin Department of Natural Resources and SEWRPC.

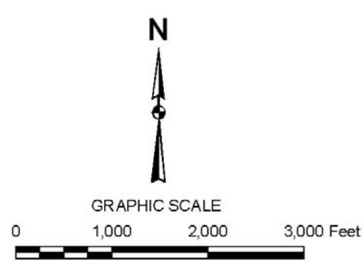


Table 26

WATERCRAFT DOCKED OR MOORED ON WIND LAKE: 2005[a]

Type of Watercraft								
Powerboat	Pontoon Boat	Fishing Boat	Personal Water Craft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
71	138	133	78	8	27	1	60	516

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

Source: SEWRPC.

Table 27

WATERCRAFT IN USE ON WIND LAKE: 2005

Date and Time	Power/Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Friday, June 17								
10:40 am to 11:40 a.m.	0	15	0	0	0	0	0	15
3:00 pm to 4:00 p.m.	0	4	1	0	0	0	0	5
Total	0	19	1	0	0	0	0	20
Percent	0	95	5	0	0	0	0	100
Saturday, July 18								
10:40 am to 11:40 a.m.	4	14	0	0	0	0	0	18
2:25 pm to 3:25 p.m.	8	13	1	0	0	0	0	21
Total	12	27	0	0	0	0	0	39
Percent	31	69	0	0	0	0	0	100

Source: SEWRPC.

and the weekend day, although powerboats were also observed in operation on the weekend day. Based upon these observations, the densities of motorized watercraft on the Lake ranged from about one boat per 52 acres to about one boat per 187 acres. Consequently, the recreational boating densities observed on Wind Lake, equivalent to between about 1 and 5 percent of the total watercraft observed, are consistent with the adopted regional guidelines.

Recreational boating activities on Wind Lake are regulated by State boating and water safety laws, and by the specific provisions of Chapter 8, *Water Traffic, Boating and Water Sports*, of the Town of Norway Code of Ordinances. This Ordinance is appended as Appendix B.

The types of motorized watercraft on a lake as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the Lake—the residents. As shown in Table 28, over 80 percent of all watercraft on Wind Lake are motorized, a proportion that is about the same as that on Pewaukee Lake in Waukesha County. However, on Wind Lake, the largest proportion of motorized watercraft is comprised of fishing boats and pontoon boats, which together comprise about 65 percent of motorized watercraft on the Lake. On Pewaukee Lake, power boats made up the largest proportion of the watercraft, comprising almost 40 percent of the motorized watercraft on the Lake. In this regard, the use of Wind Lake for recreational boating more closely resembles the observed use of Upper and Lower Phantom Lakes in Waukesha County, than it does the recreational boating use of other large lakes in the Region, supporting the initial observation that Wind Lake is likely to be utilized less intensively than similar waterbodies.

Table 28

NUMBERS AND TYPES OF WATERCRAFT OBSERVED ON SELECTED LAKES WITHIN THE SOUTHEASTERN WISCONSIN REGION

Lake	Surface Area	Motorized Watercraft				Nonmotorized Watercraft			
		Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Paddle Boat	Other
Ashippun	84	18	17	17	11	8	15	12	2
George	59	5	25	30	4	2	13	21	- -
Oconomowoc	804	23	24	7	14	6	17	5	3
Pewaukee	2,493	39	17	19	4	14	2	5	1
Lower Phantom	403	13	33	31	1	2	12	7	1
Upper Phantom	107	13	14	15	2	5	36	11	4
Wind	936	14	27	26	15	2	4	12	- -

Source: SEWRPC.

Angling

Wind Lake provides a high-quality habitat for largemouth bass and panfish. The size and the numbers of fish in the Lake provide a range of angling opportunities to both the lake residents and other lake users alike. Evidence of good fishing is provided by the numbers of ice fishing shelters present on the ice during the winter months and by the numbers of fishing boats and shoreline anglers using the Lake during the summer. All of these angling uses were observed at various times on Wind Lake by Commission staff. The WDNR has reported that Wind Lake was one of a very few lakes in the Region that had a fishable white bass population.

Other Recreational Uses

In addition to boating and angling, other lake-related activities observed by the Commission staff during the June 2005 observations included: picnicking, cooking out, entertaining guests, swimming, and lake viewing and aesthetic enjoyment of the resource. During the autumn, the Wind Lake Management District (WLMD) notes that hunting is a popular activity on and around the Lake; while in the winter, ice-fishing and operating snowmobiles and all-terrain vehicles (ATVs) is popular.

Lake Use and Water Quality Survey

During the summer of 2005, a survey of Wind Lake residents was conducted by the WLMD in cooperation with SEWRPC. The purpose of this survey was: 1) to determine the opinions and ideas of residents regarding the state of the Lake, and 2) to evaluate the success of the WLMD in implementing measures to protect and enhance the community.

The questionnaire survey was mailed to 842 residences and generated a response rate of about 20 percent. This is considered to be a good response. The five major concerns identified by those responding were: 1) numbers of boats operating on the Lake; 2) sizes of the boats operating on the Lake; 3) wetland preservation; 4) shoreline erosion, stormwater runoff, resident waterfowl, and a declining fishery; and 5) numbers of personal watercraft. Respondents generally felt that although the Lake had poor water quality, it had good aesthetic quality. High-speed boating was reported by respondents to be the most favored active recreational activity on the Lake, although it should be noted that this response is not supported by the recreational watercraft counts or observed recreational boating activities on Wind Lake, which would suggest that angling is the most favored recreational activity. This latter circumstance is borne out by the somewhat higher percentage of anglers on Wind Lake responding to the survey than has been found on other lakes in the Region. Picnicking, walking, and aesthetic enjoyment were the most favored passive recreational activities. A plurality of respondents, about 40 percent, felt that lake water quality had deteriorated over time, although a large percentage of respondents, about 30 percent, suggested that water quality had improved. Respondents indicated that visual criteria were generally used to assess water quality, suggesting that this dichotomy of responses may reflect position on the lakeshore and/or length of residency, although most respondents were long-term residents in the Wind Lake community. The results of this survey are summarized in Appendix C.

Wisconsin Department of Natural Resources Recreational Rating

Wind Lake provides a variety of outdoor recreational opportunities. Based upon the outdoor recreation rating system developed by the WDNR, Wind Lake received 46 of a possible 72 points, as shown in Table 29. This rating indicates that the Lake provides a range of recreational opportunities, including a highly productive fishery, water quality moderately conducive to swimming and boating, an adequate number of boat launch sites, water depth and surface area conditions conducive to boating, and a varied landscape that enhances the natural aesthetics of the Lake. The only features that were considered to detract from the recreational rating were related to the excessive fertility and concomitant lower overall water quality of the Lake.

WATER USE OBJECTIVES

The regional water quality management plan recommended adoption of full recreational use and warmwater fisheries objectives for Wind Lake. The findings of the inventories of the natural resource base, set forth in Chapters III through V, indicate that the use of the Lake and the resources of the area are generally supportive of such objectives, although it is expected that remedial measures will be required if the Lake is to fully meet these objectives. The recommended warmwater sportfishery objective is supported in Wind Lake by a sportfishery based largely on largemouth bass and panfish. These fishes have traditionally been sought after in Wind Lake. The foregoing recreational user survey and use surveys suggest that the full recreational use objective also is supported in Wind Lake. Nevertheless, public perceptions of the Lake, as identified through the questionnaire survey, support ongoing remedial efforts to improve water quality and enhance recreational use opportunities.

WATER QUALITY GUIDELINES

The water quality guidelines supporting the warmwater fishery and full recreational use objectives, as established for planning purposes in the regional water quality management plan, are set forth in Table 30. These guidelines are similar to the standards set forth in Chapters NR 102 and 104 of the *Wisconsin Administrative Code*, but were refined in terms of their application for planning purposes. Guidelines are recommended for temperature; pH; and dissolved oxygen, fecal coliform, and total phosphorus concentrations. These guideline values apply to the epilimnion of lakes and to streams. The total phosphorus guideline applies to spring turnover concentrations measured in the surface waters of lakes. Such contaminants as oil, debris, and scums; odors, tastes, and color-producing substances; and toxins are not permitted in concentrations harmful to the aquatic life as set forth pursuant to Chapter NR 102 of the *Wisconsin Administrative Code*.

The adoption of these guidelines is intended to support conditions in the waterways concerned that mediate against excessive macrophyte and algal growths, and promote all forms of recreational use, including angling and recreational boating, in these waters. Achievement of in-lake water quality conditions in line with these guidelines will maintain Wind Lake in a mesotrophic condition. To this end, both in-lake and watershed-based alternatives for water quality management in Wind Lake are considered in Chapter VII of this report, with the recommended lake management plan, set forth in Chapter VIII, including both in-lake and land-based interventions as a basis for improving and maintaining water quality in the Lake.

Table 29

WISCONSIN DEPARTMENT OF NATURAL RESOURCES RECREATIONAL RATING OF WIND LAKE: 1967

Space: Total Area = 936.2 acres			Total Shore Length = 9.3 miles		
Quality (18 maximum points for each item)					
Fish:					
X 9	High production	__ 6	Medium production	__ 3	Low production
__ 9	No problems	__ 6	Modest problems, such as infrequent winterkill, small rough fish problems	X 3	Frequent and overbearing problems, such as winterkill, carp, excessive fertility
Swimming:					
__ 6	Extensive sand or gravel substrate (75 percent or more)	X 4	Moderate sand or gravel substrate (25 to 50 percent)	__ 2	Minor sand or gravel substrate (less than 25 percent)
__ 6	Clean water	__ 4	Moderately clean water	X 2	Turbid or darkly stained water
__ 6	No algal or weed problems	__ 4	Moderate algal or weed problems	X 2	Frequent or severe algal or weed problems
Boating:					
__ 6	Adequate water depths (75 percent of basin more than five feet deep)	X 4	Marginally adequate water depths (50 to 75 percent of basin more than five feet deep)	__ 2	Inadequate depths (less than 50 percent of basin more than five feet deep)
__ 6	Adequate size for extended boating (more than 1,000 acres)	X 4	Adequate size for some boating (200 to 1,000 acres)	__ 2	Limit of boating challenge and space (less than 200 acres)
__ 6	Good water quality	X 4	Some inhibiting factors, such as weedy bays, algal blooms, etc.	__ 2	Overwhelming inhibiting factors, such as weed beds throughout
Aesthetics:					
X 6	Existence of 25 percent or more wild shore	__ 4	Less than 25 percent wild shore	__ 2	No wild shore
__ 6	Varied landscape	X 4	Moderately varied	__ 2	Unvaried landscape
__ 6	Few nuisances, such as excessive algae, carp, etc.	X 4	Moderate nuisance conditions	__ 2	High nuisance condition
Total Quality Rating: 46 out of a possible 72					

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 30

RECOMMENDED WATER QUALITY STANDARDS TO SUPPORT RECREATIONAL AND WARMWATER FISH AND AQUATIC LIFE USE

Water Quality Parameter	Water Quality Standard
Maximum Temperature	89°F[a,b]
pH Range	6.0-9.0 standard units
Minimum Dissolved Oxygen	5.0 mg/l[b]
Maximum Fecal Coliform	200/400 MFFCC/100 ml[c]
Maximum Total Residual Chlorine	0.01 mg/l
Maximum Un-ionized Ammonia Nitrogen	0.02 mg/l
Maximum Total Phosphorus	0.02 mg/l[d]
Other	- -[e,f]

[a]*There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed 3°F for lakes.*

[b]*Dissolved oxygen and temperature standards apply to the epilimnion of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. Trends in the period of anaerobic conditions in the hypolimnion of stratified inland lakes should be considered important to the maintenance of water quality, however.*

[c]*The membrane filter fecal coliform count per 100 milliliters (MFFCC/100 ml) shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month, nor a level of 400 per 100 ml in more than 10 percent of all samples during any month.*

[d]*This standard for lakes applies only to total phosphorus concentrations measured during spring when maximum mixing is underway.*

[e]*All waters shall meet the following minimum standards at all times and under all flow conditions: Substances that will cause objectionable deposits on the shore or in the bed of any body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts that are acutely harmful to animal, plant, or aquatic life.*

[f]*Unauthorized concentrations of substances are not permitted that alone or in combination with other material present are toxic to fish or other aquatic life. Standards for toxic substances are set forth in Chapter NR 105 of the* Wisconsin Administrative Code*.*

Source: SEWRPC.

Chapter VII

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon review of the inventories and analyses set forth in Chapters II through VI, five issues were identified requiring consideration in the formulation of alternative and recommended lake management measures. These issues are related to: 1) land use, 2) pollution abatement, 3) water quality, 4) aquatic biota, and 5) water uses. The management measures considered herein are focused primarily on those measures which are applicable to the Wind Lake Management District (WLMD), and to the Town of Norway. Additional measures, to be considered by other municipal, county and State governmental bodies within the drainage area tributary to Wind Lake are identified where appropriate. Based upon an evaluation of the potential effectivity and costs of the alternative measures outlined below, the recommended lake management actions are set forth in Chapter VIII of this report.

TRIBUTARY AREA MANAGEMENT ALTERNATIVES

Land Use

A basic element of any water quality management effort for a lake is the promotion of sound land use development and management in the tributary area. The type and location of current and future urban and rural land uses in the tributary area to Wind Lake 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, stormwater management; and, to some degree, the water quality of the Lake.

Development in the Shoreland Zone

Existing 2000 and planned buildout land use patterns and existing zoning regulations in the tributary area to Wind Lake have been described in Chapter II. If the recommendations set forth in the adopted regional land use plan are followed,[1] under buildout conditions, some additional urban residential development within the area tributary to Wind Lake would occur. Much of this residential development is likely to occur on agricultural lands. Infilling of existing platted lots and some backlot development, as well as the redevelopment and reconstruction of existing single-family homes on lakefront properties and commercial structures, also may be expected to occur. Recent surveillance indicates that this type of development is currently occurring. Accordingly, given the potential impact of lakeshore development on the lake resources, land use development or redevelopment proposals around the shoreline of Wind Lake and within the area tributary to the Lake should be evaluated for potential impacts on the Lake, as such proposals are advanced.

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[1]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

Recent studies of the potential impact of riparian landscaping activities on the nutrient loadings to lakes in southeastern Wisconsin have suggested that urban residential lands can contribute up to twice the mass of phosphorus to a lake when subjected to an active program of urban lawn care than similar lands managed in a more natural fashion.[2] The application of agrochemicals to such lands, in excess of the plant requirements, therefore, results in enhanced nutrient loading directly to the adjacent waterbodies. To address these concerns, a number of communities are debating the enactment of fertilizer control ordinances in addition to the public informational programming discussed below. In the spring of 2007, the Town of Norway passed a no-phosphorus sale or use ordinance. Some communities, such as the Big Cedar Lake Protection and Rehabilitation District, also have purchased bulk lots of phosphorus-free lawn and garden fertilizers for resale to riparian landowners. Given the increasing importance of urban land uses within the riparian area of Wind Lake, and within its tributary area, consideration of a comprehensive program to regulate urban agricultural practices appears to be warranted.

Development in the Tributary Area

The level of development envisioned in the Racine County land use plan for the area tributary to Wind Lake indicates continuing urban development, generally on large, suburban-density lots. Careful review of applicable zoning ordinances to incorporate levels and patterns of development consistent with the plan within the area tributary to Wind Lake is recommended. Changes in the zoning ordinances could be considered to better reflect the land use patterns recommended in the County land use plan. Consideration should be given to minimizing the areal extent of development by providing specific provisions and incentives to cluster residential development on smaller lots while preserving portions of the open space on each property or group of properties considered for development, utilizing the principles of conservation development.[3]

Stormwater Management

With respect to stormwater management on development sites, as of 2000, the Town of Norway had not adopted a separate stormwater management ordinance, rather these controls were built into other ordinances. Periodic review of these ordinances and their provisions for consistency with best management practices, and to ensure their currency with the state-of-the-art, should be undertaken on a regular basis to facilitate control of urban-source contaminants that would likely be delivered to the Lake.

Protection of Environmentally Sensitive Lands

Environmentally sensitive lands within the area tributary to Wind Lake include wetlands, woodlands, and wildlife habitat areas. Nearly all of these areas within the Wind Lake tributary area are included in the environmental corridors and isolated natural resource features delineated by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). Upland areas, woodlands, and wildlife habitat areas, currently, are protected primarily through local land use regulation, while wetlands enjoy a wider range of protections set forth in State and Federal legislation.

Wetland protection can be accomplished through land use regulation and, in cases where land use regulations may not offer an adequate degree of protection, through public acquisition of sensitive sites. These wetland areas are currently protected to a degree by current zoning and regulatory programs administered by the U.S. Army Corps of Engineers (USCOE), Wisconsin Department of Natural Resources (WDNR), and County and municipal authorities under one or more of the Federal, State, County, and local regulations. Within the total area tributary to Wind Lake, Racine and Waukesha Counties have each adopted a countywide shoreland zoning ordinance; the Cities of Franklin, Muskego, and New Berlin have adopted their own shoreland zoning ordinances; and, the Towns of Norway, Raymond, and Vernon have adopted the county shoreland zoning ordinance relevant to their jurisdictions, as shown in Table 10 in Chapter III of this report. The regional natural areas and critical species

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[2]*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.*

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

habitat protection and management plan recommends public acquisition of the Wind Lake Tamarack Swamp, Wind Lake Shrub-Fen, and Wind Lake Wet Meadow that are currently partly or completely under private ownership.[4]

Pollution Abatement

All human activities upon the land surface result in some degree of mobilization of contaminants and modification of surface runoff patterns that can affect lakes and streams, their quality, and biotic condition. Many human activities can be mitigated to a large extent by the implementation of sound planning, appropriate nonpoint source pollution abatement measures, and the actions of an informed public. In the first instance, sound land use development and management in the tributary area, and protection of environmentally sensitive lands, are the fundamental building blocks for protecting lake and stream water quality and habitat, and preserving human use opportunities that will support a broadly based recreational and residential community. In addition, specific nonpoint source pollution control and abatement measures should be integrated into land use regulations and promoted by a far-reaching informational and educational program within the area tributary to individual lakes and streams.

Nonpoint Source Pollution Abatement

Tributary area management measures may be used to minimize nonpoint source pollutant loadings from the tributary area by locating development within a tributary basin in accordance with sound planning. Beyond such actions, specific interventions may be required to control the mass of contaminants generated by various types of land use activity that are transported to the Lake. Rural sources of contaminants arise as pollutants transported by runoff from cropland and pastureland; urban sources include contaminants transported by runoff from residential, commercial, industrial, transportation, and recreational land uses, and from construction activities. Alternative tributary area-based nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan[5] and in the Racine County land and water resource management plan.[6]

The regional water quality management plan recommends that the nonpoint source pollutant loadings from the areas tributary to Wind Lake be reduced by up to 50 percent in urban areas and by up to 75 percent in rural areas, in addition to implementation of urban construction erosion controls, streambank erosion controls, and onsite sewage disposal system management practices. As described in Chapter IV, the most readily controllable loadings are associated, primarily, with runoff from urban lands within the area tributary to the Lake and from urbanizing lands throughout the area tributary to the Lake that are linked to the Lake by way of streams, agricultural channels, and stormwater drainage systems. These loadings constituted about 15 percent of the total phosphorus loadings, 10 percent of the sediment loadings, and 100 percent of the heavy metals loadings to Wind Lake, based upon year 2000 land uses. Phosphorus loadings from the remainder of the tributary area, and from direct deposition onto the lake surface, contributed the balance of the total loadings. The contributions of phosphorus, sediment, and heavy metals from urban lands are expected to increase as agricultural lands are progressively converted to urban uses.

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

[5]*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; SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

[6]*SEWRPC Planning Report No. 259,* Racine County Land and Water Resource Management Plan: 2000-2004, *September 2000.*

While some proportion of these contaminant loads may be attenuated as a consequence of the extensive wetland areas, the ability of these wetlands to assimilate pollutants is wholly dependent upon the maintenance of their structure and function within their ecosystems. These features can be overwhelmed by inappropriate land uses that result in the degradation of the wetlands, diminishing their ability to capture contaminants, or creating contaminant loads of such magnitude that the wetlands are overloaded. Thus, the control of nonpoint sources of water pollution at their sources is an important consideration. Properly applied, such controls can reduce the pollutant loadings to a lake by about 25 percent or more.

Appendix D presents a list of alternative nonpoint source pollution management measures that could be considered for use in the Wind Lake area to reduce loadings from nonpoint sources of pollution. Information on the cost and effectivity of the measures is also presented in Appendix D. It should be noted that appropriate public informational programming, described below, provides a means of disseminating information on various nonpoint source control measures that can be targeted to specific sectors of the community. Many of the measures are low-cost or no-cost measures that can be implemented by individual landowners. Selected measures are discussed below.

Rural Nonpoint Source Controls

Upland erosion from agricultural and other rural lands is a contributor of sediment to streams and lakes. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the area tributary to Wind Lake were presented in Chapter IV. These data were utilized in determining the pollutant load reduction that could be achieved, the types of practices needed, and the extent of the areas to which the practices need to be applied within the area tributary to Wind Lake.

Based upon the pollutant loading analysis set forth in Chapter IV, a total annual phosphorus load of 12,000 pounds is estimated to be contributed to Wind Lake. Of that mass, it is estimated that 10,000 pounds per year, or 85 percent of the total loading, were contributed by runoff from rural land. In addition, it is estimated that 2,300 tons of sediment, or about 75 percent of the total sediment load to Wind Lake, were contributed annually from agricultural lands in the area tributary to the Lake. As of 2000, such lands comprised about 10,250 acres, or about 40 percent of the area tributary to Wind Lake, which area is anticipated to diminish to about 6,400 acres, or about 25 percent, of the tributary area by the year 2020.

While agricultural land uses are anticipated to be a declining form of land usage within the area tributary to Wind Lake, the agricultural operations that remain within the tributary area will continue to contribute a significant proportion of the sediment load to the waterbody. Table 13, in Chapter IV of this report, suggests that, based upon estimated contaminant loadings, agricultural land uses will continue to contribute about 60 percent of the total sediment load, or about 1,450 tons of sediment annually, to Wind Lake. Thus, detailed farm conservation plans are likely to continue to be required to adapt and refine erosion control and nutrient and pest management practices for individual farm units. Generally prepared with the assistance of staff from the U.S. Natural Resources Conservation Service (NRCS) or County Land Conservation Department, such plans identify desirable tillage practices, cropping patterns, and rotation cycles. The plans also consider the specific topography, hydrology, and soil characteristics of the farm; identify the specific resources of the farm operator; and articulate the operator objectives of the owners and managers of the land.

With respect to rural nonpoint source pollution abatement, implementation of the recommended actions set forth in the adopted Racine County land and water resource management plan is endorsed.

It should be noted that many of the agricultural operations within the drainage area tributary to Wind Lake, particularly those tributary to the Muskego Canal upstream of the Lake, are no longer actively employed in farming activities. Nevertheless, the lands are being retained in open space use, in part as conservancy areas acquired by the Wind Lake Management District and the Wisconsin Department of Transportation, among others. Use of some of these lands for the management of sediment loads to Wind Lake as a consequence of the proposed future drawdown of Big Muskego Lake has been proposed.[7] Implementation of this management recommendation is strongly endorsed as the principle basis for minimizing excessive sediment loadings to Wind Lake during the proposed future drawdown of Big Muskego Lake. To this end, the establishment of an ongoing dialogue between the Big Muskego Lake/Bass Bay Protection and Rehabilitation District and the Wind Lake Management District is considered to be a viable alternative.

Urban Nonpoint Source Controls

As of 2000, established urban land uses comprised about 7,100 acres, or about 27 percent, of the total area tributary to Wind Lake. The annual phosphorus loading from these urban lands was estimated to be 1,940 pounds, or about 15 percent of the total load of phosphorus to the Lake. This is anticipated to increase to about one-third of the total load of phosphorus under year 2020 conditions. Those urban-source pollutant loadings that are most controllable include runoff from the residential lands adjacent to the Lake, and urban runoff from areas with a high proportion of impervious surface. The potential also exists within the Wind Lake tributary area for significant construction site erosion impacts if development continues in the tributary area as has been the recent trend.

Potentially applicable urban nonpoint source control measures include stormwater management measures, wet detention basins, grassed swales, and good urban "housekeeping" practices. Generally, the application of low-cost urban housekeeping practices may be expected to reduce nonpoint source loadings from urban lands by about 25 percent. Public educational 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. 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, and continued use of reduced quantities of street deicing salt.

Particular attention also should be given to reducing pollutant loadings from high pollutant loading areas, such as commercial sites, parking lots, and material storage areas. To the extent practicable, parking lot stormwater runoff should be diverted to areas covered by pervious soils and appropriate vegetation, rather than being directly discharged to surface waters. Material storage areas may be enclosed or periodically cleaned, and diversion of stormwater away from these sites may further reduce pollutant loadings. Street sweeping, increased catch basin cleaning, stream protection, leaf litter and vegetation debris collection, and stormwater storage and infiltration measures can enhance the control of nonpoint source pollutants from urban and urbanizing areas, and reduce urban nonpoint source pollution loads by up to about 50 percent.

Enforcement of turf management ordinance requirements by the Town of Norway should be considered as a means of managing voluntary applications of phosphorus-rich fertilizers in urban areas. As has been noted in Chapter IV, applications of phosphorus-rich fertilizers have been shown to contribute significantly more phosphorus to lakes within southeastern Wisconsin than fertilizers containing low- or no-phosphorus.[8] Consequently, implementation of a program to minimize phosphorus applications in urban areas, as set forth in the statewide turf nutrient management standard,[9] would be beneficial to maintaining the water quality of Wind Lake.

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[7]*City of Muskego and Big Muskego Lake/Bass Bay Protection and Rehabilitation District,* Big Muskego Lake and Bass Bay Management Plan*, June 2004.*

[8]*U.S. Geological Survey Water-Resources Investigations Report No. 02-4130,* op. cit*.*

[9]*Wisconsin Department of Natural Resources Technical Standard No. 1100,* Turf Nutrient Management*, January 2006.*

As stated above, in the spring of 2007, the Town of Norway adopted a no-phosphorus turf management ordinance.[10]

As has been noted above, as of 2000, the Town of Norway had not adopted separate stormwater management ordinances applicable to new development within the areas under their jurisdiction, rather these controls were built into other ordinances. While these measures limit the potential impacts of new development, they do not address impacts from existing land uses nor do they address the cumulative impacts of past development. Therefore, additional measures to reduce nonpoint source pollution from existing development would appear to be warranted. Proper design and application of structural urban nonpoint source control measures, such as grassed swales and detention basins, requires the preparation of a detailed stormwater management system plan that addresses stormwater drainage problems and controls nonpoint sources of pollution.

Developing Area Nonpoint Source Controls

Developing areas can generate significantly higher pollutant loadings than established areas of similar size. Developing areas include a wide array of activities, including urban renewal projects, individual site development within the existing urban area, and new land subdivision development. The regional land use plan envisions only limited new urban development within the tributary area. However, as previously noted, some large-lot, suburban-density development is currently taking place in the area tributary to Wind Lake, together with the redevelopment of existing, platted lakefront lots.

Construction sites, especially, may be expected to produce suspended solids and phosphorus loadings at rates several times higher than established urban land uses. Control of sediment loss from construction sites can be provided by measures set forth in the model ordinance developed by the WDNR in cooperation with the Wisconsin League of Municipalities.[11] These controls are temporary measures taken to reduce pollutant loadings from construction sites during stormwater runoff events. Construction erosion controls may be expected to reduce pollutant loadings from construction sites by about 75 percent. Such practices are expected to have only a minimal impact on the total pollutant loading to the Lake due to the relatively small amount of land proposed to be developed. However, such controls are important pollution control measures that can abate localized short-term loadings of phosphorus and sediment from the tributary area and the upstream tributary area. The control measures include such revegetation practices as temporary seeding, mulching, and sodding, and such runoff control measures as filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins.

At the present time, Racine County has not adopted a separate construction site erosion control ordinance. Rather, the County and the Town of Norway have included construction site erosion control provisions within other ordinances governing shorelands and subdivisions, for example. The provisions of these ordinances apply to all development, except single- and two-family residential construction. Single- and two-family construction erosion control measures are to be specified as part of the building permit process. Because of the potential for development, some of it albeit unplanned, in the area tributary to Wind Lake, it is important that adequate construction erosion control programs, including enforcement, be in place.

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[10]*An increasing number of communities within the Southeastern Wisconsin Region have adopted municipal ordinances limiting the application of phosphorus-rich fertilizers within residential areas. Such ordinances typically exempt agricultural operations from the ordinance provisions, allow for the use of phosphorus fertilizers under conditions wherein a soil test indicates the need for supplemental phosphorus, and permit the use of compost-based fertilizers containing not more than 3 percent phosphorus. In Racine County and the Middle Fox River drainage area, the Town of Waterford has adopted such an ordinance as of 2006.*

[11]*Wisconsin League of Municipalities and Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practices Handbook*, April 1994.*

Within the Waukesha County portion of the drainage area tributary to Wind Lake, the City of Muskego enforces a stringent stormwater management ordinance set forth in Chapter 34, *Storm Water Management*, of the City of Muskego Code of Ordinances. This ordinance, adopted in September 2003, regulates long-term, post-construction stormwater discharges from land development activities within the City. The ordinance also controls peak flow rates, and the quantity and quality of stormwater discharges from land development activities in order to maintain and enhance the quality of life within the community, the natural environment, and waterways within the City of Muskego. The ordinance implements the Milwaukee Metropolitan Sewerage District (MMSD) Chapter 13 requirements governing rates of runoff from impervious surfaces, to reduce the probability of increased regional floods. Similarly, the City of New Berlin enforces stormwater management requirements pursuant to Chapter 226, *Stormwater Runoff*, of the City of New Berlin Code of Ordinances. This ordinance, adopted in April 2003, regulates stormwater quantity and quality, and, similarly, implements MMSD Chapter 13 requirements, during and following development activities within the City.

Public Sanitary Sewerage System Management

At the time of the current study, urban-density residential development located along the shoreline of Wind Lake and within the drainage area tributary to Wind Lake have been included within a public sanitary sewer service area, as recommended in the adopted regional water quality management plan,[12] although isolated developments lying outside these service areas, but within the area tributary to Wind Lake, continue to be provided with sewage disposal through the use of onsite sewage disposal systems. Portions of the Cities of Muskego and New Berlin are served by the MMSD facilities. Within the drainage area directly tributary to Wind Lake, sanitary sewer services are provided by the Town of Norway Sanitary District No. 1. The regional plan recommends that sewerage needs in the service areas be periodically reevaluated in light of changing conditions.

Onsite Sewage Disposal System Management

While the immediate lakeshore is sewered, portions of the area tributary to Wind Lake continue to be served by onsite sewage disposal systems. As reported in Chapter IV, onsite sewage disposal systems are estimated to contribute an insignificant proportion of the total phosphorus load to the Lake, which proportion is anticipated to further decline as public sanitary sewerage services are extended within the tributary area pursuant to the adopted regional water quality management plan.[13] Nevertheless, in addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property values. Consequently, onsite sewage disposal is an important consideration in the portions of the tributary area not within the planned public sanitary sewer service area.

Two basic alternatives are available for abatement of pollution from onsite sewage disposal systems: continued reliance on, and management of, the onsite sewage disposal systems, and, alternatively, the expansion of the existing public sanitary sewer system. Where onsite sewage disposal systems remain the primary wastewater treatment method, it is recommended that an onsite sewage disposal system management program be carried out, including the conduct of an ongoing informational and educational effort. Homeowners in areas served by onsite systems should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs.

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[12]*SEWRPC Community Assistance Planning Report No. 247,* Sanitary Sewer Service Area for the Town of Norway Sanitary District No. 1 and Environs, Racine and Waukesha Counties, Wisconsin*, June 1999; see also, SEWRPC,* Amendment to the Regional Water Quality Management Plan, City of Muskego*, June 2006; and SEWRPC,* Amendment to the Regional Water Quality Management Plan, City of New Berlin*, June 2005.*

[13]*SEWRPC Memorandum Report No. 93,* op. cit.

IN-LAKE MANAGEMENT ALTERNATIVES

The reduction of external nutrient loadings to Wind Lake by the aforedescribed measures should help to prevent further deterioration of lake water quality conditions. These measures, however, may not completely eliminate existing water quality and lake-use problems. In mesotrophic and eutrophic lakes, the nutrients previously delivered to, and retained in, such lakes can result in increased macrophyte growth, which, in turn, can result in restricted water use potentials, even after the implementation of tributary area-based management measures. Given that Wind Lake falls within the meso-eutrophic range, the awareness of in-lake rehabilitation techniques may be of value.

The applicability of specific in-lake rehabilitation techniques is highly dependent on lake-specific characteristics. The success of any lake rehabilitation technique can seldom be guaranteed, and because of the relatively high cost of applying most techniques, a cautious approach to implementing in-lake rehabilitation techniques is generally recommended. Certain in-lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs have been reduced below the critical level; 2) there is a high probability of success in applications of the particular technology to lakes of similar size, shape, and quality; and 3) the possibility of adverse environmental impacts is minimal. Finally, it should be noted that most in-lake rehabilitation techniques require the issuance of permits from appropriate State and Federal agencies prior to implementation.

Alternative lake rehabilitation measures include in-lake water quality management, water level management, and aquatic plant and fisheries management measures. These measures address issues relating to water quality, water quantity, and the response of biological organisms to water quality and/or quantity stressors. Water quality monitoring, although not a management measure *per se*, is an essential part of understanding and evaluating the impacts of lake and watershed management interventions on the lake. Each of these groups of management measures is described further below.

Water Quality Monitoring
As discussed in Chapter IV, water quality information for Wind Lake has been compiled during the current study period mainly utilizing data provided under the auspices of the U.S. Geological Survey (USGS) Trophic State Index (TSI) monitoring program. Federal field personnel conduct a series of approximately five samplings annually beginning with the spring turnover and continuing through the summer months. Samples are analyzed for an extensive array of physical and chemical parameters as reported in Chapter IV. The USGS also offers an array of other specialist services, including groundwater modeling and monitoring.

The WDNR coordinates the Self-Help Monitoring Program, currently administered by the University of Wisconsin-Extension under the auspices of the Citizen Lake Monitoring Network. Volunteers enrolled in this program gather data at regular intervals on water clarity through the use of a Secchi disc. Because contamination tends to reduce water clarity, Secchi-disc measurements are generally considered one of the key parameters in determining the overall quality of a lake’s water, as well as a lake’s trophic status. Secchi-disc measurement data are added to the statewide data base containing lake water quality information for many lakes in Wisconsin and is accessible on-line through the WDNR website. An Expanded Self-help Monitoring Program also is offered that involves the collection of chlorophyll-*a* and total phosphorus concentration data in addition to the Secchi-disc measurements. Under this program, samples of lake water are collected by volunteers at regular intervals and analyzed by the State Laboratory of Hygiene. The WDNR offers Chapter NR 190 Small-Scale Lake Management Planning Grant funding that can be applied for to defray the costs for lab analysis and sampling equipment.

Continuing the ongoing water quality monitoring by the USGS is considered to be a viable option for Wind Lake. Participation in the Citizen Lake Monitoring Network also is considered to be a viable option for the Wind Lake community.

Water Quality Improvement Measures
This group of in-lake management practices includes a variety of measures designed to directly modify the magnitude of either a water quality determinant or biological response. Specific measures, aimed at managing aquatic plants and the fishery, are considered separately below.

Phosphorus Precipitation and Inactivation
Nutrient inactivation is a restoration measure that is designed to limit the biological availability of phosphorus by chemically binding the element in the lake sediments using a variety of divalent or trivalent cations, or highly positively charged elements. Aluminum sulfate (alum), ferric chloride, and ferric sulfate are commonly used cation sources. The use of these techniques to remove phosphorus from nutrient-rich lake waters is an extension of common water supply and wastewater treatment processes. Costs depend on the lake volume and type and dosage of chemical used. Approximately 100 tons of alum, costing about $150 per ton, can treat a lake area of about 40 acres. Effectiveness depends, in part, on the ability of the alum flocculent to form a stable "blanket" on the lakebed; to wit, on flushing time, turbulence, lake water acidity (pH), and the rate of continued sedimentation. Impacts can include the release of toxic quantities of free aluminum into the water, while the resulting improved water clarity can also encourage the spread of rooted aquatic plants.

Nutrient inactivation utilizing alum was undertaken on Wind Lake during 1997 with an anticipated duration of effectiveness to be about eight to 10 years.[14] The current planning program has coincided with this period of effectivity. Areas of Wind Lake treated during the 1997 alum application included all areas of the Lake with a depth of five feet and greater. The application was conducted in late-May over an approximately 10-day period. The alum was applied in solution to the selected areas of the Lake. Approximately 97,680 pounds of elemental aluminum were applied in about 200,000 gallons of aluminum sulfate to achieve a flocculent "blanket" with a concentration of about 4.4 milligrams per liter (mg/l) of elemental aluminum. This dosage was estimated to maintain an in-lake pH of greater than 6.0. As a result of this application, hypolimnetic phosphorus concentrations in Wind Lake decreased from about 0.06 mg/l to about 0.03 mg/l at spring overturn between 1999 and 2004. Hypolimnetic phosphorus concentrations at spring overturn in 2005 were reported by the USGS to be about 0.11 mg/l.

Reevaluation of the nutrient levels in Wind Lake, as set forth in Chapter IV of this report, would suggest that the periodic employment of aluminum sulfate should remain a viable option at this time.

Nutrient Load Reduction
Nutrient diversion is a restoration measure, which is designed to reduce the trophic state or degree of over-feeding of a waterbody and thereby control the growth response of the aquatic plants in the system. Control of nutrients in surface water runoff in the tributary area is generally preferable to attempting such control within a lake. Many of the techniques presented in the tributary area management section above are designed for this purpose.

In-lake control of nutrients generally involves removal of contaminated sediments or encapsulation of nutrients by chemical binding—the latter alternative having been considered above under the nutrient inactivation methodology. With respect to the removal of nutrient-rich sediment, costs are generally high, involving an engineered design and usually some form of pumping or excavation. Effectiveness is variable, and impacts include the rerelease of nutrients into the environment. While some limited deepening of specific areas within the lake basin may be warranted for navigational purposes, the widespread use of in-lake nutrient load reduction measures is not warranted in Wind Lake.

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[14]*Aron & Associates,* Wind Lake Internal Loading Management Strategy—1998 Alum Treatment*, February 1998.*

Hydraulic and Hydrologic Management
This group of in-lake management measures consists of actions designed to modify the depth of water in the waterbody. Generally, the objectives of such manipulation are to enhance a particular class of recreational uses, to control the types and densities of organisms within a waterbody, and/or to minimize high water or flooding problems. Consideration can be given to outlet control modifications, drawdown, and dredging.

Outlet Control Operations
The outflow from Wind Lake is located at the southeastern end of the Lake. The outlet structure, as described earlier in this report, consists of a 30-foot-wide, broad-crested dam containing two 10-foot-wide Tainter gates. Onsite observations by SEWRPC staff during 2005 indicated that the outlet structure appeared to be in good physical condition and operating within its design specifications. Consequently, no changes in outlet operations are suggested at this time. Consideration of outlet operations, however, is a viable, ongoing action.

Drawdown
Drawdown refers to a manipulation of lake water levels, especially in impounded lakes, in order to change or create specific types of habitat and thereby manage species composition within a waterbody. Drawdown may be used to control aquatic plant growth and to manage fisheries. With regard to aquatic plant management, periodic drawdowns can reduce the growth of some shoreland plants by exposing the plants to climatic extremes, while the growth of others is unaffected or enhanced. Both desirable and undesirable plants are affected by such actions. Costs are primarily associated with loss of use of the waterbody surface area during drawdown, provided there is a means of controlling water level in place, such as a dam or other outlet control structure. Effectiveness is variable with the most significant side effect being the potential for increased plant growth.

Drawdown can also affect the lake fisheries both indirectly, by reducing the numbers of food organisms, and directly, by reducing available habitat and desiccating (drying out) eggs and spawning habitat. In contrast, increasing water levels, especially during spring, can provide enhanced fish breeding habitat for some species, such as pike and muskellunge, and increase the food supply for opportunistic feeders, such as bass, by providing access to terrestrial insects, for example. Costs are primarily associated with loss of use. Effectiveness for fisheries management is better than for aquatic plant control, but the potential for side effects remains high given that undesirable fish species may also benefit from water level changes.

Sediment exposure and desiccation by means of lake drawdown has been used as a means of stabilizing bottom sediments, retarding nutrient release, reducing (some forms of) macrophyte growth, and reducing the volume of bottom sediments. During the period of drawdown, the exposed sediments are allowed to oxidize and consolidate. It is believed that by reducing the sediment oxygen demand and increasing the oxidation state of the surface layer of the sediments, drawdown may retard the subsequent movement of phosphorus from the sediments. Sediment exposure may also curb sediment nutrient release by physically stabilizing the upper flocculent, sediment-water interface zone of the sediments which plays an important role in the exchange reaction and mixing of the sediments with the overlying water. Drawdown may, thus, deepen the Lake by dewatering and compacting the bottom sediments. The amount of compaction depends upon the organic content of the sediment, the thickness of sediment exposed above the water table, and the timing and duration of the drawdown.

Possible improvements resulting from a lake drawdown include reduced turbidity from wind action, improved gamefishing, enhanced opportunities to collect fish more effectively in fish removal programs, improved opportunities to place and maintain docks and dams, and opportunities to clean and repair shorelines and deepen areas using conventional earth-moving equipment. Limited, over-winter drawdowns are designed to limit shoreland damage by ice and ice movements during the winter months.

In contrast, depending on the timing and duration of the drawdown, drawbacks include loss of fish breeding habitat, loss of benthic food organisms, and disruption of waterfowl feeding and roosting patterns. Increased turbidity and unpleasant odors from rotting organic matter may occur during the period of the drawdown. Other adverse impacts of lake drawdown include algal blooms after reflooding, loss of use of the lake during the drawdown, changes in species composition, and a reduction in the density of benthic organisms following drawdown and reflooding. In some drawdown projects, it has been found that several years after reflooding, flocculent sediments began to reappear because of algal and macrophyte sedimentation. Therefore, to maintain the benefits of a drawdown project, the lake may have to be drawn down every five to 10 years to recompact any new sediments.

Because of the unpredictability of the results, the impairment of recreational uses, and the temporary nature of the beneficial effects of a drawdown, drawdown is not considered a viable option for Wind Lake.

Water Level Stabilization

While water level management in a lake is a common technique for managing fish and aquatic macrophytes, the consequences of manipulating lake water levels can be both beneficial and deleterious. The major impacts from the riparian owner's standpoint is that the fluctuating water levels affect shoreline erosion, interfere with proper pier height and placement, as well as the correct placement of shoreline protection structures.

Periodic changes in precipitation and weather patterns between years often result in fluctuation of water loads to a lake. These fluctuations in turn can affect lake levels. Most plant and animal species can cope with this level of water surface fluctuation without experiencing the consequences, both positive and negative, noted above. Nevertheless, while artificial stabilization of the water surface is not considered a viable option for Wind Lake, it is desirable from the point of view of aquatic habitat that water level fluctuations be maintained within natural limits.

Lake Level and Hydrology

Records of lake surface elevations at the dam impounding Wind Lake have been maintained by the USGS since 1985. The USGS report that the gauge datum is 760.30 feet above mean sea level, with extreme lake surface elevations ranging from an all time low of 5.95 feet in winter of 1996 to an all time high of 8.61 feet in the autumn of 1989. The crest of the dam is at approximately 8.3 feet. During the period of record, the lake elevation was generally below the dam crest. Ongoing monitoring of the lake elevations is considered to be a viable alternative, especially given the relatively few stream gauging stations remaining within the Southeastern Wisconsin Region. These structures allow calculation of actual runoff volumes and field validation of volumes calculated using standard engineering relationships.

Where there are structures that augment lake levels, it is recommended that periodic inspections of such structures be carried out by the WDNR. These inspections are conducted at approximately five-year intervals. In the interim periods, it is recommended that visual inspections of the structure be carried out at regular intervals to ensure the proper operation of the gates and to determine that there is no excessive seepage along the structure. Continued inspections of the structure at regular intervals, as noted under outlet control operations above, are considered to be a feasible option.

Lastly, the continued passage of flows downstream is necessary to ensure the continuity of the riverine ecosystems downstream of Wind Lake and to maintain the structure and function of the hydrological system. In part, these flows reflect the ability of the impoundment to safely pass the one-percent-annual-probability (100-year recurrence interval) flood flows to avoid upstream flooding. It should be noted that the downstream stream reaches are within Racine County Farm Drainage District No. 1 created as a special-purpose district pursuant to Chapter 88 of the *Wisconsin Statutes* and operated by the Racine County Drainage Board pursuant to Chapter ATCP 48 of the *Wisconsin Administrative Code* for the purpose of draining land, primarily for agricultural purposes. In certain circumstances, set forth in Section ATCP 48.04 of the *Wisconsin Administrative Code*, a county drainage board can: initiate legal action to recover damages that are sustained by a drainage district as a result of an action or omission by an owner of land located outside the district, and order the annexation to a drainage district of lands outside the district that benefit from the operation of a district drain. To the extent that the actions of the Racine County Drainage Board complement the operations of the Wind Lake Management District, the continuation of operations by the Racine County Drainage Board downstream of Wind Lake is considered to be a feasible alternative. Further, the continued operation of the Drainage Board to maintain the streamcourse downstream of Wind Lake in a condition to pass the one-percent-annual-probability flood event is recommended.

Dredging

Sediment removal is a restoration measure that is carried out using a variety of techniques, both land-based and water-based, depending on the extent and nature of the sediment removal to be carried out. For larger-scale applications, a barge-mounted hydraulic or cutterhead dredge is generally used. For smaller-scale operations a shore-based, drag-line system is typically employed. Both methods are expensive, especially if a suitable disposal site is not located close to the dredge site. Costs for removal and disposal begin at between $10 and $15 per cubic yard, with the cost of sediment removal alone beginning at between $3.00 and $5.00 per cubic yard. Effectiveness of dredging varies with the effectiveness of tributary area controls in reducing or minimizing the sediment sources. Federal and State permits are required for use of this option.

Dredging in Wind Lake could be accomplished using several different types of equipment, including a hydraulic cutterhead dredge mounted on a floating barge in deeper water areas; a bulldozer and backhoe equipment in the shoreland area, especially if the Lake was drawn down; and a clamshell, or bucket, dragline dredge from the shoreline. While the use of conventional earth-moving equipment and shore-based draglines has some advantages over hydraulic dredging, particularly since these methods would not require large disposal and dewatering sites in close proximity to the project area, these methods would be dependent, to some extent, on the drawdown of the Lake. Reducing the water level in the Lake would be especially advantageous for dragline dredging because it would not require the removal of shoreland trees, resulting in less disturbance of the shoreline to provide access for trucks and equipment. Likewise, reduced water levels would allow conventional construction equipment access to the littoral portions of the waterbody. Nevertheless, given the potential recreational use impacts of a drawdown during the summer and winter recreational seasons, use of these methods is not considered feasible.

Hydraulic cutterhead dredging is the most commonly employed method in the United States. The dredge is typically a rotating auger or cutterhead on the end of an arm that is lowered to the sediment-water interface. Sediment excavated by the cutterhead is pumped as a slurry of 10 to 20 percent solids by a centrifugal pump to the disposal site. This pumping usually limits the distance between the lake and disposal site to less than a mile, even using intermediate booster pumps. Because of the large volume of slurry produced, a relatively large disposal site is typically required. Water returned from the disposal site, whether returned to the lake or a stream, would have to meet effluent water quality standards of the State and would be subject to State permitting.

Dredging is the only restoration technique that directly removes the accumulated products of degradation and sediment from a lake system and can return a lake to a younger "age." If carried to the extreme, dredging can be used, in effect, to construct a new lake with a size and depth to suit the management objectives. Dredging has been used in other lakes to increase water depth, remove toxic materials, decrease sediment oxygen demand, prevent fish winterkills and nutrient recycling, restore fish breeding habitat, and decrease macrophyte growth. The objective of a dredging program at Wind Lake should be to increase water depth to maintain recreational boating access and increased public safety.

Even so, dredging may have serious, though generally short-term, adverse effects on the Lake. These adverse effects could include increased turbidity caused by sediment resuspension, toxicity from dissolved constituents released by the dredging, oxygen depletion as organic sediments mix with the overlying water, water temperature alterations, removal of native plant seeds, and destruction of benthic and fisheries habitats. There may also be impacts at upland spoil disposal sites, such as odor problems, restricted use of the site, and disturbances associated with heavy truck traffic. In the longer term, disruption of the lake ecosystem by dredging can encourage the colonization of disturbed portions of the lakebed by less desirable species of aquatic plants and animals, including Eurasian water milfoil, which is present in Wind Lake.

In addition, while dredging can result in an immediate increase in lake depth, such increases may be short-lived if the sources of sediment being deposited in the lake are not controlled within the area tributary to the lake. The sediment load reaching Wind Lake comes from both urban and agricultural lands within the area tributary to Wind Lake. Sediment also may be generated from streambank and shoreland erosion. Many of these sources can be effectively controlled through the adoption, implementation, and maintenance of recommended control measures within the tributary area. Such practices should be implemented in the area tributary to the Lake, as noted above, regardless of the likely conduct of any dredging project.

As noted above, dredging of lakebed material from navigable waters of the State requires a WDNR Chapter 30 permit and a USCOE Chapter 404 permit. In addition, current solid waste disposal regulations define dredged material as a solid waste. Chapter NR 180 of the *Wisconsin Administrative Code* requires that any dredging project of over 3,000 cubic yards submit preliminary disposal plans to the WDNR for review and potential solid waste licensing of the disposal site. Because sodium arsenite was applied to Wind Lake during the 1950s and 1960s, as noted in Chapter V, sediment samples may need to be analyzed to determine the extent and severity of any residual arsenic contamination; no elevated concentrations of arsenic have been reported in the Wind Lake sediments to date.

Limited deepening of specific areas of the Lake for navigational purposes may be warranted, subject to WDNR permitting requirements.

Nuisance Species, Fisheries, and Aquatic Plant Management

Nuisance Species Management Measures

Beginning in 2003, Wind Lake has been the site of a U.S. Department of Agriculture (USDA) Fish and Wildlife Service-sponsored program to manage nuisance levels of Canada geese on Wind Lake. Continuation of this program is considered a viable option. A depredation permit granted by the USDA Fish and Wildlife Services is required to conduct these activities. The program targets nonmigratory waterfowl. Testing of the birds for environmental contaminants is required prior to the issuance of the harvesting permit. The tests, completed during the first year of the proposed culling program, indicated that the geese harvested were: not contaminated with synthetic organic chemicals or heavy metals, not requiring of being land-filled as hazardous waste, and able to be donated to the local food pantry for human consumption. This experience has been replicated elsewhere in the Southeastern Wisconsin Region where nonmigratory Canada geese have reached nuisance proportions.

Management of nuisance aquatic plants, such as Eurasian water milfoil, is discussed below. Likewise, alternatives for the management of roughfish populations are discussed in the fisheries management section below.

Fisheries Management Measures

Wind Lake provides a quality habitat for a healthy, warmwater fishery. Currently, adequate water quality, sufficient dissolved oxygen levels, appropriate bottom substrate materials along shorelines, and a diverse aquatic plant community support the maintenance of a sportfish population in the lake. Winterkill currently is not a problem. The lake supports a largemouth bass-panfish fishery. In addition, the striped shiner, a State Endangered species, and the pugnose minnow, a State special concern species, have been reported being present in the Lake, as mentioned in Chapter V.

Habitat Protection

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat, including measures, such as restricting recreational use and other intrusions into gravel-bottomed shoreline areas during the spawning season. For bass, this is mid-April to mid-June, annually. Use of natural vegetation in shoreland management zones and other “soft” shoreline protection options aids in habitat protection. Costs are generally low, unless the habitat is already degraded. Modification of aquatic plant harvesting operations, if being utilized, may be considered to support restoration and protection of native aquatic plant beds and maintenance of fish breeding habitat during the early summer period. Effectiveness is variable depending in part on community acceptance and enforcement. Generally, it is more effective to maintain a good habitat than to restore a habitat after it is degraded.

Loss of habitat should be a primary concern of any fisheries management program. Environmentally valuable areas within the lake and its tributary area are the most important areas to be protected. In addition, limiting or restricting certain activities in those areas of the Lake containing important fish habitat will prevent significant disturbance of fish activities and aquatic plant beds. Within these areas, aquatic plant management measures should be restricted, and dredging, filling, and the construction of piers and docks should be discouraged. It also should be noted that water level fluctuations other than those consequent to natural climatic variability and water quality conditions can affect fish habitat and the breeding success of fishes. In this regard, the maintenance of lake water levels within natural limits, and the maintenance of good water quality, cannot be overemphasized as fish habitat protection measures.

Shoreline Maintenance
Shoreline maintenance refers to a group of measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related actions of the water. Most of the shoreline of Wind Lake is protected by some type of structural measure. Four shoreline erosion control techniques were in use in 2003: natural vegetative buffer strips, rock and riprap revetments, wooden and concrete bulkheads, and beach. Maintenance of a vegetated buffer strip 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.

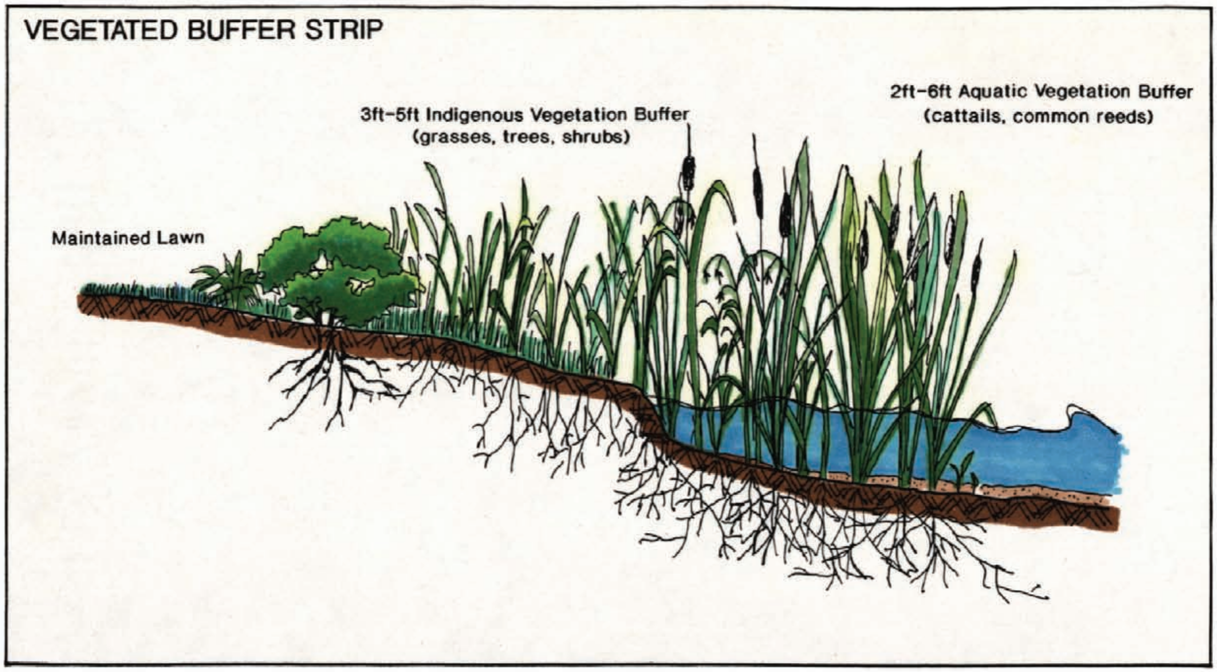
Desirable plant species that may be expected and encouraged to invade a buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium eurycarpum*), and 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.

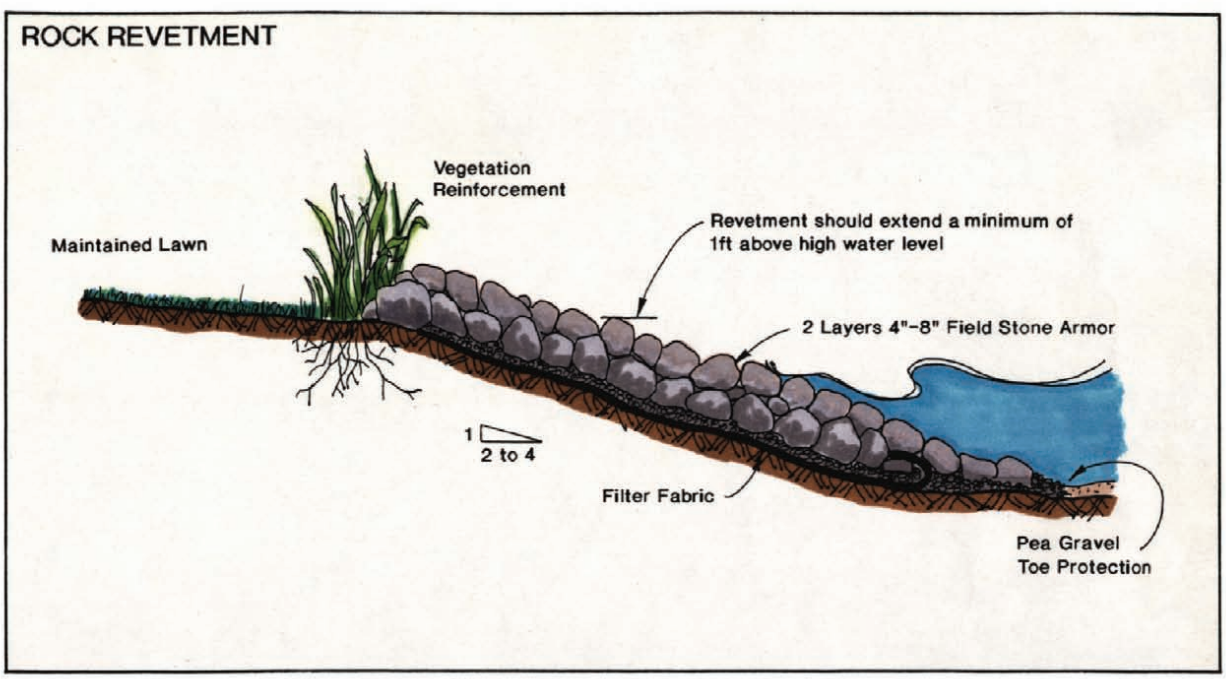
Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. Many of these structures are already in place at Wind Lake. The technique involves the shaping of the shoreline slope, 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 between $25 and $35 per linear foot.

The use of natural vegetated buffer strips and riprap, as shown in Figure 12, is recommended, especially in those areas subject to significant wind-wave, boat wake, and ice scour erosion. 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*, which chapter contains a worksheet that must be completed in order to determine the type of shoreline protection structure that is appropriate for a particular portion of shoreline. Table 1, the "Erosion Intensity (EI) Score Worksheet," set forth in Section NR 328.08(2) of

Figure 12

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.

the *Wisconsin Administrative Code*, is required to be completed by applicants and WDNR staff in order to calculate erosion intensity prior to the issuance of any permit for shoreline protection structure.[15]

Shoreline protection structures should be maintained. Routine maintenance, like initial installation, is subject to WDNR permitting. However, limited maintenance is regulated under a general statewide permit which allows limited repair and upkeep of such protection structures; to wit, up to 100 feet of riprap and placement of up to two cubic feet of sand or gravel is allowed without the need for an individual permit. It should be noted that placement of vertical walls, bulkheads, or seawalls is not permitted under Chapter NR 328 of the *Wisconsin Administrative Code*. While minor repair of these structures is allowed, it is the stated policy of the WDNR that these structures be replaced over time with less intrusive shoreline protection technologies that offer habitat benefit for fish and aquatic life. Where appropriate, use of riprap and natural shorescaping alternatives is considered to be viable; maintenance of such shoreline protection structures is recommended.

Modification of Species Composition

Species composition management refers to a group of conservation and restoration measures that include selective harvesting of undesirable fish species and stocking of desirable species designed to enhance the angling resource value of a lake. These measures also include water level manipulation, both to aid in the breeding of desirable species, for example, increasing water levels in spring to provide additional breeding habitat for pike, and to disadvantage undesirable species, for example, drawing a lake down to concentrate foragefish and increase predation success and also to strand juveniles and desiccate the eggs of undesirable species. Costs, as with water level management above, are primarily associated with loss of use; effectiveness is good, but by no means certain; and side effects include collateral damage to desirable fish populations.

More extreme measures include organized fishing events and selective cropping of certain fish species, poisoning, and enhancement of predation by stocking. In lakes with an unbalanced fishery, dominated by carp and other roughfish, chemical eradication has been used to manage the fishery. Lake drawdown is often used along with chemical treatments to expose spawning areas and eggs and concentrate fish in shallow pools, thereby increasing their availability to anglers, commercial harvesters, or chemical eradication treatments. Fish barriers are usually used to prevent reintroduction of undesirable species from up- or downstream, and the habitat thus created will benefit the desired gamefish populations. Chemical eradication is a drastic, costly measure and the end result may be highly unpredictable. Although effectiveness is generally good, such extreme measures are not currently considered viable for Wind Lake.

As noted in Chapter V, Wind Lake is currently managed for warmwater sportfish, and selective stocking is undertaken primarily by the WDNR. Continued fish stocking by the WDNR is considered a viable option for Wind Lake, subject to monitoring and creel surveying data collected from the Lake by the WDNR. Additional fish population control measures do not appear to be warranted at this time, although roughfish populations should continue to be monitored. An annual "carp out" event to help manage roughfish populations is considered a viable option. Currently, up to about 16,500 pounds of carp are removed annually from Wind Lake by seine net by a contractor under a program initiated by the Wind Lake Management District during 2000.

Regulations and Public Information

To reduce the risk of overharvest, the WDNR has placed restrictions on the number and size of certain fish species caught by anglers. The open season, size limits, and bag limits for the fish species of Wind Lake are given in Table 20 in Chapter V of this report. Enforcement of these regulations is critical to the success of any sound fish management program.

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[15] *An abbreviated version of the "Erosion Intensity Score Worksheet," which can be completed online is available at: http://dnr.wi.gov/org/water/fhp/waterway/erosioncalculator.shtml. This abbreviated worksheet can be printed and used in support of a shoreline protection permit application. It should be noted that this calculator is limited to the evaluation of wind wave erosion and does not include the evaluation of boat wake-induced shoreline loss.*

Aquatic Plant Management Measures

Aquatic plant management refers to a group of management and restoration measures aimed at both removal of nuisance vegetation and manipulation of species composition in order to enhance and provide for recreational water use. Generally, aquatic plant management measures are classified into four groups: chemical measures, which include using aquatic herbicides; mechanical measures, which include harvesting and manual removal; biological measures, which include the use of various organisms, including insects; and physical measures, which include lake bottom coverings and water level management. All aquatic plant management measures are stringently regulated and require a State permit.

Costs of aquatic plant management measures range from minimal for manual removal of plants using rakes and hand-pulling to upwards of $100,000 to $160,000 for the purchase of a mechanical plant harvester and ancillary equipment, the operational costs for which can approach $10,000 to $20,000 per year depending on staffing and operating policies. Harvesting is probably the measure best applicable to larger areas while chemical controls may be best suited to use in confined areas and for initial control of invasive plants. Planting of native plant species is largely experimental in lakes, but can be considered a specialized shoreland management zone at the water's edge. Physical controls and mechanical harvesting may have side effects in the expansion of plant habitat and the spread of reproductive vegetative fragments.

Chemical Measures

Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. Chemicals are applied to the growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophyte growth are the relative ease, speed, and convenience of application. Herbicides also offer a degree of selectivity, targeting specific types of aquatic plants. However, the disadvantages associated with chemical control include the following:

1. The short-term, lethal effects of chemicals are relatively well known. However, properly applied, chemical applications should not result in such effects. Potential long-term, sublethal effects, especially on fish, fish-food organisms, and humans, are relatively unknown.

2. The elimination of macrophytes eliminates their competition with algae for light and nutrients. Algal blooms may then develop unless steps are taken simultaneously to control the sources of nutrient input.

3. Since much of the dead plant materials are left to decay in the lake, nutrients contained in them are rapidly released into the water and fuel the growth of algae. The decomposition of the dead plant material also consumes dissolved oxygen and increases the potential for fish kills. Accretion of additional organic matter in the sediments as a result of decomposition also increases the organic content of the soils and predisposes the sediments toward reintroduction of other (or the same) nuisance plant species. Long-term deposition of plant material may result in the need for other management measures, such as dredging.

4. The elimination of macrophyte beds destroys important cover, food sources, and spawning areas for desirable fish species.

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton *Daphnia* and *Hyalella*, both important fish foods. *Daphnia* is the primary food for the young of nearly all fish species found in the Region's lakes.[16]

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[16]*P.A. Gilderhus, "Effects of Diquat on Bluegills and Their Food Organisms,"* The Progressive Fish-Culturist*, Vol. 2, No. 9, 1967, pp. 67-74.*

6. Areas generally must be treated again in the following season and weedbeds may need to be treated more than once in a summer, although certain herbicides may give relief over a period of up to three years in some lakes.

7. Many of the chemicals available often affect nontarget, desirable species, such as water lilies, as well as the target "weeds," such as Eurasian water milfoil, as both species share similar biological characteristics, being dicotyledons.

The advantages and disadvantages of chemical macrophyte control also apply to the chemical control of algae. Copper, the active ingredient in algicides, may accumulate in the bottom sediments, where excessive amounts are toxic to fish and benthic animals. Fortunately, copper is rapidly eliminated from human systems and few cases of copper sensitivity among humans are known.[17]

Costs of chemical treatments vary widely. Large, organized treatments are more efficient and tend to decrease unit costs for commercial applications compared to individual treatments. Other factors, such as the type of chemical used and the number of treatments needed, are also important. Estimated costs for lakes in southeastern Wisconsin range from $240 to $480 per acre. Chemical treatments must be permitted by the State under Chapter NR 107 of the *Wisconsin Administrative Code*.

Although there is a demonstrated need to control aquatic plants in selected areas of Wind Lake, chemical treatment is considered to be a viable management option only in limited, nearshore areas of the Lake, around piers and structures. Widespread use of chemical herbicides is not considered a viable option.

Mechanical Measures

Aquatic macrophytes are 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. Advantages of macrophyte harvesting include the following:

1. Harvesting removes the plants from the lake. The removal of this plant biomass decreases the rate of accumulation of organic sediment. A typical harvest of submerged macrophytes from eutrophic lakes in southeastern Wisconsin can yield between 140 and 1,100 pounds of biomass per acre per year.[18]

2. Harvesting removes plant nutrients, including nitrogen and phosphorus, which would otherwise "refertilize" the lake as the plants decay. A typical harvest of submerged macrophytes from eutrophic lakes in southeastern Wisconsin can remove between four and 34 pounds of nitrogen and 0.4 to 3.4 pounds of phosphorus per acre per year. In addition to the physical removal of nutrients, plant harvesting may reduce internal nutrient recycling. Several studies have shown that aquatic macrophytes can act as nutrient pumps, recycling nutrients from the bottom sediments into the water column. Ecosystem modeling results have indicated that a harvest of 50 percent of the macrophytes in Lake Wingra, Wisconsin, could reduce instantaneous phosphorus availability by about 30 percent, with a maximum reduction of 40 to 60 percent, depending on the season.

3. Repeated macrophyte harvesting may reduce the regrowth of certain aquatic macrophytes. The regrowth of milfoil has been reported to have decreased as harvesting frequency was increased.

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[17]*J.A. Thornton, and W. Rast, "The Use of Copper and Copper Compounds as an Algicide,"* Copper Compounds Applications Handbook*, H.W. Richardson, ed., Marcel Dekker, New York, 1997.*

[18]*James E. Breck, Richard T. Prentki, and Orie L. Loucks, editors,* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting*, Proceedings of Conference at Madison, Wisconsin, February 14-16, 1979.*

4. Where dense growths of filamentous algae are closely associated with macrophyte stands, they may be harvested simultaneously.

5. The macrophyte stalks remaining after harvesting provide cover for fish and fish-food organisms, and stabilize the bottom sediment against wind erosion.

6. Selective macrophyte harvesting may reduce stunted populations of panfish in lakes where excessive cover has adversely influenced predator-prey relationships. By allowing an increase in predation on young panfish, both gamefish and the remaining panfish may show increased growth.[19]

7. The cut plant material can be used as mulch.

The disadvantages of macrophyte harvesting include the following:

1. Harvesting is most effective in water depths greater than two feet. Large harvesters cannot operate in shallow water or around docks and buoys. Operation of harvesting equipment in shallow waters can result in significant increases in turbidity and disruption of the lake bottom and lake bottom-dwelling fauna.

2. The reduction in aquatic macrophytes by harvesting reduces their competition with algae for light and nutrients. Thus, algal blooms may develop.

3. Fish, especially young-of-the-year bluegills and largemouth bass, as well as fish-food organisms, are frequently caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A WDNR study found that four pounds of fish were removed per ton of plants harvested.[20] To protect the fish community from excessive mortality from harvesting, the WDNR generally recommends harvesting be conducted in areas three feet in depth or greater. Additionally, it is generally recommended that harvesting activities not begin before June 15th in order to reduce disturbing fish spawning activities.

4. The reduction in aquatic macrophyte biomass by harvesting or chemical control can reduce the diversity and productivity of macroinvertebrate fish-food organisms feeding on the epibiota. Bluegills generally move into the shoreline area after sunset, where they consume these macroinvertebrates. After sunrise they migrate to open water, where they graze, primarily on zooplankton. If harvesting or chemical control shifts the dominance of the littoral macroinvertebrate fauna to sediment dwellers, the macroinvertebrate component of the bluegill diet could be restricted.[21] This would increase predation pressure on zooplankton and reduce the growth rate of the panfish; it could eventually lead to undesirable ramifications throughout the food web in a lake.

5. Macrophyte harvesting may influence the community structure of macrophytes by favoring such plants as milfoil (*Myriophyllum* spp.) that propagate from cut fractions. This may allow these plants to spread into new areas through the rerooting of the cut fractions.

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[19] *James E. Breck, and J.F. Kitchell, "Effects of Macrophyte Harvesting on Simulated Predator-Prey Interactions,"* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting*, 1979, pp. 211-228.*

[20] *Wisconsin Department of Natural Resources,* Environmental Assessment Aquatic Nuisance Control (NR 107) Program*, 3rd Edition, 1990, 213 pp.*

[21] *James E. Breck, et. al.,* op. cit.

6. Certain species of plants, such as coontail, are difficult to harvest due to lack of root system.

7. The efficiency of macrophyte harvesting is greatly reduced around piers, rafts, and buoys because of the difficulty in maneuvering the harvesting equipment in those restricted areas. Manual methods have to be used in these areas.

8. High capital and labor costs may be associated with harvesting programs. Macrophyte harvesting on Wind Lake could be conducted through cooperative agreements among various municipalities in the tributary area or be contracted to a private company. These costs are largely staff costs and operating costs, such as fuel, oil, and maintenance.

Harvesting programs should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do not utilize these dense beds.[22] Narrow channels may be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. "Shared access" lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. "Clear cutting" of 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 13, is suggested. Application of this technique to Sterlingworth Bay by the Lauderdale Lakes Management District in Walworth County, resulted in a significant increase in species diversity, and reduction of aquatic plant-related citizen concerns, in an area that historically was dominated by Eurasian water milfoil.[23]

Water depth, numbers and arrangement of docks and moored boats, and nature of bottom substrate are important factors when considering mechanical harvesting. As explained above, most harvesting equipment is large and not well-suited to close operation around docks and moored boats where precise control of movement is needed. Areas of shallow depths, two to three feet or less, containing muck or other soft, loose bottom materials are generally not considered to be well-suited to harvesting as the equipment tends to churn up these bottom materials, creating turbid water conditions, affecting established benthic communities and fragmenting rooted aquatic macrophytes.[24] Plants, such as Eurasian water milfoil, which propagate through the spread of plant fragments, may actually be at an advantage as a result of the chopping action of harvesting equipment. Mechanical harvesting is best suited to areas free of docks and moored watercraft or recreational equipment, where lake bottom materials are firm and water is of sufficient depth to offer a degree of protection against potential lake bottom disruption by harvester equipment. The harvest of water lilies and emergent native plants should be avoided.

Protecting native aquatic plant communities from disturbances can help prevent Eurasian water milfoil from spreading within a lake. Recent studies show that native plants can effectively compete with Eurasian water milfoil. However, the exotic species tends to outcompete native plants when the lake's ecosystem is stressed.[25]

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[22]*S. Nichols, Wisconsin Department of Natural Resources Technical Bulletin No. 77,* Mechanical and Habitat Manipulation for Aquatic Plant Management: A Review of Techniques*, 1974.*

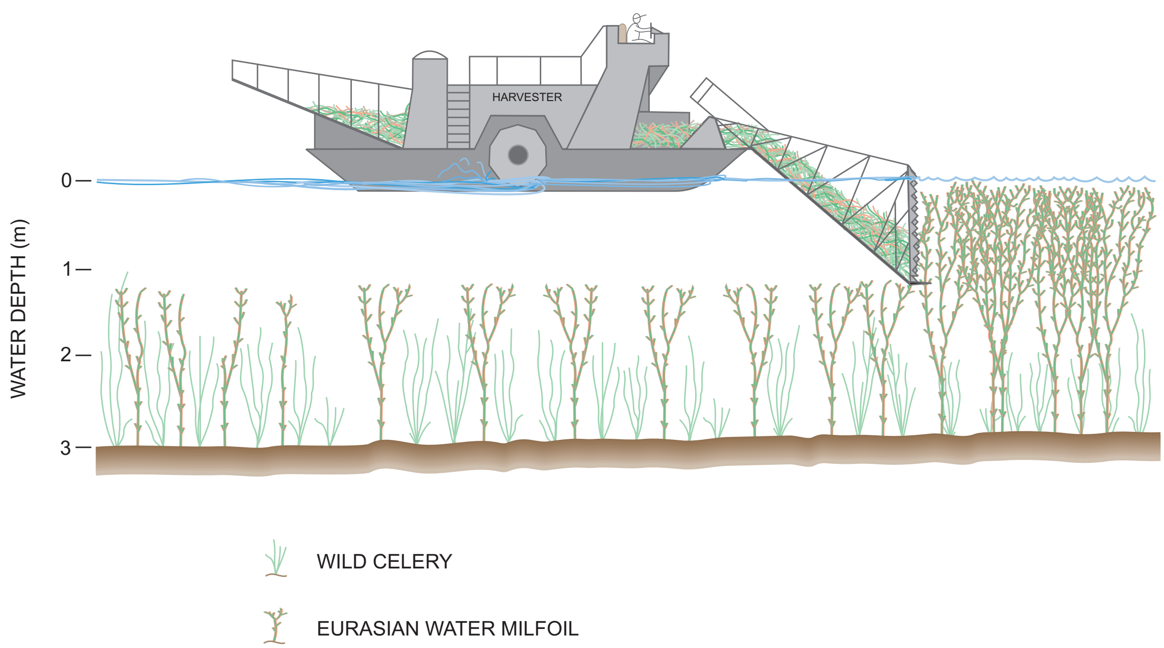
[23]*See SEWRPC Memorandum Report No. 143,* An Aquatic Plant Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin*, August 2001; see also SEWRPC Staff Memorandum entitled, "Eurasian Water Milfoil Management in Mill Lake: 2002," August 2002.*

[24]*Wisconsin Department of Natural Resources, Publication No. PUBL-WR-201-88,* Do You Need A Mechanical Aquatic Plant Harvester? Machine Harvesting of Aquatic Plants*, 1988.*

[25]*Wisconsin Department of Natural Resources,* Eurasian Water Milfoil in Wisconsin: A Report to the Legislature*, 1992.*

Figure 13

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.

Stress can be brought on by tributary area pollution, shoreline development, changing water levels, boating activity, carp, and aquatic nuisance controls. This maintenance of a healthy aquatic plant community has been found to be the most efficient way of managing aquatic plants, as opposed to other means of managing problems once they occur. Furthermore, native aquatic plant communities contribute most effectively to the maintenance of good water quality by providing suitable habitat for desirable fish and other aquatic organisms which promote stable or increased property values and quality of life.[26]

Because of the demonstrated need for control of aquatic plants, harvesting is considered a viable option in areas of Wind Lake that are conducive to this method of management. Mechanical harvesting of aquatic plants must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*. Currently, the WLMD contracts with private companies to conduct harvesting operations on Wind Lake. Due to the intermittent use of harvesting in the past, purchase of harvesting equipment by WLMD is unlikely to be cost-effective in the long run and is, therefore, not considered a viable option at this time.

Due to water depth limitations imposed by the size and maneuverability of the harvesters, it is not always possible for harvesters to reach the shoreline of every property. Likewise, because of the cost and other concerns relating to the use of chemical herbicides, alternative measures for the control of aquatic plant growth in specific areas of the lake should be considered. A number of specially designed rakes are available from commercial outlets to

[26]*Roy Bouchard, Kevin J. Boyle, and Holly J. Michael,* Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes*, Miscellaneous Report 398, February 1996.*

assist lakefront homeowners in manually removing aquatic plants from the shoreline area. The advantages of these rakes are that they are easy and quick to use, and result in an immediate result, in contrast to chemical treatments that involve a waiting period. This method also removes the plants from the lake, thereby avoiding the accumulation of organic matter on the lake bottom. Unfortunately, manual harvesting is feasible in only very limited areas and is not practical for large-scale use. Nevertheless, manual harvesting does offer a reasonable level of aquatic plant control in the vicinity of docks and piers, and is therefore considered a viable option. Manual harvesting beyond a 30-foot-wide recreational corridor, or within a WDNR-delineated environmentally sensitive area, must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*. Pursuant to the provision of this chapter, piers and other recreational areas must be placed within the 30-foot-wide recreational corridor.

Biological Measures

Another alternative approach to controlling nuisance weed conditions, in this particular case Eurasian water milfoil, is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[27] Recent documentation states that *Eurhychiopsis lecontei*, an aquatic weevil species, has the potential as a biological control agent for Eurasian water milfoil. In 1989, the weevil was discovered during a study investigating a decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* proved to have significant negative effects on Eurasian water milfoil in the field and in the lab. The adult weevil feeds on the milfoil causing lesions which make the plant more susceptible to pathogens, such as bacteria or fungi, while the weevil larvae burrows in the stem of the plant causing enough tissue damage for the plant to lose buoyancy and collapse.[28] The few studies that have been done since that time have indicated the following potential advantages to use of this weevil as a means of Eurasian water milfoil control:

1. *Eurhychiopsis lecontei* is known to cause fatal damage to the Eurasian water milfoil plant and over a period of time has the potential to cause a decrease in the milfoil population.

2. *Eurhychiopsis lecontei* larvae are easy to produce.

3. *Eurhychiopsis lecontei* are not known to cause damage to existing native aquatic plants.

The potential disadvantages of using *Eurhychiopsis lecontei* include:

1. The potential for "wash-off" of *Eurhychiopsis* from the stems of the plant as a result of boat wakes, predation of the weevil by fishes, and the "lag time" associated with the occurrence of sufficiently large natural populations to effect control.[29]

2. Since the upper portion of the Eurasian water milfoil plant is preferred by the weevil, harvesting would have to be extremely limited or not used at all in conjunction with this type of aquatic plant management control.

Relatively few studies concerning the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control have been completed. Such cases have resulted in variable levels of control, and, although priced

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[27]*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; C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology*, John Wiley, New York, New York, USA.*

[28]*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.*

[29]*The use of* Eurhychiopsis *sp. on an experimental basis to control Eurasian water milfoil was monitored in selected Wisconsin lakes by the Wisconsin Department of Natural Resources and the University of Wisconsin-Stevens Point from 1995 through 1998. These results indicated mixed success, suggesting that this organism has specific habitat requirements that limit its utility as a Eurasian water milfoil control agent within Wisconsin.*

competitively with aquatic herbicides, the use of *Eurhychiopsis lecontei* is not considered a viable option for Wind Lake at this time. Use of biological control agents must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*. While the use of biological control agents such as the Eurasian water milfoil weevil and the beetles, *Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus,* used to control infestations of purple loosestrife in wetlands and along shorelands has been shown to be beneficial in certain circumstances, including use at Wind Lake, the use of other biological control agents is prohibited in Wisconsin; the use of the grass carp, *Ctenopharyngodon idella*, for aquatic plant control is expressly prohibited.

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 materials, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. The screens are flexible and can be anchored to the lakebed in spring or draped over plants in summer.

The advantages of bottom covers and screens are that control can be confined to specific areas, the covers and screens are usually unobtrusive and create no disturbance on shore, and the covers are relatively easy to install over small areas. The disadvantages of bottom covers and screens are that they do not reduce eutrophication of the lake, they are expensive, they are difficult to spread and anchor over large areas or obstructions, they can slip on steep grades or float to the surface after trapping gases beneath them, and they may be difficult to remove or relocate.

Screens and covers should not be used in areas of strong surfs, heavy angling, or shallow waters where motorboating occurs. They should also not be used where aquatic vegetation is desired for fish and wildlife habitat. To minimize interference with fish spawning, screens should be placed before or after spawning. A permit from the WDNR is required for use of sediment covers and light screens. Permits require inspection by the Department staff during the first two years, with subsequent permits issued for three-year periods. Annual removal of such barriers is generally required as a permit condition.

The estimated cost of lake bottom covers that would control plant growth along a typical shoreline property, an area of about 700 square feet, ranges from $100 for burlap to $300 for aquascreen. Placement of lake bottom screens requires a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*. Because of the limitations involved, placement of lake bottom covers as a method to control aquatic plant growth is not a viable option for Wind Lake.

Use of sand blankets and pea gravel deposits has also been proposed as a physical barrier to aquatic plant growth in certain situations. Placement of materials on the bed of a navigable lake or waterway also requires a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*, and the use of these materials is generally confined to the creation and augmentation of swimming beaches. Use of these materials for aquatic plant management purposes is not a viable option as deposition of sediments above the sand or gravel layer limits the longer term viability of this technique.

Public Informational Programming

Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public views all aquatic plants as “weeds” and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impacts. As shown in Table 15 in Chapter V of this report, many aquatic plants have positive ecological value within the lake ecosystem, and most native aquatic plants rarely interfere with human water uses. Thus, public information is an important component of an aquatic plant management program and should include informational programming on:

1. The types of aquatic plants in Wind Lake and their value to water quality, fish, and wildlife.

2. The preservation of existing stands of desirable plant species.

3. The identification of nuisance species and the methods of preventing their spread.

4. Alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method.

An organized aquatic plant identification/education day is one method of providing hands-on education to lake residents. Other sources of information and technical assistance include the WDNR and the University of Wisconsin-Extension (UWEX). The aquatic plant species lists provided in Chapter V, and the illustrations of common aquatic plants present in Wind Lake appended hereto as Appendix A, may serve as a checklist for individuals interested in identifying the plants near their residences. Residents can observe and record changes in the abundance and types of plants in their part of a lake on an annual basis.

Of the submerged floating and free-floating aquatic plant species found in Wind Lake, Eurasian water milfoil is one of the few species likely to cause lake-use problems, although it has been reported that water celery and chara have been, at times, problematic. Eurasian water milfoil, unlike most aquatic plants, can reproduce from fragments and often forms dense, monotypic beds with little habitat value for fish or waterfowl. Lakeshore residents should be encouraged to collect fragments that wash ashore after storms and, especially, from weekend boat traffic. The plant fragments can be used as mulch on flower gardens or ornamental planting areas. Likewise, lake users should be encouraged to inspect boats and trailers both prior to launch and following recover as Eurasian water milfoil and other aquatic plants can be transported between lakes as fragments on boats and boat trailers. This effort also limits the likelihood of transporting zebra mussel, *Dreissena polymorpha*, between lakes or into new areas of lakes.

To prevent unwanted introductions of plants and invasive aquatic animals into lakes, boaters should remove all plant fragments from their boats and trailers when exiting a lake, and allow wet wells, engine water jackets, and bilges to dry thoroughly for up to one week. Alternatively, boaters can run their vessels through a car wash, where high-pressure, high-temperature water sprays can remove and destroy organisms, such as the zebra mussel juveniles (veligers).[30] Providing the opportunity for the removal of plant fragments at the boat landing on Wind Lake, and provision of signage at the boat landing, including provision of disposal containers at the boat landing, may help motivate boaters to utilize this practice. Posters and pamphlets are available from the WDNR and UWEX that provide information and illustrations of milfoil, zebra mussel, and other nonnative aquatic species; discuss the importance of removing plant fragments from boats; and, remind boaters of their duty in this regard.

Recreational Use Management

Regulatory measures provide a basis for controlling lake use and use of the shorelands around a waterbody. On land, shoreland zoning, requiring set backs and shoreland buffers can protect and preserve views both from the water and from the land, controls development around a lake to minimize its environmental impacts and manages public and private access to a waterbody. On water, recreational use zoning can provide for safe and multiple-purpose use of lakes by various groups of lake users and protect environmentally sensitive areas of a lake. Use zoning can take the form of allocating times of use, such as the annual fishing season established by the State, or areas of use, wherein the types or rate of use is controlled, as in the case of shallow water, slow-no-wake speed limits. A key issue in zoning a waterbody for use is equity; the same rules must apply to both riparian owners/residents and off-lake users. This condition is usually met in situations where use zoning is motivated by the protection of fish habitat, for example, as both on- and off-lake users would appreciate an enhanced fishery.

[30]*See Wisconsin Department of Natural Resources Publication No. PUBL-WR-383 95-REV.,* Zebra Mussel Boater's Guide*, 1995; See also Wisconsin Department of Natural Resources Publication No. PUBL-WR-463 96-REV.,* The Facts...On Eurasian Water Milfoil*, February 1996.*

Costs are relatively low, associated with creating and posting the ordinance, and effectiveness can be good with regular/consistent enforcement. Costs increase for measures requiring buoyage.

Currently, watercraft are restricted to slow-no-wake speeds within 300 feet of shore. This typically coincides with water depths of less than five feet. Demarcation of Eurasian water milfoil control areas and similar environmentally valuable or sensitive areas of the Lake is recommended. It is also recommended that the Town of Norway continue to enforce recreational boating ordinance appended hereto as Appendix B.

Public Informational and Educational Programming

Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the UWEX, the WDNR, and the Racine County Public Works/Parks Department. These latter cover topics, such as beneficial lawn care practices and household chemical use guidelines. These brochures could be provided to homeowners through local media, direct distribution, or targeted school or public library displays. Many of these ideas can be integrated into ongoing, larger-scale municipal activities, such as anti-littering campaigns, recycling drives, and similar pro-environment activities.

The WLMD regularly presents informational programs of general interest to community residents. These programs have included aquatic plant identification, lake history, lake water quality, and related topics

In addition to public informational programming, or informal educational programming, discussed above, there are a number of school-based educational opportunities that the community can utilize at the middle school level and at the high school level. Such programming as Project WET (Water Education Training) are available from and supported by the UWEX and provide youth the opportunity to experience "hands on" the aquatic environment and become better informed about current and future lake issues and concerns. Therefore, activities of this type, such as Project WET or Adopt-A-Lake, which could be arranged through agreements involving local lake organizations, municipalities, and school districts, are considered a viable option.

Finally, reporting of water quality sampling results to the public and participation of the WLMD in the USGS Lake Water Quality Monitoring Program should be continued. Volunteer monitoring under the auspices of the WDNR "Self-Help Monitoring Program," operated by the UWEX as the Citizen Lake Monitoring Network, should be considered. This program involves citizens in taking Secchi-disc transparency readings in the Lake at regular intervals. The Lake Coordinator of the WDNR-Southeast Region can assist in enlisting volunteers in this program. The information gained at first hand by the public during participation in this program increases the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

SUMMARY

This chapter has described options that could be employed in managing the types of problems recorded as occurring in Wind Lake and which could, singly, or in combination, assist in achieving and maintaining the water quality and water use objectives set forth in Chapter VI of the lake tributary area inventory. Selected characteristics of these measures are summarized in Table 31.

An evaluation of the potential management measures for improving the Wind Lake water quality was carried out on the basis of the effectiveness, cost, and technical feasibility of the measures. Those alternative measures not considered further at this time include: phosphorus precipitation and inactivation, nutrient load reduction through sediment management, water level control by drawdown or modifications of outlet control operations, dredging, chemical eradication of roughfish, biological control of aquatic plants, lake bottom covering, development of time and/or space-zone schemes for managing surface use, and development of alternative institutions. The remaining measures are considered viable options to be considered further for incorporation in the recommended plan described in Chapter VIII.

Table 31

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR WIND LAKE

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Land Use	Zoning	Implement regional land use and county development plans within tributary area	Yes
		Maintain existing density management in lakeshore areas; consider conservation development principles	Yes
	Stormwater management	Develop and implement consistent stormwater management ordinances in all riparian communities; periodic review of stormwater ordinances	Yes
	Protecting environmentally sensitive lands	Implement regional natural areas and critical species habitat protection and management plan recommendations within tributary area; protect wetlands, woodlands, shorelands, and other environmental corridor lands and natural features	Yes
Pollution Abatement	General nonpoint source pollution abatement	Implement regional water quality management plan and county land and water resource management plan recommendations within tributary area	Yes
	Rural nonpoint source controls	Develop farm conservation plans that encourage conservation tillage, contour farming, contour strip cropping, crop rotation, grassed waterways, and pasture and streambank management in agricultural areas of the tributary area	Yes
	Urban nonpoint source controls	Promote urban housekeeping practices, public educational programming, and grassed swales	Yes
		Enforce lawn care management and shoreland protection ordinances	Yes
	Developing area nonpoint source controls	Enforce construction site erosion control ordinances; review ordinances for concurrency with proposed NR 152	Yes
		Use conservation subdivision designs and develop integrated stormwater management systems	Yes
	Public sanitary sewerage system management	Conduct periodic review of sewer service area needs within sewered areas of the tributary area	Yes
	Onsite sewage disposal system management	Implement onsite sewage disposal system management, including inspection and maintenance	Yes
Water Quality	Water quality monitoring	Continue participation in USGS water quality monitoring program; consider participation in WDNR Expanded Self-Help Program or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	Yes
	Water quality improvement	Monitor internal phosphorus loading and consider periodic alum treatment to achieve phosphorus inactivation in lake sediments	Yes
		Promote nutrient load reduction within the Lake basin through sediment management	No
		Modify outlet control operations	No
		Drawdown	No
		Water level stabilization	No
		Dredging	Yes[a]

Table 31 (continued)

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Water Quality (continued)	Lake level and hydrology	Maintain outlet structure and monitor water levels	Yes
		Maintain hydrologic capacity of inflow canal as necessary to one-percent-annual-probability; maintain navigability	Yes
Aquatic Biota	Nuisance species management	Continue management of Canada goose population under permit by USDAFWS	Yes
	Fisheries management	Protect fish habitat	Yes
		Maintain shoreline and littoral zone fish habitat by maintaining existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Yes
		Encourage shoreline restoration projects and creation of buffer strips, and promote consistency in application of landscaping practices in sensitive shoreline areas, through informational programming and demonstration sites	Yes
		Continue stocking of selected game fish species and monitor rough fish populations	Yes
		Chemical eradication of rough fish populations	No
		Consider conducting annual “carp out” event to reduce carp population in the Lake	Yes
		Enforce size and catch limit regulations	Yes
	Aquatic plant management	Conduct periodic aquatic plant reconnaissance surveys and update aquatic plant management plan every three to five years	Yes
		Limited use of aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife; consider coordinating timing of treatment to avoid flushing of chemicals from treatment area as a result of lake drawdowns in Big Muskego Lake	Yes[a]
		Mechanically harvest aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants	Yes[b]
		Manually harvest aquatic plants from around docks and piers where feasible	Yes
		Employ biological controls using inocula of Eurasian water milfoil weevils	No
		Consider using biological controls for management of purple loosestrife on an as needed basis	Yes
		Use sediment covers to shade out aquatic plant growth around piers and docks	No
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	Yes

Table 31 (continued)

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Water Use	Recreational Use Management	Enforce boating regulations to maximize public safety; improve signage	Yes
		Develop time and/or space zone schemes to limit surface use conflicts	No
		Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	Yes
		Maintain navigational access, especially from public recreational boating access site(s) to main basin of Lake; maintain adequate depths for navigation as required, subject to WDNR permits	Yes
Ancillary Management Measures	Public Informational and Educational Programming	Conduct public informational programming and educational programming on aquatic plants, options for their management, and other topics of relevance to lake residents utilizing seminars and distribution of informational materials	Yes
		Support participation of schools in Project WET, Adopt-A-Lake, etc.	Yes
		Encourage methods of preventing unwanted intrusions of invasive biota at public recreational boat access	Yes

[a] *Limited areas when necessary for hydraulic improvement and navigational access.*

[b] *In areas where water depth, bottom substrate material, and dock/moored watercraft densities are within desirable limits to promote the effectiveness of this method of aquatic plant management.*

Source: SEWRPC.

Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR WIND LAKE

INTRODUCTION

This chapter presents a recommended management plan for Wind Lake. The plan is based upon inventories and analyses of land use and land and water management practices, pollution sources in the area tributary to Wind Lake, the physical and biological quality of the waters of the Lake, recreational use and population forecasts, and an evaluation of alternative lake management measures. The recommended plan sets forth means for: 1) providing water quality conditions suitable for full-body contact recreational use and the maintenance of healthy communities of warmwater fish and other aquatic life, 2) reducing the severity of existing or perceived problems which constrain or preclude desired water uses, 3) improving opportunities for water-based recreational activities, and, 4) protecting environmentally sensitive areas. The elements of the recommended plan were selected from among the alternatives described in Chapter VII, and evaluated on the basis of those feasible alternatives, set forth in Table 31 in Chapter VII of this report, that may be expected to best meet the foregoing lake management objectives.

Analyses of water quality and biological conditions indicate that the general condition of the water of Wind Lake is very good. There appear to be few impediments to water-based recreation, although access by recreational watercraft is limited in some portions of the Lake by water depths and growths of aquatic macrophytes. Nevertheless, based upon a review of the inventory findings and consideration of planned developments within the area tributary to the Lake, as set forth in the adopted regional land use plan,[1] measures will be required to continue to protect and maintain the high quality of the Lake for future lake users. Therefore, this plan sets forth recommendations for: land use management, including protecting environmentally sensitive lands, in the area tributary to Wind Lake; pollution abatement; water quality monitoring and improvement; aquatic plant and fisheries management; recreational water use; and informational programming. These measures complement and refine the tributary area land use controls and management measures recommended in the adopted regional water quality management plan[2] and the Racine County land and water resource management plan.[3]

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[1]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

[2]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume Three,* Recommended Plan*, June 1979; SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

[3]*SEWRPC Planning Report No. 259,* Racine County Land and Water Resource Management Plan: 2000-2004, *September 2000.*

The recommended management measures for Wind Lake are graphically summarized on Maps 23 and 24, and are listed in Table 32. The recommended plan measures are more fully described in the following paragraphs. The recommended management agency responsibilities for tributary area land management also are set forth in Table 32.

PAST AND PRESENT MANAGEMENT MEASURES

The initial lake management plan for Wind Lake set forth a comprehensive program of lake management measures recommended for application in Wind Lake and its tributary area.[4] These measures included both tributary area-based actions and in-lake actions, and included measures applicable to both Wind Lake and the upstream Big Muskego Lake. The recommended plan elements are summarized in Table 33. Since the publication of the initial plan, the watershed-based management measures were refined by the Wisconsin Department of Natural Resources (WDNR) priority watershed plan for the Muskego and Wind Lakes.[5] With respect to these recommended management measures, the Wind Lake Management District (WLMD) has executed a program of land and water resources management that has implemented many of the recommendations. This program of active lake management forms the foundation upon which the recommendations set forth in this Chapter are based.

Recommended Management Actions

Tributary Area Management Actions

The initial lake management plan for Wind Lake set forth four major recommended actions with respect to land management in the tributary area, as summarized in on Map 25 and Table 33. These measures included the implementation of best practices on both rural agricultural lands and urban lands, the management of construction site erosion, and the protection of high-value wildlife habitat. Rural nonpoint source pollution control measures recommended included the development of detailed farm plans with the assistance of the County land conservation departments in the drainage area, as well as implementation of nutrient management plans. Recommended urban management practices included implementation of stormwater management practices in the watershed, including grassed swales, wet detention basins, and urban good housekeeping practices. Implementation of the construction site best management practices set forth in the *Wisconsin Construction Site Best Management Practices Handbook* also was recommended. Finally, the plan recommended protection of the high-value wildlife habitat located adjacent to Wind Lake.

Wind Lake Lake Management Actions

The initial plan for Wind Lake included both in-lake management measures applicable to Wind Lake itself and to Big Muskego Lake. These will be discussed below *seriatim*. Several measures recommended for consideration by the Wind Lake community were designed to facilitate the application of recommended lake management measures in Big Muskego Lake, providing only indirect benefit to Wind Lake itself.

The recommended in-lake management measures applicable to Wind Lake included the conduct of a nutrient inactivation program, or so-called alum treatment, as a method of minimizing internal loading from the lake sediments, following the recommended program of watershed management summarized above. Continuing water quality sampling was also recommended as a means of tracking the implementation of the watershed-based and nutrient inactivation management measures.

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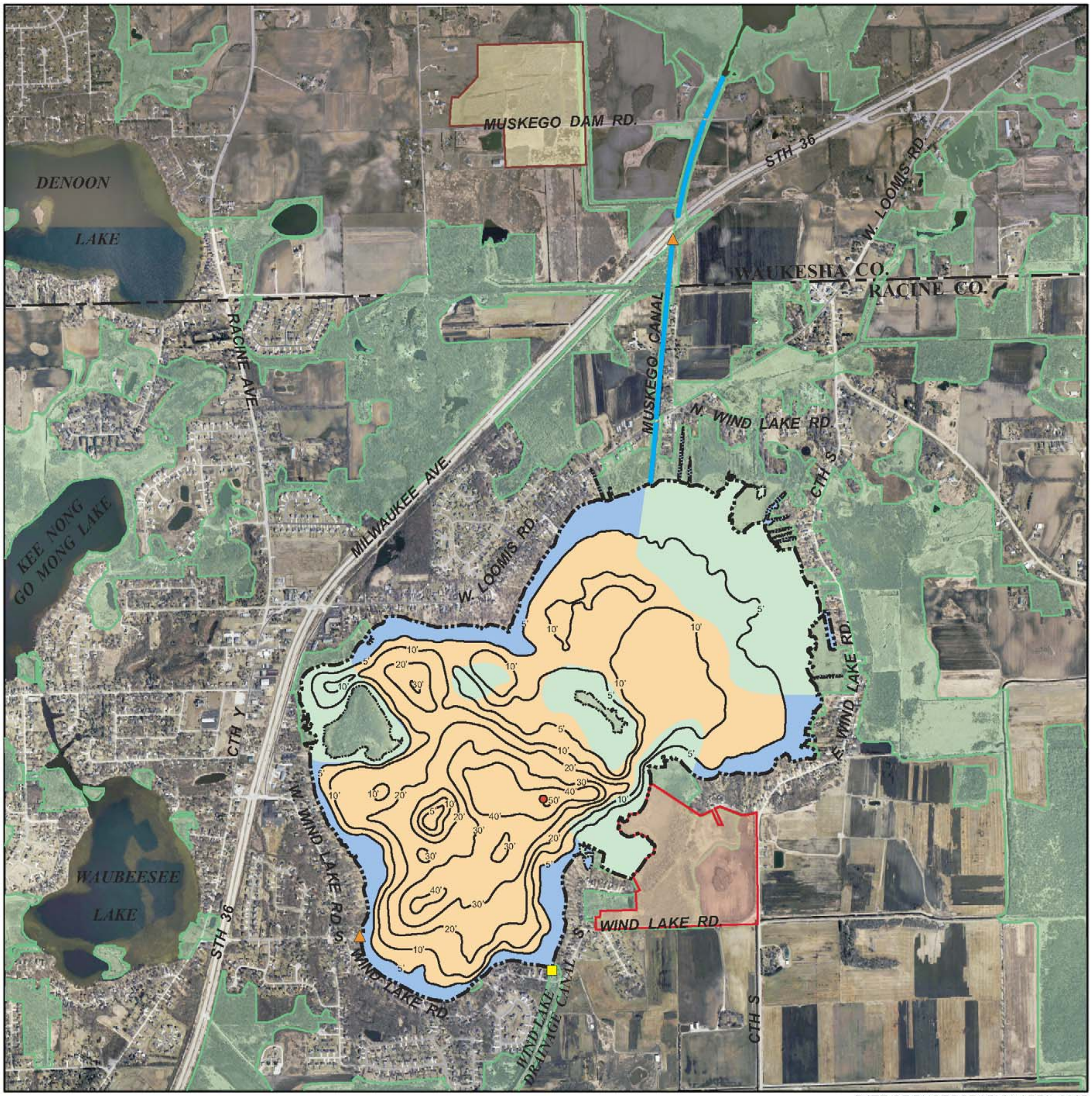
[4]*SEWRPC Community Assistance Planning Report No. 198,* A Management Plan for Wind Lake, Racine County, Wisconsin*, December 1991.*

[5]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-375-94,* Nonpoint Source Control Plan for the Muskego-Wind Lakes Priority Watershed Project*, October 1993.*

Map 23

RECOMMENDED MANAGEMENT PLAN FOR WIND LAKE: 2008



DATE OF PHOTOGRAPHY: APRIL 2005

— 20' — WATER DEPTH CONTOUR IN FEET

LAND USE MANAGEMENT

- PROTECT ENVIRONMENTALLY SENSITIVE LANDS
- OBSERVE WDNR SENSITIVE AREA GUIDELINES
- PUBLIC ACQUISITION OF WELCH PROPERTY FOR NATURE PRESERVE/CONSERVATION LAND
- WLMD PROPERTY TO SERVE AS POTENTIAL SETTLING BASIN

WATER QUALITY MANAGEMENT

- CONTINUE WATER QUALITY MONITORING
- MAINTAIN WATER LEVEL CONTROL STRUCTURE, CONTINUE LAKE LEVEL MONITORING
- MAINTAIN ADEQUATE PUBLIC RECREATIONAL BOATING ACCESS
- MAINTAIN ADEQUATE DEPTH FOR ACCESS
- CONTINUE PERIODIC NUTRIENT INACTIVATION BASED UPON MONITORING DATA

MANAGEMENT OF AQUATIC BIOTA

- CONTINUE MANAGEMENT OF NONMIGRATORY CANADIAN GEESE
- PROTECT/RESTORE FISH/SHORELINE HABITAT
- CONTROL NONNATIVE SPECIES: EURASIAN WATER MILFOIL, CURLY-LEAF PONDWEED, AND PURPLE LOOSESTRIFE; MAINTAIN NAVIGABILITY

WATER USE MANAGEMENT

- MAINTAIN ADEQUATE PUBLIC RECREATIONAL BOATING ACCESS
- CONTINUE TO ENFORCE BOATING REGULATIONS
- CONTINUE PUBLIC INFORMATIONAL PROGRAMMING

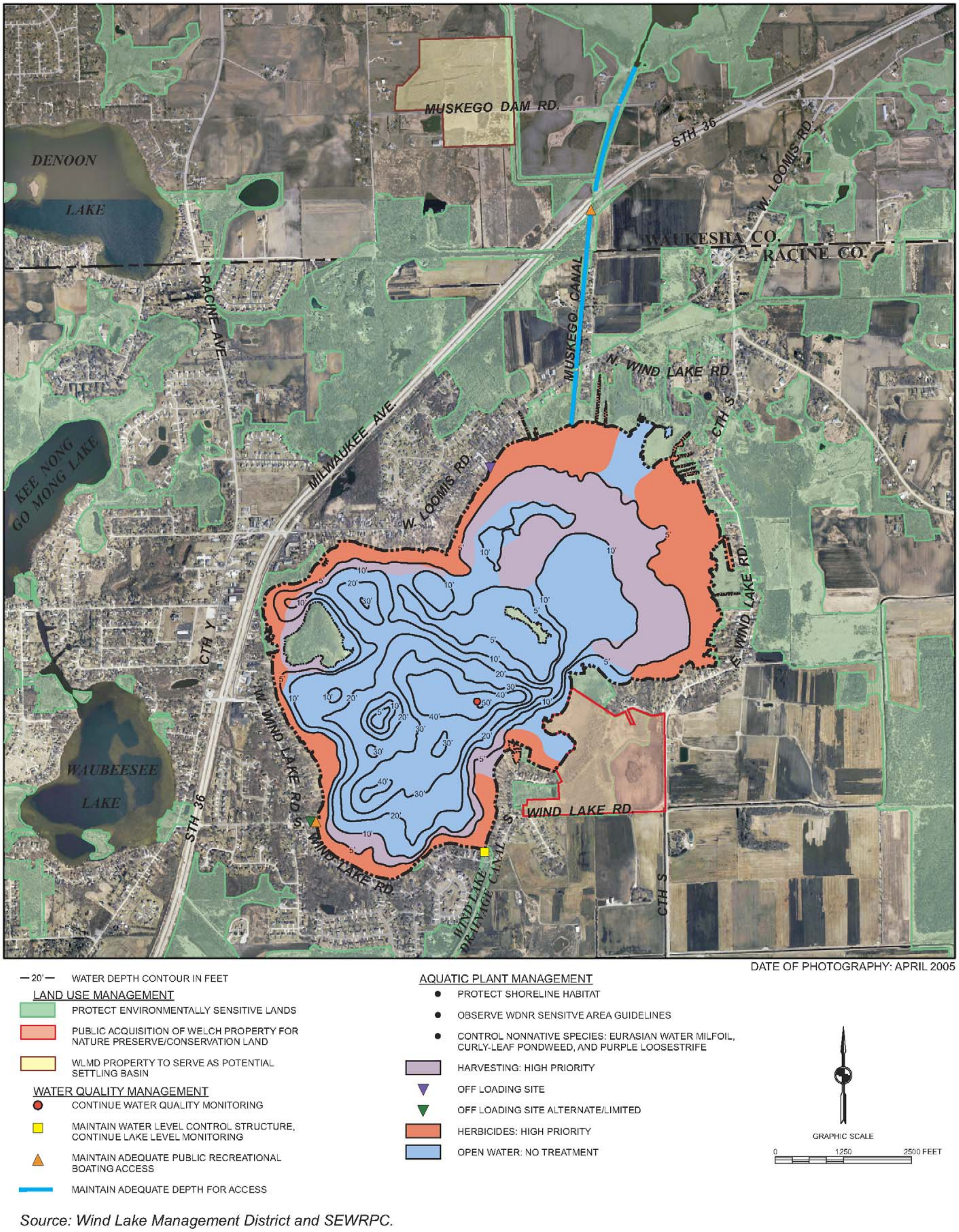
GRAPHIC SCALE

0 1250 2500 FEET

Source: Wind Lake Management District and SEWRPC.

Map 24

RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR WIND LAKE: 2008



Source: Wind Lake Management District and SEWRPC.

Table 32

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR WIND LAKE

Plan Element	Subelement	Management Measures	Management Responsibility
Land Use	Zoning	Observe guidelines set forth in the regional land use plan and Waukesha County development plan	Racine County, Waukesha County, City of New Berlin, City of Muskego, and Town of Norway
		Enforce adequate setbacks and promote environmentally friendly landscaping practices in shoreland areas	Racine County, Town of Norway, WDNR
		Maintain historic lake front residential dwelling densities to extent practicable	Town of Norway
	Stormwater Management	Develop and implement consistent stormwater management ordinances in all riparian communities; periodic review of stormwater ordinances	Town of Norway
		Restrict pollutant loading from stormwater discharges to the Lake through implementation of stormwater management practices	Racine County, Town of Norway, WDNR
		Install construction site erosion control measures as required by local ordinance; enforce construction site erosion control and stormwater ordinance provisions	Private landowners, Racine County, Town of Norway, WDNR
	Protection of Environmentally Sensitive Lands	Establish adequate protection of wetlands and shorelands, and other environmental corridor lands and isolated natural features, and consider public or private acquisition of features of local or greater significance, as set forth in the regional natural areas and critical species habitat protection and management plan	WDNR, Racine County, Town of Norway, Wind Lake Management District
	Land acquisition	Public acquisition of Welch property recommended in county park and open space plan be modified to retain property for permanent nature preserve/conservancy land	Racine County, Wind Lake Management District
		Continued acquisition and/or expansion of property (such as the property west of the Muskego Canal) is recommended to serve as a potential settling basin for flocculants mobilized by any future drawdown undertaken on Big Muskego Lake	Wind Lake Management District
Pollution Abatement	General Nonpoint Source Pollution Abatement	Implement regional water quality management plan and county land and water resource management plan recommendations within tributary area	Racine County, Town of Norway
	Rural Nonpoint Source Management	Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans in accordance with the county land and water resource management plans	USDA, WDATCP, Racine County, Waukesha County, Racine County Drainage Board
	Urban Nonpoint Source Management	Promote sound urban housekeeping and yard care practices through informational programming	Town of Norway, Racine County, Wind Lake Management District
		Consider development of lawn care management and shoreland protection ordinances	Town of Norway and Wind Lake Management District
	Developing Area Nonpoint Source Management	Enforce construction site erosion control and stormwater management ordinances; review ordinances for concurrency with proposed NR 152	Racine County, Waukesha County, City of New Berlin, City of Muskego, Town of Norway
		Use conservation subdivision designs and develop integrated stormwater management systems where appropriate densities exist	Racine County, Town of Norway

Table 32 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility
Point Source Pollution Control	Sewerage System Management	Implement refined regional water quality management plan recommendations to provide sanitary sewerage services to selected urban areas of the lake drainage area	City of New Berlin, City of Muskego, Town of Norway, Town of Norway Sanitary District No. 1, Milwaukee Metropolitan Sewerage District
		Implement onsite sewage disposal system management, including inspection and maintenance, in those portions of the watershed not served by public sanitary sewerage systems	Racine County, Waukesha County, private landowners
Water Quality	Water Quality Monitoring	Continue participation in U.S. Geological Survey TSI monitoring program	WDNR, USGS, Wind Lake Management District
	Water Quality Management	Monitor internal phosphorus loading and consider periodic aluminum sulfate (alum)/nutrient inactivation treatments as necessary	Wind Lake Management District
		Maintenance of navigation channels and public recreational boating access opportunities Consider selective dredging for hydraulic improvement and navigational access	WDNR, Wind Lake Management District
		Liaison with Big Muskego Lake/Bass Bay Protection and Rehabilitation District with respect to future drawdown and potential construction of a sedimentation basin to limit transport of suspended solids downstream	WDNR, Wind Lake Management District, BML-BBMD
	Hydrology	Maintain outlet structure and monitor water levels	WDNR, Racine County, Wind Lake Management District
		Maintain hydrologic capacity of inflow canal as necessary to one-percent-annual-probability; maintain navigability	WDNR, Racine County
Aquatic Biota	Nuisance Species Management	Continue to manage Canada goose population through USDAFWS depredation permit	USDA, Wind Lake Management District
	Fisheries Management	Protect fish habitat	Wind Lake Management District, WDNR, individuals
		Conduct periodic fish surveys to determine management and stocking needs; continue stocking; conduct periodic creel census; enforce size and catch limit regulations	WDNR
		Continue carp control measures to manage carp populations in the Lake; continue annual carp removal via private contract at Big Muskego Dam	Wind Lake Management District
		Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Racine County, Town of Norway, WDNR, private landowners
		Encourage shoreline restoration projects and creation of buffer strips, and promote consistency in application of landscaping practices in sensitive shoreland areas, through informational programming and demonstration sites	Private landowners, Racine County, Town Norway, Wind Lake Management District, WDNR, UWEX

Table 32 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility
Aquatic Biota (continued)	Aquatic Plant Management	Conduct periodic reconnaissance surveys of aquatic plant communities and update aquatic plant management plan every three to five years	WDNR, Wind Lake Management District
		Manually harvest around piers and docks as necessary[a]	Private landowners
		Mechanically harvest boating access lanes and fish cruising lanes as necessary	WDNR, Wind Lake Management District
		Focused use of aquatic herbicides for control of nuisance aquatic plant growth where necessary; specifically target Eurasian water milfoil[b]	WDNR, Wind Lake Management District
		Limited use of aquatic herbicides for control of invasive plant growth where necessary; specifically purple loosestrife infestations[b]	WDNR, Wind Lake Management District, private landowners
		Use purple loosestrife beetles and weevils to control purple loosestrife infestations as appropriate	Wind Lake Management District, private landowners
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lake	Private landowners
Water Use	Recreational Use Management	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	WDNR
		Maintain navigational access, especially from public recreational boating access site(s) to main basin of Lake; maintain adequate depths for navigation as required, subject to WDNR permits	WDNR, Wind Lake Management District
		Continue to enforce and periodically review, recreational boating (summer) and vehicular use (winter) ordinances	Town of Norway, Wind Lake Management District, WDNR
Ancillary Measures	Public Informational and Educational Programming	Continue public awareness and informational programming	Racine County, Waukesha County, City of New Berlin, City of Muskego, Town of Norway, Wind Lake Management District, WDNR, UWEX
		Encourage inclusion of lake studies in environmental curricula (e.g., Project WET, Adopt-A-Lake)	Muskego-Norway School District, Waterford Union High School, UWEX, WDNR, Wind Lake Management District

[a]*Manual harvesting beyond a 30 linear foot width of shoreline harvesting is subject to WDNR permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code*. Mechanical harvesting could be considered by the Wind Lake Management District should the area of aquatic plant growth warrant the possible use of larger-scale aquatic plant management measures. Such a determination should be based upon the conduct of future aquatic plant surveys; use of mechanical harvesting is subject to WDNR permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code*.*

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

Source: SEWRPC.

Table 33

IMPLEMENTATION STATUS OF INITIAL MANAGEMENT PLAN ELEMENTS FOR WIND LAKE: 1990-2007

Plan Element	Subelement	Management Measures	Management Responsibility	Implementation Status: 2007
Tributary Area Management	Rural Land Management	Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans, particularly from the sod farms in the watershed	WDNR, local units of government, local residents	Ongoing: supported by Waukesha and Racine Counties Land and Water Resource Management Plan Implementation
	Urban Land Management	Promote sound urban housekeeping and yard care practices through informational programming	WDNR, Town of Norway, City of Muskego, local residents	Ongoing: supported by Wind Lake Management District newsletter articles
	Construction Site Erosion Control	Enforce construction site erosion control and stormwater management ordinances, implement practices recommended by the Wisconsin League of Municipalities and WDNR	Private firms and individuals	Ongoing: enforced by local units of government
	Wildlife Habitat Management	Protect high-value wildlife habitat within the tributary area; enhance migratory waterfowl habitat; manage wetland vegetation to minimize purple loosestrife infestations	WDNR, Wind Lake Management District	Ongoing: Wind Lake Management District has acquired key parcels along the Muskego Canal
In-Lake Management	Fisheries Management	Protect fish habitat; conduct periodic fish surveys to determine management and stocking needs; continue stocking; conduct periodic creel census; enforce size and catch limit regulations	WDNR, USEPA	Ongoing: implemented by WDNR fisheries management staff
	Nutrient Inactivation	Conduct alum treatment of Wind Lake	WDNR, USEPA	Completed: 1997
	Dredging	Deepen selected areas of the Lake: East Channel, Breezy Bay Channel, Wood Island, and WDNR Boat Launch site	Local residents	Pending
	Water Quality Monitoring	Continue water quality monitoring program	Wind Lake Management District, USGS	Ongoing: implemented by the Wind Lake Management District through the UWEX Citizen Lake Monitoring Network
	Aquatic Plant Management	Implement aquatic plant management program on 9.7 acres: mechanically harvest 10-foot-wide by five-foot-deep channels at 300-foot intervals outside of ecologically valuable habitat areas; harvest three channels 300-feet-wide and five-feet-deep in the northeastern area of the Lake and one channel west of Wood Island; conduct a comprehensive macrophyte survey	Private landowners, Wind Lake Management District	Ongoing: implemented annually by the Wind Lake Management District utilizing harvesting and herbicide applications
	Shoreline Protection	Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits; encourage shoreline restoration projects	Local residents	As necessary
	Public Informational and Educational Programming	Conduct public awareness and informational programming	Wind Lake Management District, WDNR, and UWEX	Ongoing: included in Wind Lake Management District meetings; the District publishes a periodic newsletter—the *Wind Lake Management District News*—and maintains a website: www.wlmd.org

Table 33 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility	Implementation Status: 2007
Big Muskego Lake	Drawdown	Prepare engineering plans for the conduct of a drawdown of Big Muskego Lake, including channel improvements in the Muskego Canal	Wind Lake Management District, Big Muskego Lake Protection and Rehabilitation District, USEPA	Completed: 1994-1995
	Dam Operations and Water Level Monitoring	Conduct a drawdown of Big Muskego Lake to consolidate sediments and allow lake shore debris clean up	Wind Lake Management District, Big Muskego Lake Protection and Rehabilitation District, USEPA	Completed: 1995-1996
	Muskego Canal and Wind Lake Inlet Dredging	Enhance hydraulic integrity of the Muskego-Wind Lake Canal system to minimize flooding risk to Wind Lake	Big Muskego Lake Protection and Rehabilitation District, USEPA	Completed: 1993 Restored following Big Muskego Lake drawdown: 1996
	Lake Water Pumping and Draining	Conduct an over-winter drawdown of Big Muskego Lake; allow one year for sediment compaction and drying prior to refilling	USEPA	Completed: 1995-1996
	Wildlife Management	Conduct fish eradication during fall following drawdown; manage emergent vegetation to enhance wildlife habitat	WDNR	Completed: 1996

Source: SEWRPC.

With respect to the biological systems of Wind Lake, periodic fisheries surveys were recommended to be conducted by the WDNR. These surveys were recommended to form the basis for ongoing stocking by the WDNR. In addition, implementation of a program of aquatic plant management based upon selective harvesting of aquatic plants as shown on Map 25 was recommended. This mechanical harvesting-based aquatic plant management program would create access channels at key locations around the Lake, while preserving important aquatic plant and animal habitat. Ongoing monitoring of the aquatic plant community was also recommended. Supplementing these actions, implementation of a program of vegetation-based shoreline maintenance was recommended. Included in this recommendation was the maintenance of existing shoreline protection structures, and their replacement as appropriate with vegetative protection measures. All of these actions were intended to protect and preserve important in-lake habitat.

Lastly, the initial plan recommended continued provision of recreational boating access to the Lake, through limited dredging of the East Channel, Breezy Bay, WDNR public recreational boating access site, Wood Island channel, and Muskego Canal, including the Wind Lake inlet, this latter being designed to facilitate the drawdown of the upstream Big Muskego Lake.

Big Muskego Lake Lake Management Actions

The initial plan recommended interventions within the drainage area tributary to Big Muskego Lake that would complement the watershed-based management measures recommended for Wind Lake. These recommendations specifically included, among others, the implementation of nonpoint source pollution control measures in the drainage area tributary to Big Muskego Lake. Nutrient management practices applied to Big Muskego Lake were expected to contribute to the reduction in nutrient loads to Wind Lake, and hence to the rehabilitation of Wind Lake in addition to the direct benefits to Big Muskego Lake. These latter benefits were expected to be achieved through the drawdown of Big Muskego Lake, consolidation of the flocculent sediments in that lake basin, and the establishment of aquatic vegetation in the basin.

Status of Lake Management Plan Implementation

As of the 2007, the recommended lake management measures set forth in the initial lake management plan for Wind Lake have been largely implemented by the WLMD and its partner agencies, including the WDNR, City of

Map 25

RECOMMENDED LAKE MANAGEMENT PLAN FOR WIND LAKE: 1990-2010

LEGEND

WATER QUALITY

NUTRIENT INACTIVATION FOR WATER DEPTHS GREATER THAN 15 FEET

ENVIRONMENTAL PROTECTION

VALUABLE AQUATIC HABITAT AREA
SLOW NO-WAKE BOATING ONLY
LIMIT DREDGING TO AREA FOR BOAT ACCESS

ADJACENT WETLAND AND WILDLIFE HABITAT AREA
MAINTAIN AND ENHANCE

AQUATIC PLANT MANAGEMENT

MECHANICALLY HARVEST TEN FEET WIDE AND FIVE FEET DEEP CHANNELS AT 300-FOOT INTERVALS OUTSIDE OF VALUABLE HABITAT AREA

MECHANICALLY HARVEST THREE CHANNELS, THIRTY FEET WIDE AND FIVE FEET DEEP WITHIN THE NORTHEASTERN VALUABLE AQUATIC HABITAT AREA AND ONE CHANNEL WEST OF WOOD ISLAND WITHIN THE VALUBLE AQUATIC HABITAT AREA

SHORELINE PROTECTION

REVEGETATE UNSTABLE UNPROTECTED SHORELINE WITHIN THE VALUABLE AQUATIC HABITAT AREA

PROTECT UNSTABLE UNPROTECTED SHORELINE OUTSIDE OF VALUABLE AQUATIC HABITAT AREAS; USE VEGETATION FOR 75% AND RIPRAP REVETMENTS OR BEACHES FOR 25%

RECONSTRUCT EXISTING STRUCTURES IN NEED OF REPAIR WHICH LIE OUTSIDE VALUABLE AQUATIC HABITAT AREAS

BOATING ACCESS

SLOW NO-WAKE BOATING ONLY

DREDGE EAST CHANNEL, DNR BOAT LAUNCH, BREEZY BAY AND WOOD ISLAND CHANNEL TO IMPROVE BOATING ACCESS

DREDGE MUSKEGO CANAL AND THE WIND LAKE INLET TO IMPROVE BOATING ACCESS, TO INCREASE THE HYDRAULIC CAPACITY OF THE CANAL, AND TO INSURE THAT THE DRAWDOWN OF BIG MUSKEGO LAKE BE COMPLETED BETWEEN OCTOBER AND MID-JANUARY

Source: SEWRPC.

Muskego, and Big Muskego Lake/Bass Bay Protection and Rehabilitation District (BML-BBMD). The WLMD completed the Muskego Canal channel improvements, as recommended in the initial lake management plan, during 1993. This allowed the drawdown of Big Muskego Lake to proceed as recommended during 1995. While the WDNR attempted to create a stilling basin on the upstream side of the dam at the Big Muskego Lake outlet, the need to pump water from Big Muskego Lake into the Muskego Canal resulted in a significant quantity of flocculent sediment being discharged to the Canal, effectively negating the potential benefits created through the 1993 hydraulic improvements. This led to a redredging of the Muskego Canal during 1996 to restore the Canal to its post-1993 design depth. Although the WDNR prevailed upon the City of Muskego to conduct the 1996 redredging, the WDNR provided much of the finance required, although the WLMD noted that, as a result of the City selecting an inexperienced contractor, considerable additional investment was required from the District, to the value of approximately $75,000 in direct costs and more than $10,000 in labor cost equivalent—the WLMD noted that these costs represented more than 2,000 hours of staff time, engineering and legal costs, and costs of professional services associated with the restoration of the Muskego Canal.[6] Based upon this experience, the WLMD has strongly recommended the inclusion of a sedimentation basin in the City of Muskego Big Muskego Lake and Bass Bay lake management plan as a basis for intercepting flocculent sediments mobilized through any future drawdown undertaken of the upstream waterbody.[7] It is recommended that the City of Big Muskego and BML-BBMD liaison with the WLMD with respect to any future drawdown and potential construction of a sedimentation basin to limit transport of suspended solids downstream.

The WLMD also undertook a major alum treatment of Wind Lake itself during spring 1997. This treatment was undertaken across all areas of Wind Lake deeper than about five feet, at a cost to the District of approximately $160,000. Approximately 200,000 gallons of liquid alum (aluminium sulphate) were applied to these two areas of the Lake. The design life of this application is between six and eight years.

Finally, the WLMD has supported the implementation of land-based management measures set forth in the adopted lake management plan and the priority watershed plan.[8] These actions have included the acquisition of 80 acres of land within the drainage area tributary to the west of the Muskego Canal, and the protection of habitat areas in the Lake through expanded slow-no-wake areas, demarcated by buoys, and supported by a Town of Norway ordinance, set forth in Appendix B. Continued acquisition and/or expansion of property, such as the property west of the Muskego Canal as shown on Map 23, is recommended in order to serve as a potential settling basin for flocculants mobilized by any future drawdown undertaken on Big Muskego Lake.

With respect to the Big Muskego Lake management planning elements set forth in the initial lake management plan for Wind Lake, the residents of the BML-BBMD, during March 1994, supported the implementation of a lake restoration plan that included both a 12-month drawdown and a total renovation of the Big Muskego Lake fishery. The stated objectives of the drawdown were to: 1) facilitate rough fish eradication, 2) oxidize and compact organic materials in the Lake sediment, thereby increasing the depth of Big Muskego Lake by an average of about one foot compaction, 3) improve habitat for desirable aquatic plants, fish, and invertebrates as well as wildlife, including endangered and threatened species, and 4) provide favorable conditions for shoreline improvements including the reduction in extent of the existing cattail stands in the Lake basin. By the time the project was completed and the lake refilled in early 1997, the lake management actions implemented included: 1) an 18-month drawdown initiated in September 1995 and achieved through the installation of two pumps rated at 26.8 cubic feet per second (cfs) discharge, 2) dredging of a channel leading to outlet and deepening of the former river bed upstream of the dam with explosives to facilitate drawdown, and redredging of the Muskego Canal, 3) elimination of the pre-existing fish community beginning in October 1996, targeting carp and using the piscicide

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[6]*Memorandum to Mr. Thomas Zagar of the City of Muskego from Ms. Kathy Aron, Executive Director of the WLMD, dated March 26, 2004, regarding the then draft Big Muskego/Bass Bay Lake Management Plan.*

[7]*City of Muskego,* Big Muskego Lake and Bass Bay Management Plan*, June 2004.*

[8]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-375-94,* op. cit.

rotenone, and restocking of zooplankton, amphibians, and fishes, 4) implementation of more restrictive fishing regulations to protect the restocked fishes, 5) conduct of a controlled burn to limit the extent of the cattails and the chemical and biological control of Eurasian water milfoil and purple loosestrife to improve habitat, 6) reconstruction of the outlet control structure, repair of the southern dike, and construction of an electric fish barrier at the outlet of Big Muskego Lake, 7) construction of three waterfowl nesting islands, the construction of osprey nesting platforms and introduction of osprey, 8) the implementation of nonpoint source pollution abatement practices in the area tributary to the Lake and conduct of an alum treatment in Bass Bay, and 9) provision of a public recreational boating facility on Big Muskego Lake commensurate with the standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*.[9]

Current interventions within the area tributary to Big Muskego Lake and the Lake itself are set forth in the adopted lake management plan for Big Muskego Lake and Bass Bay.[10] The principal recommendations set forth in this plan include both structural measures such as detention ponds, streambank buffer strips, and maintenance of stormwater conveyance systems, and nonstructural measures such as improved tillage methods and good housekeeping practices implemented by individual homeowners. In-lake management measures would be designed to maintain Big Muskego Lake in an aquatic macrophyte-dominated state—versus an algal dominate state—through periodic drawdowns; application of biological manipulation practices such as periodic carp removal, fish stocking, and habitat management, including control of cattail growths and nonnative species occurrences; and, ongoing aquatic plant management practices utilizing chemical control techniques in targeted areas of the Lake.

The implementation of the adopted lake management plan for Big Muskego Lake contains elements identified by the WLMD Board of Commissioners as having implications for lake management strategies in the downstream waterbody.

CURRENT RECOMMENDATIONS FOR TRIBUTARY AREA MANAGEMENT MEASURES

Land Use Control and Management

A fundamental element of a sound management plan and program for Wind Lake is the promotion of a sound land use pattern within the area tributary to the Lake. The type and location of rural and urban land uses in the tributary area will determine, to a considerable 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, ultimately, the water quality of the Lake.

The recommended land use plan for the area tributary to Wind Lake under buildout conditions is described in Chapter II. The framework for the plan is the regional land use plan as prepared and adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), as refined through the aforereferenced regional land use plan. The recommended land use plan envisions that urban land use development within the area tributary to Wind Lake will occur primarily at low densities and only in areas which are covered by soils suitable for the intended use; which are not subject to special hazards, such as flooding, and which are not environmentally sensitive, that is, not encompassed within the Regional Planning Commission-delineated environmental corridors described in Chapter V.

Development in the Shoreland Zone

A major land use issue which has the potential to affect Wind Lake is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density, multi-family dwellings with potential for increased roof areas, parking areas, and other areas of impervious surfaces. Replacement of a pervious land surface with an

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[9]*See SEWRPC Memorandum Report No. 94,* A Recommended Public Boating Access and Waterway Protection Plan for Big Muskego Lake, Waukesha County, Wisconsin*, July 1994.*

[10]*City of Muskego,* op. cit.

impervious surface will increase the rate of stormwater runoff to the Lake, increase pollutant loadings on the Lake, and will reduce groundwater recharge. While these effects can be moderated to some extent through structural stormwater management measures, there is likely to be an adverse impact on the Lake from significant redevelopment in the area tributary to the Lake involving conversion to higher-density land uses. For this reason, maintenance of the historic, low- and medium-density residential character of the shoreline of Wind Lake to the maximum extent practical is recommended.

It is further recommended that lakefront developments, as well as setback and landscaping provisions, be carefully reviewed by the Town of Norway and the Wisconsin Department of Natural Resources (WDNR). Such review would address specific shoreland zoning requirements, and could consider the stormwater and urban nonpoint source pollution abatement practices proposed to be included in shoreland development activities. Provision for shoreland buffers, use of appropriate and environmentally friendly landscaping practices, and inclusion of stormwater management measures that provide water quality benefits are practices to be encouraged.

Development in the Tributary Area

Another land use issue which has the potential to affect the lake is the potential development for urban uses of the agricultural and other open space lands in the tributary area. As previously noted, large-lot residential development is occurring in areas of the lake tributary area in which such development was not envisioned in the adopted regional land use plan. If this trend continues, much of the open space areas remaining in the tributary area will be replaced over time with large-lot urban development. This may significantly increase the pollutant loadings to the lake and increase the pressures for recreational use of the lake. Under the full buildout conditions envisioned under the adopted regional land use plan, a significant portion of the undeveloped lands outside of the environmental corridors and other environmentally sensitive areas, could potentially be developed for low-density urban uses.

The existing zoning in the tributary area basin permits development, generally on large, suburban-density lots, over much of the remaining open lands other than the environmental corridors. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes. It is recommended that the impact of future land use development on Wind Lake be minimized through review and modification of the applicable zoning ordinance regulations and zoning district maps to address the concerns noted. Changes in zoning ordinances are recommended to minimize the areal extent of development by providing specific provisions and incentives for the clustering of residential development on smaller lots within conservation subdivisions, thus preserving significant portions of the open space within each property or group of properties considered for development.

Stormwater Management

It is recommended that the Town of Norway take an active role in promoting urban nonpoint source pollution abatement. Actions to promote urban nonpoint source pollution abatement would include the conduct of specific stormwater management planning within specific portions of the tributary area located within each municipality where further urban development or redevelopment is anticipated. Such a planning program should include a review of the stormwater management ordinances, to ensure that the ordinance provisions reflect state-of-the-art runoff and water quality management requirements, and to ensure that there is harmony between the ordinances governing urban-density development in each of the municipalities draining to Wind Lake. Adoption by all riparian municipalities of common stormwater management ordinance provisions is strongly recommended.

Management of Environmentally Sensitive Lands

Wetland, woodland, and groundwater recharge area protection can be accomplished through land use regulation and public land acquisition of critical lands. Both measures are recommended for the area tributary to Wind Lake.[11] The wetland areas within the area tributary to the Lake are currently largely protected through the existing

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

regulatory framework provided by the U.S. Army Corps of Engineers permit program, State shoreland zoning requirements, and local zoning ordinances. Nearly all wetland areas in the Wind Lake tributary area are included in the environmental corridors delineated by the Regional Planning Commission and protected under one or more of the existing Federal, State, County, and local regulations. Consistent and effective application of the provisions of these regulations is recommended. Public acquisition of the Welch property as shown on Map 23 for proposed park or open space use is recommended in the Racine County Park and Open Space Plan,[12] however, it is recommended such acquisition be modified to retain the property for permanent nature/conservancy land.

Nonpoint Source Pollution Control

The recommended tributary area land management measures are specifically aimed at reducing the water quality impacts on Wind Lake of nonpoint sources of pollution within the tributary area. These measures are set forth in the aforereferenced regional water quality management plan and the Racine County land and water resource management plan. As indicated in the lake and tributary area inventory, the only significant sources of phosphorus loading to the Lake that are subject to potential controls are rural and urban nonpoint sources. The remaining onsite sewage disposal systems in the tributary area are not considered to be a significant nutrient source to Wind Lake; however these systems should be inspected and maintained on a regular basis. All of the lakeshore areas tributary to Wind Lake are served by public sanitary sewerage systems.

Nonpoint source control measures should be considered for the areas tributary to Wind Lake. The regional water quality management plan recommended a reduction of about 50 percent in urban, and of up to 75 percent in rural, nonpoint source pollutants, plus streambank erosion control, construction site erosion control, and onsite sewage disposal system management be achieved in the area tributary to Wind Lake.

Nonpoint source pollution abatement controls in the tributary area are recommended to be achieved through a combination of rural agricultural nonpoint controls, urban stormwater management, and construction erosion controls. The implementation of the land management practices described below may be expected to result in a reduction in nonpoint-source pollutants that is considered to be the maximum practicable given the findings of the inventories and analyses compiled during the planning effort. These measures are consistent with the recommended measures set forth in the Racine County land and water resource management plan.

Rural Nonpoint Source Pollution Controls

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the Town of Norway, Racine County, and private landowners. Technical assistance can be provided by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS); the Wisconsin Department of Agriculture, Trade and Consumer Protection; and the Racine County Department of Public Works. As discussed previously, it is recommended that the Town of Norway, in coordination with the WDNR, Racine County, and the local units of government involved, develop a strategy to address nonpoint source pollution. State and Federal soil erosion control and water quality management programs, individually or in combination, can be used to achieve pollutant reduction goals. Such programs include the USDA Environmental Quality Incentive Program (EQIP), the WDNR runoff management and lake protection programs, and various local land acquisition initiatives.

Highly localized, detailed, and site-specific measures are required to effectively reduce soil loss and contaminant runoff in rural areas. These measures are best defined and implemented at the local level through the preparation of detailed farm conservation plans. Practices which are considered most applicable within the area tributary to Wind Lake include conservation tillage, integrated nutrient and pesticide management, and pasture management. In addition, it is recommended consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics for each farm. A reduction of about 25 percent in the nonpoint source loading from rural lands could provide up to about a 15 percent reduction in total phosphorus

[12]*SEWRPC Community Assistance Planning Report No. 141,* A Park and Open Space Plan for Racine County*, September 1988, amended July 2001.*

loading to Wind Lake. Implementation of the recommendations and work planning activities set forth in the Racine County land and water resource management plan would constitute a major step toward implementation of these lake management recommendations.

The cost of the needed measures will vary depending upon the details of the recommended farm conservation plans. These costs may be expected to be incurred to a large extent for purposes of agricultural land erosion control in any case. As noted above, with the promulgation of Chapters NR 153 and NR 154 of the *Wisconsin Administrative Code*, which became effective during October 2003, cost-share funding may be available to encourage installation of appropriate land management measures. Likewise, cost-share funding may be available under the Chapter NR 120 nonpoint source pollution abatement program for the repair and maintenance of those management measures installed pursuant to the priority watershed plan.[13]

Urban Nonpoint Source Pollution Controls

The development of urban nonpoint source pollution abatement measures for the Wind Lake areas should be the primary responsibility of the Town of Norway. In addition to the adoption of stormwater management ordinances, the most viable measures to control urban nonpoint sources of pollution appear to be good urban land management and urban housekeeping practices. Such practices consist of fertilizer and pesticide use management, litter and pet waste controls, and management of leaf litter and yard waste. The promotion of these measures requires an ongoing public informational program. It is recommended that the WLMD, in cooperation with the Town, take the lead in sponsoring such programming for the Wind Lake community through regular public informational meetings and mailings. The District should also ensure that relevant literature, available through the University of Wisconsin-Extension (UWEX) and the WDNR, is made available at these meetings and at the local public library and government offices.

As an initial step in carrying out the recommended urban practices, it is recommended that a fact sheet identifying specific residential land management measures beneficial to the water quality of Wind Lake be prepared and distributed to property owners. This fact sheet could be distributed by the Town of Norway, with the assistance of the UWEX and Racine County Department of Public Works/Parks offices. The recommended measures may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff and up to about a 5 percent reduction in total phosphorus loadings to the Lake.

Developing Areas and Construction Site Erosion Control

It is recommended that Racine County and the Town of Norway continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter III, the Town of Norway has not yet adopted construction erosion control ordinances, but these regulations are part of other ordinances. Enforcement of the ordinances is generally considered effective. The provisions of these ordinances apply to all development except single- and two-family residential construction. The single- and two-family construction erosion control is to be carried out as part of the building permit process.

Construction site erosion controls may include the use of silt fences, sedimentation basins, rapid revegetation of disturbed areas; the control of “tracking” from the site; and careful planning of the construction sequence to minimize the areas disturbed. Construction site erosion control is particularly important in minimizing the more severe localized short-term nutrient and sediment loadings to Wind Lake that can result from uncontrolled construction sites. Consideration should be given to incorporating construction site erosion control measures into a formal stormwater management system serving larger developments following construction.

Construction site erosion control measures may be expected to reduce the phosphorus loading from that source by about 75 percent. Because of the potential for development in the tributary area to Wind Lake, it is important that adequate construction erosion control programs remain in place.

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[13] *Wisconsin Department of Natural Resources Publication PUBL-WR-375-94,* Nonpoint Source Control Plan for the Muskego-Wind Lakes Priority Watershed Project, *October 1993.*

The cost for construction site erosion control will vary depending upon the amount of land under construction at any given time. Typical costs are $250 to $500 per acre under development.

Onsite and Public Sewage Disposal System Management

The lakeshore areas and areas tributary to Wind Lake are served primarily by public sanitary sewerage systems. The relatively few onsite systems have been estimated to contribute less than 1 percent of the total phosphorus load to the Lake. Current County ordinance provisions requiring the regular inspection and maintenance of onsite sewage disposal systems should be enforced to minimize potential phosphorus loadings from this source. It also is recommended that Racine County, in cooperation with the Town of Norway, assume the lead in providing the public informational and educational programs to encourage affected property owners to have existing onsite systems inspected and any needed remedial measures undertaken, as appropriate. Homeowners should be advised of the rules and regulations governing, and the limitations of onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs, especially of those older systems not yet subject to the inspection requirements of the County ordinance.

Typical costs for a basic inspection and maintenance service range from about $100 to $200 per year, although more extensive programs could be more expensive. The costs of the informational programming typically have been included within the operating budget of the County.

For those portions of the area tributary to Wind Lake served by public sanitary sewerage systems, it is recommended that the Town of Norway Sanitary District No. 1 and the Milwaukee Metropolitan Sewage District (MMSD) assume the lead in providing public informational and educational programs to encourage affected property owners to use their respective sewerage systems appropriately and wisely. In an analogous recommendation, the WLMD, in cooperation with the Fox River Partnership and other civic conservation groups, should support the stenciling of storm drains and related informational programming that encourage Lake Management District residents to dispose of waste products safely, avoiding discharge directly to the surface waters or indirectly through the wastewater treatment works to the environment. To this end, collaboration between the various governmental entities and public information campaigns such as anti-littering programs is recommended, as noted below.

CURRENT RECOMMENDATIONS FOR IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for Wind Lake are summarized in Table 32 and are graphically summarized on Maps 23 and 24. The major recommendations include: water quality monitoring, fisheries management and habitat protection, nonpoint source pollution abatement, shoreland protection, aquatic plant management, recreational use management, and informational and educational programming.

Surface Water Quality Management

Continued water quality monitoring of Wind Lake is recommended. Lake sampling protocol conducted under the current U.S. Geological Survey (USGS) regimen is recommended with various water quality parameters being measured several times a year at a central station in the deepest portion of the lake basin. It is also recommended that consideration be given to enrollment in programs such as the volunteer WDNR Self-Help expanded trophic status index (TSI) Self-Help Monitoring Program operated as the Citizen Lake Monitoring Program by UWEX, or the University of Wisconsin-Stevens Point Water and Environmental Analysis Laboratory (WEAL) lake monitoring program.

Phosphorus Precipitation and Inactivation

Nutrient inactivation is a restoration measure that is designed to limit the biological availability of phosphorus by chemically binding the element in the lake sediments using a variety of divalent or trivalent cations, highly positively charged elements. Aluminum sulfate (alum), ferric chloride, and ferric sulfate are commonly used cation sources. Nutrient inactivation through this method was employed in 1997 with an anticipated duration of effectiveness to be about seven years. Based upon an evaluation of the nutrient levels in Wind Lake conducted during the present planning program, consideration of a further nutrient inactivation treatment appears warranted. Application of aluminum sulfate in the deeper water areas of Wind Lake, as was carried out during 1998, is recommended.

Water Quantity and Lake Level Management

As indicated in the lake and tributary area inventory, outflow from Wind Lake is controlled by a dam located on the southeastern end of the Lake. Lake level is a major concern among lake users, since fluctuations in lake levels can present various problems. The placement of shore protection could be more or less effective, depending upon the magnitude and frequency of variations in water levels. These variations also affect fish and aquatic life habitat availability, with extreme fluctuations potentially being disadvantageous to mollusks and other less mobile life forms. It is recommended that the dam be regularly inspected for proper operation and that the lake levels be monitored.

Additionally, selected areas of Wind Lake were dredged in 1993. These areas were identified by the WLMD and included areas where excessive sediment deposition had occurred, areas which supported abundant aquatic plant growth which obstructed recreational boating access, and areas which were too shallow for safe navigation. Commission staff conducted a sediment depth survey in 2005, the results of which are shown on Map 26. It is recommended that consideration be given to selective dredging for hydraulic improvement and navigational access.

Nuisance Species Management

Wind Lake has been the site of a USDA Fish and Wildlife Services-sponsored program to manage nuisance levels of Canada geese on Wind Lake. Continuation of this program, on an as needed basis, is recommended. A depredation permit issued by the USDA Fish and Wildlife Services is required to conduct these activities. It is further recommended that the WLMD continue to monitor the Lake for nonnative invasive species and take action as may be appropriate. Monitoring for the occurrence of new species of concern should be undertaken as necessary.

Fisheries Management

A baseline fishery survey, consisting of mini fyke nets and electrofishing, was conducted by the WDNR in 2006. This survey had the following objectives:

1. To identify changes in fish species composition that may have taken place in the Lake since the previous surveys;

2. To permit any changes in fish populations, species composition and condition factors to be related to such known interventions as stocking programs, water pollution control activities, and aquatic plant management programs;

3. To refine and update information on fish spawning areas, breeding success, and survival rates;

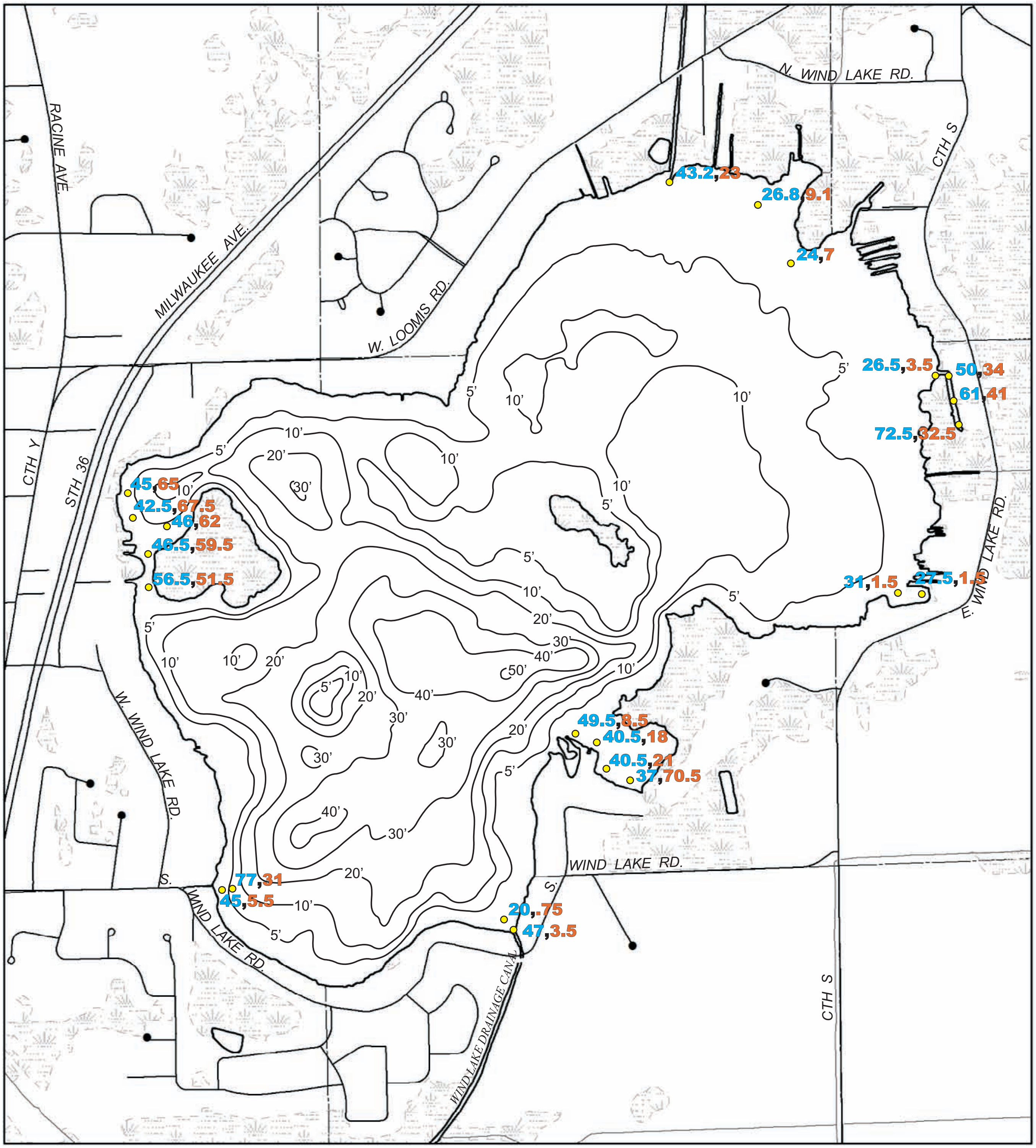
4. To confirm the lack of disturbance by roughfish populations and inform management measures, such as the annual carp removal program initiated during 2000; and,

5. To determine the need for, and inform the timing of, any additional stocking of northern pike, walleyed pike, and/or other gamefish species, as appropriate, by the WDNR, in order to maintain a continuing, viable sportfishery.

These actions should provide a sound basis for the District and the WDNR to develop a stocking program and to revise, as may be found necessary, the current fishing regulations regarding the size and number of fish to be taken seasonally. Should roughfish population increases be shown to warrant intervention, continued application of carp control measures is recommended. Periodic fisheries surveys should continue to be conducted in the Lake, and mangement programs implemented, as indicated.

Map 26

SEDIMENT SAMPLING SITES IN WIND LAKE: 2005



— 20' — WATER DEPTH CONTOUR IN FEET

SEDIMENT SAMPLING SITE

61 WATER DEPTH IN INCHES

41 SEDIMENT DEPTH IN INCHES

Source: SEWRPC.

GRAPHIC SCALE

0 750 1500 FEET

Habitat Protection
The habitat protection measures recommended for Wind Lake are designed to provide for habitat protection by avoiding disturbances in fish breeding areas during spring and early summer, managing aquatic plants and maintaining stands of native aquatic plants. In particular, this recommendation extends to, and includes, the WDNR-delineated, Chapter NR 107 sensitive areas located in the Lake. In addition, it is recommended that environmentally sensitive lands, including wetlands along the lakeshore and in the tributary area, be preserved.

Shoreland Protection
Most of the Wind Lake shoreline is protected and no major areas of erosion, which require additional protection against wind, wave, and wake erosion, were identified in the planning effort. Various protection options are described in Chapter VII for consideration in the repair or replacement of existing protection structures. Adoption of the vegetated buffer strip method is recommended to be used in lakeshore areas and on tributary waterways wherever practical in order to maintain habitat value and the natural ambience of the lakeshore. Continued maintenance of existing revetments and other protection structures is also recommended. Conversion of bulkheads to revetments or natural vegetated shoreline or combinations is recommended to be considered where potentially viable at such time as major repairs are found necessary. Natural vegetated buffer strips should also be considered for shorelines, where practical. Guidance provided in the proposed Chapter NR 328 of the *Wisconsin Administrative Code* sets forth a methodology for determining appropriate shoreline protection structures for inland lakes based upon wind wave action and fetch, substrate, and likely boat wake action.[14]

In addition to the foregoing measures, it is also recommended that the Town of Norway continues to enforce existing shoreland setback requirements, and construction site erosion control ordinances. Provision of informational materials to shoreland property owners is recommended, as set forth in the informational and educational programming element of this plan.

Aquatic Plant Management
The aquatic plant management strategy set forth below recognizes the importance of recreational uses of Wind Lake. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat. In addition, this strategy recognizes the ecosystem values and functions provided within Wind Lake by a healthy and diverse aquatic plant community, and seeks to maximize these ecosystem-level benefits necessary to ensure a balanced lake ecosystem capable of supporting a variety of diverse recreational uses and economic activities.

Alternative Methods for Aquatic Plant Control
Various aquatic plant management techniques—chemical, mechanical, biological, and physical—are potentially applicable on Wind Lake. A number of these methods have been employed on Wind Lake in the past, although a combination of chemical control and mechanical harvesting has been the major method utilized throughout the Lake in recent years.

Chemical Controls
Chemical controls, in the form of herbicides and algicides, have been used as the primary means of aquatic plant control on Wind Lake. As noted in Chapter V of this report, the aquatic herbicides diquat, endothal, sodium arsenite, and 2,4-D have been applied to Wind Lake to control aquatic macrophyte growth; copper sulfate compounds have been used to control algae. Diquat is a nonselective herbicide that will kill many aquatic plants, such as the pondweeds, bladderwort, and naiads, that provide significant habitat value for the fishes and wildlife of the Lake. Endothall primarily kills pondweeds, but does not control such nuisance species as Eurasian water milfoil, while 2,4-D and fluridone are systemic herbicides that are considered to be more selective and generally used to control Eurasian water milfoil. However, 2,4-D also will kill high-value species, such as water lilies, and fluridone will also affect coontail and elodea. In addition, in some lakes, the use of chemical control techniques may contribute to an ongoing aquatic plant problem by augmenting the natural rates of accumulation of decayed

[14]*See Table 1, the "Erosion Intensity Score Worksheet," of Chapter NR 328 of the* Wisconsin Administrative Code*, which is available online at: http://www.legis.state.wi.us/rsb/code/nr/nr328.pdf.*

organic matter in the lake's sediments, releasing the nutrients contained in the plants back into the water column where they can be reused by new plants, inducing biomass production. The use of chemical control measures may also contribute to the oxygen demand that produces anoxic conditions in a lake, damaging or destroying nontarget plant species that provide needed habitat for fish and other aquatic life.

Selective use of chemical control may be a suitable technique for the control of infestations of Eurasian water milfoil and other nuisance species, especially in areas where other means are not practicable. Chemical applications in early spring or late autumn have been found to be effective in controlling such infestations of milfoil and facilitating the resurgence of growth of native plant species in lakes in southeastern Wisconsin. Chemical applications should be conducted in accordance with current administrative rules,[15] under the authority of a State permit, and by a licensed applicator working under the supervision of WDNR staff. Records accurately delineating treated areas and the type and amount of herbicide used in each area, should be carefully documented and used as a reference in applying for permits in the following year.

Mechanical Controls
Mechanical harvesting of aquatic plants has been used intermittently to supplement chemical treatments as a means of controlling plant growth and associated filamentous algae on Wind Lake, especially in the northeast end of the Lake, since the early 1990s. The most significant benefits of mechanical harvesting for Wind Lake are in controlling nuisance aquatic plant growth, opening up navigation channels, and the creation of fishing lanes. Potential negative impacts of mechanical harvesting, as outlined by the U.S. Environmental Protection Agency,[16] include: the removal of small fish, limited depths of operation, propagation of plant fragments, and time needed to treat specific areas of a waterbody. However, mechanical harvesting does offer temporary relief from nuisance aquatic plant growths, especially when conducted in accordance with a management plan designed to optimize benefits and minimize adverse impacts.

In addition to controlling nuisance aquatic plant growth conditions, harvesting has been shown to promote better balance within the in-lake fishery by providing access for larger gamefish, such as the largemouth bass, to smaller prey fishes and organisms which can utilize the dense plant beds. Narrow channels harvested to provide navigational access also provide "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. Consideration of continued use of harvesting as a supplement to chemical treatments to control nuisance levels of aquatic macrophytes or invasive species, such as Eurasian water milfoil, is recommended.

Manual Controls
Manual methods of aquatic plant control, such as raking or hand-pulling, while environmentally sound, are difficult to employ on a large-scale. Although very effective for small-scale application—for example, in and around docks and piers—manual techniques are generally not practical for large-scale plant control methods. Manual removal of native aquatic vegetation beyond the 30-foot riparian use area requires a permit from the WDNR; removal of plants should concentrate on exotic species. Manual means are recommended on Wind Lake to control nearshore plant growths, especially around piers and docks. Should such harvesting exceed the 30-foot maximum width in 100 feet of shoreline, an individual permit would be required under Chapter NR 109 of the *Wisconsin Administrative Code*.

Informational and Educational Programming
In addition to the in-lake rehabilitation methods, an ongoing campaign of community informational programming can support the aquatic plant management program by encouraging the use of shoreland buffer strips, responsible use of household and garden chemicals, and environmentally friendly household and garden practices to minimize the input of nutrients from these riparian areas. In addition, a community information campaign should emphasize

[15]*See Chapters NR 107 and NR 109 of the* Wisconsin Administrative Code.

[16]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition*, Washington, D.C., August 1990, p. 146.*

the need to clean boats and motors/propellers when removing boats from the Lake and upon launching boats into the Lake to limit the redistribution of invasive organisms. Plants removed from boats and motors should be retained onboard and/or disposed of by composting at the boat launch or homestead to avoid their being reintroduced into the water. An informational program can also remind riparian residents and others of the habitat and ecological benefits, such as shoreline stabilization, provided by the aquatic flora of the Lake, thereby promoting the preservation of a healthy aquatic flora in the Lake.

In addition to informational programming, educational programs such as Project WET (Water Education Training), Adopt-A-Lake, and other school-based programs can help to build community awareness of the value of lake ecosystems, and the need for vigilance on the part of individual citizens and households within the area tributary to the Lake. School groups and other community service organizations also form a cadre of volunteers that can assist in shoreland management programs and in the dissemination and conduct of community informational programs.

The Wind Lake community has consistently supported informational and educational programming within their community, have encouraged environmentally sound behaviors within the Lake, but have contributed to shoreland restoration efforts and lake monitoring, as well. Thus, ongoing informational and educational programming is recommended.

Recommended Aquatic Plant Management Measures

It is recommended that continued aquatic macrophyte surveys 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: major areas of nuisance plant growth; areas chemically treated and/or harvested; and in areas where harvesting is conducted, species harvested and amounts of plant material removed from the Lake, and species and approximate numbers of fish caught in the harvest. This information, in conjunction with the conduct of the recommended aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program over time and allow adjustments to be made in the program to maximize its benefit.

To enhance the use of Wind Lake while maintaining the quality and diversity of the biological communities, the following recommendations are made:

1. Reconnaissance surveys of the aquatic plant communities in Wind Lake are recommended to be conducted periodically and the approved aquatic plant management plan should be updated every three to five years.

2. Mechanical harvesting is recommended as a supplemental management method. Due to the intermittent nature of the need for harvesting on Wind Lake, the lack of well-placed, adequate off-loading sites along the shoreline, and unfavorable cost-benefit comparisons, it is recommended that harvesting continue to be carried out by means of contracting with private companies rather than the WLMD purchasing harvesting equipment. In areas where harvesting occurs, it is recommended that shared-access channels be harvested to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common channels would help to delay the regrowth of vegetation in these areas. Additionally, surface harvesting is recommended, cutting to a depth to remove the surface canopy of nonnative aquatic plants, such as the Eurasian water milfoil. This should provide a competitive advantage to the low-growing native plants present in the Lake. By not disturbing the low-growing species which generally grow within one to two feet of the lake bottom and in relatively low densities, leaving the root stocks and stems of all cut plants in place, the resuspension of sediments in Wind Lake will be minimized, and some degree of cover will continue to be provided for panfish populations which support the bass population in the Lake. Further, cutting should not be broad-based, but focused on boating channels and selected navigation areas.

3. It is recommended that the use of chemical herbicides be focused on controlling nuisance growths of exotic species, especially in shallow water around docks and piers where harvesting is unable to

reach. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners. 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, such as 2,4-D and fluridone, should be used. Algicides, such as Cutrine Plus, are not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in the Wind Lake and valuable macroscopic algae, such as *Chara* and *Nitella* are killed by this product. Periodic applications of algicide may be required when conditions warrant.

4. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned, as it is time consuming and costly for a mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. The WLMD may wish to obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to inform residents of the control options available. Pursuant to Chapter NR 197 of the *Wisconsin Administrative Code*, individuals may remove aquatic vegetation from a 30-foot width of shoreline in 100 feet to enhance access; however, maintenance of a healthy shoreline flora helps to stabilize shorelines and provides essential habitat in the land-water transition areas.

5. The ongoing collection of aquatic plant fragments and other debris along shoreline areas is recommended.

6. It is recommended that ecologically valuable areas be excluded from aquatic plant management activities during fish spawning seasons in spring and early summer. Aquatic plant management limitations set forth by the WDNR pursuant to the authorities granted under Chapter NR 107 of the *Wisconsin Administrative Code* relating to sensitive area determinations are incorporated herein by reference.

7. It is further recommended that the WLMD conduct public informational programming on the types of aquatic plants in Wind Lake; 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. This program 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.

The recommended aquatic plant control areas are shown on Map 23. The control measures in each area are designed to optimize desired recreational opportunities and to protect the aquatic resources.

The recommended aquatic plant management plan represents a continuation of the current aquatic plant management program conducted by the WLMD.

OTHER LAKE MANAGEMENT MEASURES

Recreational Use Management

Public Recreational Boating Access

With respect to boating ordinances applicable to Wind Lake, it is recommended that current levels of enforcement be maintained. In addition, recreational boating access users should be made aware of the presence of the exotic invasive species, such as Eurasian water milfoil, within Wind Lake. Appropriate signage should be placed at the public recreational boating sites, and supplemental materials on the control of invasive species should be made available to the public. These materials could be provided to riparian householders by means of mail drops or distribution of informational materials at public buildings, such as municipal buildings and the public library, and to nonriparian users by means of informational materials provided at the entrance to all municipal public recreational boating access sites. In addition, it is recommended that disposal bins be made available at the public recreational boating access sites for disposal of plant materials and other refuse removed from watercraft using the public recreational boating access sites.

Public Informational and Educational Programs
It is recommended that the WLMD assume the lead in the development of a public informational and educational program. Participation by the Town of Norway should be encouraged. This program should deal with various lake management-related topics, including onsite sewage disposal system management, water quality management, land management, groundwater protection, aquatic plant management, fishery management, invasive species, and recreational use. Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the WDNR and the UWEX. These cover topics such as beneficial lawn care practices and household chemical use. Such brochures should be provided to homeowners through local media, direct distribution or targeted library and civic center displays. Such distribution can also be integrated into ongoing, larger-scale activities, such as lakeside litter collections, which can reinforce anti-littering campaigns, recycling drives, and similar environmental protection activities.

Given the extent of public interest in Wind Lake, it is recommended that the WLMD consider offering regular informational programs on the Lake and issues related thereto. Such programming can provide a mechanism to raise awareness of the lake issues, and provide a focal point from which to distribute the informational materials referred to above.

The WLMD and the municipalities are also encouraged to take an active role in encouraging the local school districts to adopt and utilize lake-related educational programs, such as Adopt-A-Lake and Project WET, as means of more closely linking students to the lake environment.

The cost for conducting this informational and educational program is estimated to be $1,200 per year.

Institutional Development
In the case of Wind Lake, general oversight of lake management activities currently is provided by the WLMD with the advisory input from the Town of Norway.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the WLMD, the Town of Norway, in part, in cooperation with neighboring municipalities, and County and State agencies. The recommended plan introduces few new elements, although some of the plan recommendations represent refinements of current programs. This is particularly true in the case of the fisheries and aquatic plant management programs, where the field surveys recommended in this plan will permit more-efficient management of these resources.

Generally, aquatic plant and fisheries management practices and public awareness campaigns currently implemented by the WLMD and local municipalities, are recommended to continue with refinements as proposed herein. Some aspects of these programs lend themselves to citizen involvement through participation in the WDNR Self-Help Monitoring Program, operated as the Citizen Lake Monitoring Network by UWEX, and identification with environmentally sound owner-based land management activities. It is recommended that the WLMD, in cooperation with the local municipalities, assume the lead in the promotion of such citizen actions, with a view toward building community commitment and involvement. Assistance is generally available from agencies such as the WDNR, the County UWEX office, and SEWRPC.

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 32, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 34. In general, it is recommended that the WLMD continue to provide a coordinating role for community-based lake management actions, in cooperation with the appropriate local government units.

Table 34

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR WIND LAKE

Plan Element	Management Measures	Estimated Cost: 2000-2020[a]		Potential Funding Sources[b]
		Capital	Annual Operation and Maintenance	
Land Use	Observe regional and county land use plan guidelines	- -	- -	County, Cities, Town
	Density management in the shoreland zone; enforce adequate setbacks and promote environmentally friendly landscaping practices in shoreland areas	- -	- -	County, Town
	Develop and implement consistent stormwater management ordinances in all riparian communities; periodic review of stormwater ordinances	- -	- -	County, Cities, Town
	Protection of environmentally sensitive lands and environmental corridors	$800-$1,200 per acre[c]	- -	WDNR Lake Protection Grant and Stewardship Grant Programs, WLMD
Pollution Abatement	Implement regional and county land and water resource management plans	- -[d]	- -[d]	County, USDA EQIP, WDNR/WDATCP Runoff Management Program
	Rural nonpoint source controls	- -[d]	- -[d]	County, WDNR/WDATCP Runoff Management Program
	Urban nonpoint source controls	- -[d]	- -[d]	County, WDNR/WDATCP Runoff Management Program
	Construction site erosion controls and stormwater management ordinances	- -[d]	$250-$500 per acre[d]	County, Cities, Town, private firms, individuals
	Stormwater management systems developed where appropriate densities exist; use conservation subdivision designs	- -[d]	- -[d]	County, Town
	Public sanitary sewer system management	- -[d]	- -[d]	Local sanitary districts
	Onsite sewage system management	- -[d]	$100-$20[d]	County, Town
Water Quality	Continue participation in USGS monitoring program; consider participation in WDNR Self-Help Water Quality Monitoring Program, WDNR Expanded Self-Help Program, or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	- -	$6,500[e]	WLMD, USGS, WDNR
	Reevaluate nutrient levels in the Lake and consider nutrient inactivation through treatment with aluminum sulfate	- -	$200,000[d]	WLMD
	Dredging to accomplish maintenance of navigation channels and public recreational boating access opportunities	- -	$15 per cubic yard	WLMD
Hydrology	Maintain outlet structure and monitor water levels	- -	- -[d]	Racine County, USGS, WDNR
	Maintain hydrologic capacity of inflow and outflow canals as necessary to pass 1:100 year recurrence intervals flows	- -	- -[d]	Racine County, Racine County Drainage Board

Table 34 (continued)

Plan Element	Management Measures	Estimated Cost: 2000-2020[a] Capital	Estimated Cost: 2000-2020[a] Annual Operation and Maintenance	Potential Funding Sources[b]
Aquatic Biota	Continue to manage Canada goose population	- -	$2,000	USFWS, WLMD
	Protect fish habitat	- -	- -	WDNR, WLMD, individuals
	Maintain shoreline and littoral zone fish habitat	- -	- -	County, WLMD, individuals, WDNR
	Conduct periodic fish surveys and continue stocking of selected game fish	- -	- -	WDNR
	Enforce size and catch limit regulation	- -	- -	WDNR
	Conduct “carp out” to manage rough fish populations	- -	- -	WLMD, sports and angling clubs
	Encourage shoreline restoration projects through informational programming and demonstration sites	- -	- -	County, WLMD
	Conduct periodic reconnaissance surveys of aquatic plant communities	- -	$1,500[f]	WDNR Lake Management Planning Grant Program, WLMD
	Update aquatic plant management plan every three to five years	- -	$5,000[f]	WDNR Lake Management Planning Grant Program, WLMD
	Provide and conduct programming on aquatic plants and various management measures	- -	- -	WDNR Lake Management Planning Grant Program, WLMD
	Use (limited) aquatic herbicides for control of nuisance aquatic plants, such as Eurasian water milfoil and purple loosestrife	- -	$1,000 per acre[g]	WLMD, individuals
	Mechanically harvest aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants	$100,000[g]	$8,500[h]	WDNR Lake Management Planning Grant Program, WLMD
	Manually harvest aquatic plants from around docks and piers where feasible	$100	$100	WLMD, individuals
	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and other nonnative plants	- -	- -	WLMD, individuals
	Continue to monitor invasive species	- -	- -	WLMD, individuals
Water Use	Enforce regulations governing the operation of watercraft; improve signage and materials at public recreational access site to aid in the identification and control of exotic species	$500	$100	Towns, WLMD, WDNR
	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	- -	- -	WDNR
	Maintain navigational access, especially from public recreational boating access site(s) to main basin of Lake; maintain adequate depths for navigation as required, subject to WDNR permits	- -	- -	WDNR, WLMD
Ancillary Management Measures	Public informational and educational programming: seminars, programs, Project WET, Adopt-A-Lake	- -	$1,200	LMDs, UWEX/WDNR/WAL Lakes Partnership, school districts
Total	- -	$101,400[d]	$222,650[d]	- -

Table 34 Footnotes

[a] *All costs expressed in January 2002 dollars.*

[b] *Unless otherwise specified, USDA is the U.S. Department of Agriculture, USFWS is the U.S. Fish and Wildlife Service; USGS is the U.S. Geological Survey, WDNR is the Wisconsin Department of Natural Resources, WDA TCP is the Wisconsin Department of Agriculture, Trade and Consumer Protection, County is Racine and Waukesha Counties, Cities are the City of New Berlin and City of Muskego, Town is the Town of Norway, UWEX is the University of Wisconsin-Extension, and WAL is the Wisconsin Association of Lakes, and WLMD is the Wind Lake Management District. Local sanitary districts are the Town of Norway Sanitary District No. 1 and the Milwaukee Metropolitan Sewage District. LMDs are the Linnie Lac Lake Management District, Little Muskego Lake Management District, Big Muskego Lake/Bass Bay Protection and Rehabilitation District and the WLMD.*

[c] *Cost-share assistance may be available for land acquisition under the Chapter NR 50/51 Stewardship Grant Program and/or the NR 191 Lake Protection Grant Program.*

[d] *Costs vary with the area subject to management or development during any given year.*

[e] *Monitoring by the USGS can be cost-shared between the federal agency and local cooperators; the WDNR Self-Help Monitoring Program involves no cost but does entail a time commitment from the volunteer.*

[f] *Cost-share assistance may be available for lake management planning studies under the NR 190 Lake Management Planning Grant Program.*

[g] *Cost-share assistance may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program; additional cost-share for aquatic invasive species management may be available through the Chapter NR 198 Aquatic Invasive Species (AIS) Grant Program.*

[h] *Based on contract minimum in 2004 and 2005.*

Source: SEWRPC.

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APPENDICES

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Appendix A

ILLUSTRATIONS OF COMMON AQUATIC PLANTS FOUND IN WIND LAKE

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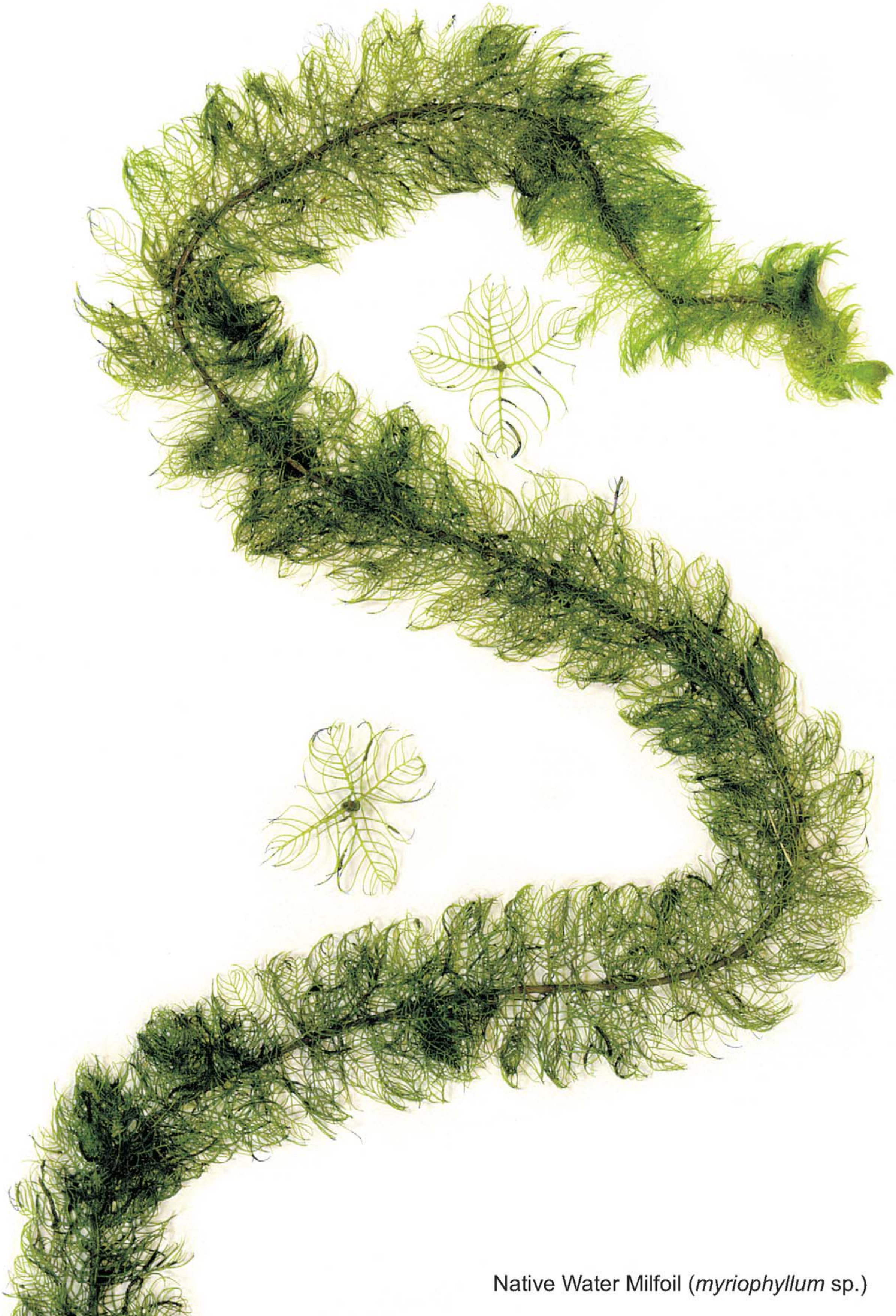
Coontail (*ceratophyllum demersum*)

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*)

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

Leafy Pondweed (*potamofeton foliosus*)

Variable Pondweed (*potamogeton gramineus*)

Illinois Pondweed (*potamogeton illinoensis*)

Long Leaved Pondweed
(*potamogeton nodosus*)

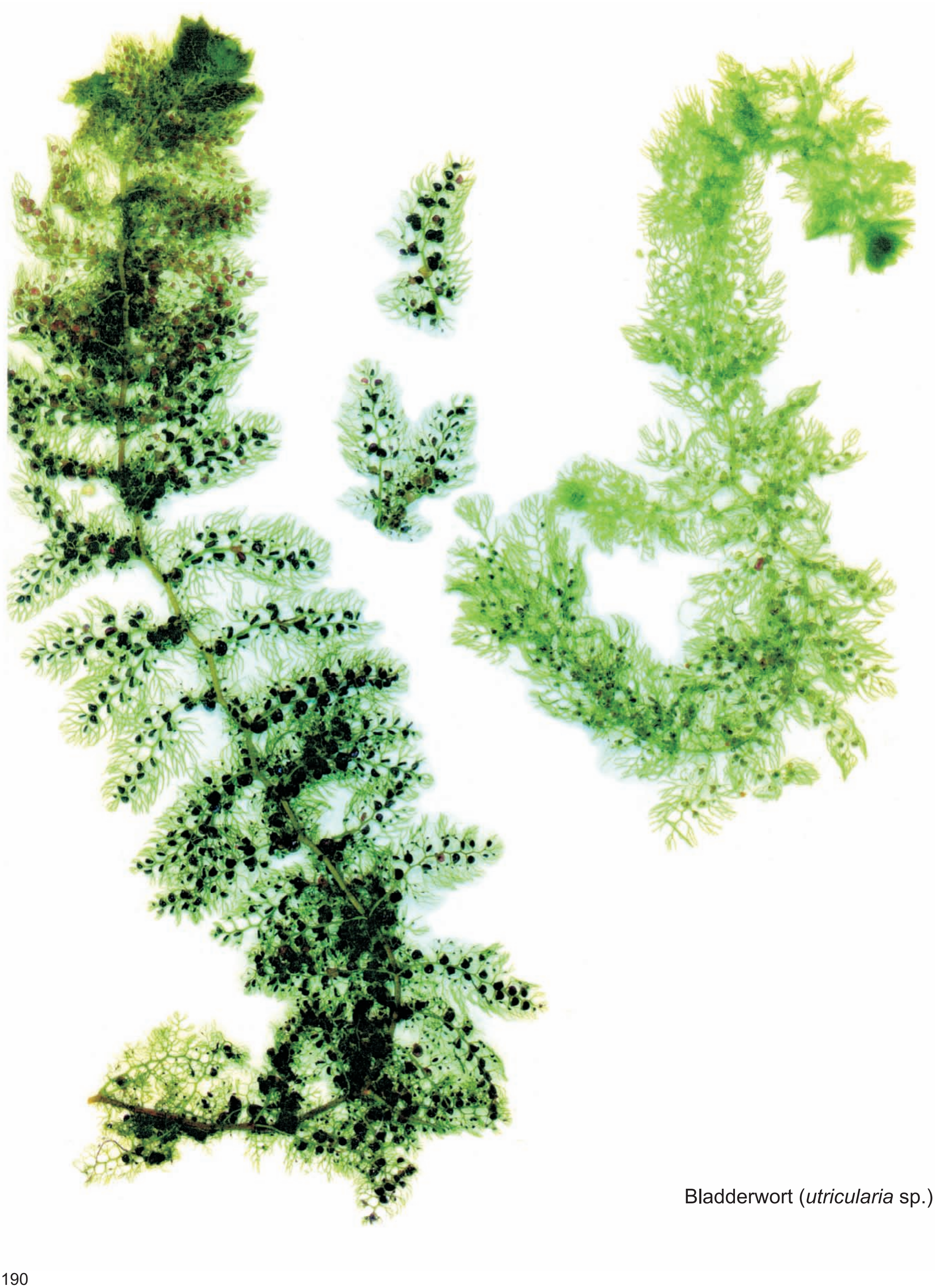
Sago Pondweed (*potamogeton pectinatus*)

White-Stem Pondweed (*potamogeton praelongus*)

Small Pondweed (*potamogeton pusillus*)

Clasping-Leaf Pondweed
(*potamogeton richardsonii*)

Flat-Stem Pondweed (*potamogeton zosteriformis*)



Bladderwort (*utricularia* sp.)

Eel Grass / Wild Celery (*valisneria americana*)

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Appendix B

BOATING ORDINANCE FOR WIND LAKE

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CHAPTER 8

RECREATION, BOATING AND SWIMMING

8.01 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.

8.02 Applicability and Enforcement

The provisions of this ordinance shall apply to the Waters of Long (KEE-NONG-GO-MONG) Lake, Waubeesee Lake, Wind Lake, the Muskego Channel, the Wind Lake Channel, and the Anderson Channel within the jurisdiction of the Town of Norway. The provisions of this Ordinance shall be enforced by the Officers of the Town of Norway Lake Patrol.

8.03 Adoption of State Boating and Safety Laws

Sections 30.50 through 30.71, Wis. Stats., as amended from time to time, exclusive of penalty provisions are adopted and incorporated herein by reference as though fully set forth herein.

ORD. 92-1 (1/13/92)

8.04 Boating Regulations

(1) Speed.

A. No person shall operate a motorboat at a speed greater than is reasonable and prudent under the conditions and having regard for the actual and potential hazards then existing. The speed of a motorboat shall be so controlled as to avoid colliding with any object lawfully in or on the water or with any person, boat or other conveyance in or on the water in compliance with legal requirements and exercising due care. In no event shall any person operate a motorboat at a speed in excess of 50 m.p.h.

B. Except as set forth under Section 8.07(3) and unless an area is otherwise marked, no person may operate a watercraft within 300 feet of any main shoreline on any lake at a speed in excess of slow-no-wake speed.

C. No person shall operate a motorboat or personal watercraft within 300 feet of any main shore line at a speed in excess of slow no wake, or as otherwise established by regulatory markers.

D. A boat granted the right of way by this section shall maintain her course and speed, unless to do so would probably result in a collision.

E. Boats leaving a dock or pier shall have the right-of-way over all other approaching motorboats.

F. No person shall operate a boat a speed in excess of 50 m.p.h. No motor boat shall be operated outside the traffic lane at a speed in excess of 5 m.p.h. or idle speed.

ORD. 92-1 (1/13/92)

(2) Contests

No person shall operate a motorboat in a contest of speed or maneuverability unless such race or contest is authorized by the Town Board.

(3) Searchlights

No person shall continually or repeatedly cause the rays of a searchlight to rest upon the pilot of another boat.

8.05 Hours of Operation

(1) Wind Lake.

No motorboat shall be propelled upon the waters of Wind Lake at a speed in excess of slow-no-wake between sunset and 9:00 a.m.

(2) Waubeesee and Long Lakes.
No motorboat shall be propelled upon the waters of Waubeesee or Long Lakes at a speed in excess of slow-no-wake between 6:00 p.m. and 9:00 a.m., Daylight Saving Time or between 5:00 p.m. and 9:00 a.m. Central Standard Time.

8.06 Swimming Regulated
No person shall swim within the water traffic lane unless accompanied by a staffed boat and shall remain within 50 feet of the boat at all times.

8.07 Water Skiing Regulated
(1) Prohibited At Certain Times Exceptions.
A. Except as provided in par. C, no person may operate a motorboat towing a person on water skis, aquaplane or similar device unless there is in the boat a competent person in addition to the operator in a position to observe the progress of the person being towed. An observer shall be considered competent if that person can in fact observe the person being towed and relay any signals to the operator. This observer requirement does not apply to motorboats classified as Class A motorboats by the Department actually operated by the persons being towed and so constructed as to be incapable of carrying the operator in or on the motorboat.

B. No person may engage in water skiing, aquaplaning, tubing or similar activity, at any time outside the hours of operation set forth in Section 8.05.

C. In addition to complying with par. A, no person may operate a personal watercraft that is towing a person who is on water skis, an aquaplane, a tube or similar device unless the personal watercraft is designed to seat at least 3 persons.

(2) Careful And Prudent Operation.
A person operating a motorboat having in tow a person on water skis, aquaplane, tube or similar device shall operate such boat in a careful and prudent manner and at a reasonable distance from persons and property so as not to endanger the life or property of any person.

(3) Restriction.
A. No person operating a motorboat that is towing persons engaged in water

skiing, aquaplaning, tubing or similar activity may operate the motorboat within 100 feet of any occupied anchored boat, any personal watercraft or any marked swimming area or public boat landing.

B. No person who is engaged in water skiing, aquaplaning, tubing or similar activity may get within 100 feet of a personal watercraft or allow the tow rope while in use to get within 100 feet of a personal watercraft.

C. No person may operate a personal watercraft within 100 feet of the following:

1. A motorboat towing a person who is engaged in water skiing, aquaplaning, tubing or similar activity.

2. The tow rope of a motorboat towing a person who is engaged in water skiing, aquaplaning, tubing or similar activity.

3. A person who is engaged in water skiing, aquaplaning, tubing or similar activity.

D. Paragraphs A. and C. do not apply to pickup or drop areas that are marked with regulatory markers and that are open to operators of personal watercraft and to persons and motorboats engaged in water skiing.

(4) <u>Intoxicated Operation</u>.
No person may use water skis, an aquaplane, a tube or a similar device while under the influence of an intoxicant to a degree which renders him or her incapable of safely using water skis, an aquaplane, a tube or a similar device, or under the combined influence of an intoxicant and any other drug to a degree which renders him or her incapable of safely using water skis, an aquaplane, a tube or a similar device.

(5) <u>Two Skiers Allowed</u>.
No motorboat operator shall tow more than two persons on water skis, aquaplanes, tubes or similar devices without prior authorization from the Town Board. All downed or dropped skiers, skis, boards, tubes and similar devices shall be picked up immediately.

(6) <u>Wake-Surfing Prohibited</u>.
No wakesurfing shall be permitted (i.e., riding on surfboard or similar contrivance on wake of the boat without the control of a rope connected to a boat).

(7) State Law Incorporated
With the exception of the Subsection 1, Paragraph B, relating to permissible hours of operation, Wisconsin Statute Sec. 30.69, and any additions or amendments thereto, is incorporated herein by reference.

Ord. 2002-03 (5/29/2002)

8.08 Ramp Prohibited
No person shall construct, install or use in any manner, a ramp for skiing, jumping or for any purpose whatsoever, without prior authorization from the Town Board.

8.09 Littering Prohibited
No person shall deposit, place or throw from any boat, raft, pier, platform or similar structure or from the shore, any cans, papers, bottles, debris, refuse, garbage, solid or liquid waste on or into the lake.

8.10 Possession of Glass Prohibited
No person shall possess or have under his or her control any bottle, jar, container, cup, other receptacle or any other object made of glass, ceramic, earthenware or similar breakable material while on any lake within the Town, whether the lake is frozen or unfrozen. This prohibition does not extend to eyeglasses, lenses or glass which is an integral part of sporting equipment used on the lake.

8.11 Seaplane Landings Prohibited
No person shall operate on the surface of any waters of the Town any seaplane or aircraft capable of landing on water. All waters shall be designated by standard marking devices to show the prohibition of such use.

8.12 Conduct at Public Access Sites

(1) In this section the term "public access site" shall refer to any parcels of land on lakes in the Town of Norway owned, under easement, leased or administered by the State of Wisconsin and under the management, supervision and control of the Department of Natural Resources.

(2) No person shall operate or park any vehicle, as defined in §340.01(74), Wis. Stat., as amended from time to time, and which is required to be registered by law, on any public access site, except as may be specifically authorized by law or administrative rule.

(3) No person may enter or be within the boundaries of any public access site, including any posted parking areas therein, between the hours of 11:00 p.m. and

the following 6:00 a.m., except as permitted under the rules and regulations of the Department of Natural Resources, as amended from time to time.

(4) No person shall park, stop or leave standing, whether attended or unattended, any vehicle or watercraft within a public access site, contrary to any posted notice therein.

(5) No person may engage in violent, abusive, indecent, boisterous, unreasonably loud or otherwise disorderly conduct which tends to cause or provoke a disturbance or create a breach of the peace while within the boundaries of any public access site.

(6) No person shall dispose of waste material in any manner at or within a public access site, except by placing the same in receptacles or other locations provided for that purpose.

(7) No person shall engage in any activity or do any act which is contrary to the lawfully posted notices of the Department of Natural Resources at a public access site.

8.13 Uniform Aids to Navigation: Waterway Markers

(1) Definitions

A. "Waterway marker" is any device designed to be placed in, or near any water within the Town, to convey an official message to a boat operator on matters which may affect health, safety, or well-being.

B. "Regulatory marker" is a marker which has no equivalent in the U. S. Coast Guard aid to navigation.

C. "State aid to navigation" is a waterway marker which is the equivalent of a U. S. Coast Guard aid to navigation.

D. "Buoy" is any device designed to float which is anchored in the water and which is used to convey a message.

(2) Authority to Place Markers.
No waterway markers shall be placed in, on or near any waters within the Town, except such buoys or other markers as have been authorized by the Town or other political subdivision of the state or federal government.

(3) Waterway Markers used on Waters within the Town of Norway.
All state aids to navigation and regulator markers are to be marked and displayed in conformity with the regulations set forth in Section NR 5.09 of the Wisconsin Administrative Code, incorporated herein by reference as though fully set forth.

(4) Wind Lake Waterway Markers to be as follows:
2-Slow-No-Wake buoys out 300' from the ordinary high water line at the DNR boat launch (South Wind Lake Road); Map 1 #A & B; GPS locations: A: N42 49.893, W088 08.152, water depth 6 ft., B: N42 49.871, W088 08.148, water depth 6 ft.

2-Slow-No-Wake buoys out 300' from the ordinary high water line from the property lines of 25313 W. Loomis Road (a.k.a. Sportsman's); Map 1 #C & D; GPS locations: C: N42 49.870, W088 08.408; water depth 7 ft.; D: N42 49.893, W088 08.379, water depth 7 ft.

1-Danger Sandbar buoy located 150' from ordinary high water line from 25713 W. Loomis Road; Map 1 #G; GPS location: N42 49.649, W088 08.616; water depth 1.5 ft.
2-Red channel markers on northwest and southeast edge of Weed Island; Map 1 #H & I; GPS locations: H: N42 49.571, W088 08.523; water depth 4 ft. I: N42 49.358, W088 08.219, water depth 3 ft.

1-Green channel marker 300' from the ordinary high water line of 25713 W. Loomis Road; Map 1 #J; GPS location: N42 49.620, W088 08.601, water depth 4 ft.

1-Green channel marker south of the channel marked on the north by the red channel marker 1; Map 1 #K; GPS location: N42 49.342, W088 08.194, water depth 6 ft.

1-Danger Rock buoy 300' out from ordinary high water line of 7157 W. Wind Lake Road; Map 1 #L; GPS location: N42 49.048, W088 08.124, water depth 2.5 ft.

1-Danger Rock buoy 500' out from ordinary high water line of 7300 W. Wind Lake Road; Map 1 #M; GPS location: N4249.113, W088 08.146, water depth 3 ft.

1-Danger Rock buoy on east edge of entrance to the bay at Breezy Point Road; Map 1 #N; GPS location: N42 49.144, W088 08.406, water depth 2.5 ft.

1-Danger Rock buoy located due south of 26111 W. Loomis Road and south of Wood Island; Map 1 #P; GPS location: N42 49.193, W088 08.945, water depth 2.5 ft.

2-Center of Channel buoys located 150' and 300' south of the centerline of the Muskego Inlet Canal; Map 1 #Q & R; GPS locations: Q: N42 50.030, W088 08.141, water depth 3 ft.; R: N42 50.006, W088 08.145, water depth 3 ft.

1-Slow-No-Wake buoy located 300' from the ordinary high water line of 26335 Schad Drive; Map 1 #S; GPS location: N42 49.332, W088 08.304, water depth 5 ft.

1-Center of Channel buoy on the centerline of the channel between Wood Island and mainland; Map 1 #S; GPS location: N42 49.332, W088 08.304, water depth 3 ft.

2-Center of Channel buoys, one located near the northern edge of the navigational channel and the other midway between the two Center-of-Channel buoys; Map 1 #U & V; GPS location: U: N42 49.482, W088 08.367, water depth 4 ft.; V: N42 49.447, W088 08.352, water depth 3.5 ft.

4-Slow-No-Wake buoys placed 400' apart and 400' from the wooded shoreline of DNR Wooded Island; Map #ZA to ZD; GPS locations: ZA: N42 49.599, W088 08.171, water depth 9 ft.; ZB: N42 49.562, W088 08.141, water depth 7.5 ft.; ZC: N42 49.520, W088 08.095, water depth 7 ft.; ZD: N42 49.429, W088 08.009, water depth 7 ft.

3-Slow-No-Wake buoys placed 400' apart 400' northeast of Weed Island; Map 1 #ZE to ZG; GPS locations: ZE: N42 49.586, W088 08.355, water depth 4.5 ft.; ZF: N42 49.541, W088 08.321, water depth 5 ft.;

3-Slow-No-Wake buoys placed 400' apart 400' southwest of Weed Island; Map 1 #ZH to ZJ; GPS locations: ZH: N42 49.446, W088 08.488, water depth 3 ft.; ZI: N42 49.398, W088 08.411, water depth 4 ft.; ZJ: N42 49.336, W088 08.349, water depth 4 ft.

4-Slow-No-Wake buoys placed 600' apart, 600' south of Muskego Inlet Canal buoys and proceeding south; Map 1 #ZK to ZN: GPS locations: ZK: N42 49.576, W088 08.714, water depth 4 ft.; ZL: N42 49.702, W088 08.790, water depth 4.5 ft.; ZM: N42 49.820, W088 08.873, water depth 4 ft.; ZN: N42 49.876, W088

08.938, water depth 4 ft.

See Following Map of Wind Lake for Layout of all Buoys.

Ord 2001-04 (6/27/2001)
Readopted with DNR approval 9/10/01

(5) Waubeesee Lake Waterway Marks to be as follows:

1-Slow-No-Wake buoy located in middle of channel behind 7718 Martha Circle

1-Slow-No-Wake buoy located in middle of channel behind 27107 Waubeesee Lake Drive

1-Slow-No-Wake buoy located 300' behind 27009 Waubeesee Lake - 10 - Drive

1-Slow-No-Wake buoy located 300' from 26625 Roosevelt Lane

1-Slow-No-Wake buoy located 300' out from 26619 Roosevelt Lane

1-Slow-No-Wake buoy located 300' out from 7236 South Loomis Road

1-Slow-No-Wake buoy located 300' out from 7152 South Loomis Road

1-'Rock' Hazard Warning Waterway Marker located approx. 70' west of the pier located at 26906 South Elm Lane.

Ord. 2006-006 12/11/2006

See Following Map of Waubeesee Lake for Details.

(6) Installation, Removal and Maintenance.

Waterway markers shall be installed and removed by the Town of Norway Lake Patrol. Off-season transportation, maintenance and storage are to be performed by the Department of Public Works.

8.14 Winter Regulations for Icebound Lakes

(1) Intent

It is the intent of this ordinance to provide the basic guidelines and parameters for the safe and healthful use of and conduct of activities on all lakes in the Town of Norway during periods when the lakes are frozen or partially frozen subject to the grant of authority under Section 30.81 of the Wisconsin Statutes.

(2) Compliance with State Laws

Except as otherwise specifically provided in this section, the provisions of Section 23.33, 86.192, 961.47, and Chapters 125, 350, 938 through 948 of the Wisconsin Statutes, described and defining regulations generally with respect to vehicles and traffic conduct, snowmobiles, signage and all terrain vehicles, exclusive of any provisions therein relating to penalties to be imposed and exclusive of any regulations for which the statutory penalty is imprisonment, and including any amendments thereto, are adopted by reference and made a part of this section as if fully set forth herein. Any act required to be performed or prohibited by any current or future statute incorporated herein by reference is required or prohibited by this section.

(3) Definitions

For the purpose of this section, the following definitions shall be applicable:

A. All-Terrain Vehicle or ATV—Any engine driven device as defined in Section 340.01 (2g), Wisconsin Statutes, and any other multiaxle, two, three or four wheeled vehicle, or combination wheel and track (runner) vehicle, not otherwise defined herein, powered by a small motor(s) or fan and designed to be operated on snow, ice, grass, dirt, gravel, sand or wetland, whether or not required to be licensed by state law.

B. Snowmobile—Any engine drive vehicle as defined in Section 340.01 (59a), Wisconsin Statutes.

C. Automobile—Any motor vehicle as defined in Section 340.01(4), Wisconsin Statutes.

D. Motor Truck—Any motor vehicle as defined in Section 340.01(34), Wisconsin Statutes.

E. Recreational Vehicles or RV—Any mobile home as defined in 3430.01(29), Wisconsin Statutes, and any motor home as defined in Section 340.01(33m), Wisconsin Statutes.

F. Motorcycle—Any motorized vehicles as defined in Section 340.01(32), Wisconsin Statutes, including a moped as defined in Section 340.01(29m), Wisconsin Statutes, and a motor bicycle as defined in Section 340.01(30), Wisconsin Statutes.

G. Iceboat—A sailboat-like structure with runners or wheels intended to be wind powered on a solid surface.

H. Vehicles—All the above vehicles plus any other vehicle powered by motor or wind.

I. Ice Shanties—Structures which are parked or erected on the ice for use as warming buildings or ice fishing shelters, but not including RVs, trucks and automobiles.

J. Activities and Events—Shall include, but not be limited tom sporting events, fisheries, and iceboat and snowmobile races.

(4) Speed Restrictions

A. No iceboat, ATV, or snowmobile shall be operated on an icebound lake in the Town of Norway at a speed greater than is reasonable and prudent under the circumstances then existing.

B. All other vehicles including, but not limited to automobiles, motor trucks, and RVs shall not exceed a speed of 10 MPH on any icebound lake in the Town of Norway.

(5) General Regulations

The following regulations shall apply to icebound lakes in the Town of Norway.

A. No person shall operate a vehicle on any cleared skating areas.

B. No person shall operate a vehicle in any area where authorized events are being held, unless the vehicle is required or permitted for such event, and only to such extent.

C. No person shall use or operate any vehicle in any manner so as to endanger any person on the lake.

D. No person while operating a vehicle shall push, pull or tow any person on skates or skis.

E. No person while operating a vehicle shall push, pull or tow any device, whether occupied or unoccupied, unless such device is attached by a rigid tow bar to the frame of the towing vehicle. Such devices shall include, but shall not be limited to, sleds, toboggans, and inner tubes.

F. No person shall operate any motorized vehicle in an erratic or free wheeling manner. All such maneuvers, including, but not limited to, "wheelies", "donuts", "skating" the vehicle, "spinning out" and wheel spinning, are prohibited.

G. No person shall operate any vehicle powered by an internal combustion engine which is not equipped with a muffler, nor shall any person operate such vehicle in a manner so as to create excessive noise.

H. No person shall operate any vehicle during hours of darkness unless equipped with and using adequate, operating head light(s) and tail Light(s).

I. No person shall throw, place or permit to remain on or below the surface of any lake any vehicles, glass, earth, stones, grass, brush, leaves, petroleum product, garbage, excrement, refuse, waste, filth or other litter.

J. Ice Shanties.

1. No ice shanty may be placed or left on the ice before December 1 or after March 5, or for such shorter period as is ordered by the police department of the Town of Norway. Any ice shanty placed or left in violation of this regulation may be impounded.

2. Ice shanties shall at all times display a red reflective material of at least nine (9) square inches in size on all sides, approximately 3 ½ feet from the bottom of the shanty and visible from 100 feet away.

3. Ice shanties or shelters left on any lake overnight shall display the name, address and phone number of the owner on the exterior of the shanty on or near the door or entryway. Letters are to be at least 2" in height.

4. Ice shanties shall be constructed of materials which will not be destroyed or quickly deteriorate in wind or rain.

K. Ice Cutting

1. Holes cut, augured, or chiseled in the ice for purposes of fishing, shall not be larger than 12 inches in diameter.

2. Holes cut, augured or chiseled in the ice for purposes of diving, may be larger than 12 inches in diameter, but such holes shall be clearly marked with light-reflective markers. When not in use, the

ice shall be replaced in such hole and markers shall be placed until the hole freezes solid and is no longer a hazard.

L. It shall be unlawful to fail, or refuse to comply with, any lawful order, signal, or direction of a Town police officer or a lake patrol officer. No person operating a vehicle, after having received a visual or audible signal from an officer or marked police vehicle, shall flee or attempt to elude any officer, willfully or wantonly disregard such signal, interfere with or endanger the operation of the police vehicle, the officer or other vehicles or persons, increase the speed of the vehicle or to extinguish the lights of the vehicle in an attempt to elude or flee apprehension.

(6) Special Events, Risks and Liabilities

A. No special sporting event, fisheree, iceboat race, exhibition or other activity or event shall be conducted on any lake unless a permit for such activity or event has been issued by the Town Board of the Town of Norway.

B. If at any time the police department concludes that the lake is unsafe for vehicle operation or other activities, it may declare the lake unsafe and order it closed to such traffic and/or activity, and all such vehicle operation and activities shall cease.

C. All traffic and activities on a lake shall be at risk of the operator of the vehicle or pedestrian as provided in Section 30.81(3), Wisconsin Statutes, and nothing in this code shall be construed as shifting or placing such risk or liability to or on any other parties or on any units or agencies of government.

D. Applicability

This section shall apply to any lake located wholly within the Town of Norway. This section shall also apply to any lake located partially within the Town of Norway if and when all other towns, villages or cities having jurisdiction over any portion of such lake have enacted identical provisions.

E. Penalty

Any person, firm, association or corporation violating any provision of this ordinance or the Wisconsin Statutes incorporated herein by reference shall be subject to the penalties provided in Section 8.30.

Ord. No. 2000-1 (01/10/2000)

8.30 **Penalty**

(1) Except as set forth below, any person, firm, association or corporation violating any provision of this chapter shall forfeit not more than $50.00 upon conviction for a first offense and not more than $100.00 upon conviction of the same offense, a second or subsequent time within one year, together with the costs of prosecution in accordance with state law.

(2) Any person violating Section 8.04(5) shall be fined not more than $200.00, together with the costs of prosecution in accordance with state law. Any person violating Section 8.04(5) shall be required to obtain a certificate of satisfactory completion of a safety course under Wis. Stat. §30.74(l).

Ord. No. 2000-1 (01/10/2000)

Appendix C

QUESTIONNAIRE SURVEY RESPONSES

The majority of respondents were year-round residents, which is what would be expected here in the Southeastern Wisconsin Region. Most are long-term residents. A large number of respondents indicated that they use a number of other area lakes. Usually, responses to surveys of this nature suggest that residents stay relatively close to home when they live on a particular lake. Curiously, not all the lakes visited were "deep" lakes, which one might have expected given the limited depth of portions of Wind Lake.

There is a somewhat higher percentage of anglers than is found on many lakes. Most rate the fishing as fair to good. Panfish seem to be the favored fish, which is consistent with the rating of that fishery. From the improve/decline numbers, smallmouth bass and yellow perch standout as fishes that most respondents felt had declined over time. In terms of the other species caught, most were equally distributed between improve/decline responses, which would suggest that the fishery has remained somewhat constant. Curiously, the same spread is seen for carp, which would suggest that the carp problem is no worse, but no better.

High-speed boating topped the list of active recreational uses, while picnicking/walking/nature viewing were favored passive recreational activities. Speed boats topped the list of watercraft, consistent with the indication that high-speed boating is the favored active use of the Lake. There was an indication that the north and south areas of the Lake were used in preference to the east and west, these latter being shallower portions of the waterbody. Family activities were dominant, consistent with the picnicking-types of passive uses. Lake use was rated as "light" during the week and "heavy" during the weekend, by a majority, which was to be expected.

From a regulatory point of view, the majority was satisfied with law enforcement activity on the Lake. In terms of zoning and stormwater regulations, respondents were fairly equally divided between satisfied and having no strong feeling, which would suggest that few people are actually aware of these issues in their daily lives. Contrast these responses to sanitation (and law enforcement) where there was a clear indication of satisfaction by a majority of respondents.

In terms of water quality, as might be expected, the Lake was rated as "good" based on clarity and aesthetics, but "poor" based on "weeds." The bases for these assessments were typically visual or olfactory. These assessments were consistent with the indication that aquatic plants were a problem. There was good support for mechanical harvesting, chemical controls, biological controls (this is a surprising result, but probably not inconsistent with the fact that weeds are generally seen as a problem and any remedy is seen as a good remedy), restricted fertilizer use on the shoreline, and shoreline development controls.

A plurality, about 40 percent, felt that the lake had deteriorated over time, but a large percentage, 30 percent, felt that it had improved, which spread probably suggests that things have stayed the same. Of course, these responses may be based on location around the Lake (see the responses to the "what part of the lake do you use" question—

those located along the eastern and western shores may feel that things have declined, while those elsewhere might feel that things are better or unchanged); however, such geographic information cannot be teased out of anonymous responses.

The top five concerns reported by respondents were: 1) numbers of boats, 2) sizes of boats, 3) wetland preservation, 4) shoreline erosion/stormwater runoff/waterfowl/decline of fishery, and 5) numbers of personal watercraft (PWCs). PWCs also stood out as the activity to be restricted in certain areas; all watercraft activities were identified as activities to be restricted to certain hours.

Payment for improvements was fairly equally split between "yes" and "no" responses; weed control being the favored activity for which respondents would pay more.

Three-quarters felt that the District was doing a good job, although four-fifths did not attend the annual meeting. Timing was indicated as a major issue in limiting attendance; weekends seemed to be preferred: Thursday through Sunday. The correlation between doing a good job and lack of attendance is a typical response.

There were about 160 responses from a mailing of 842, or about a 20 percent response rate, which is good.

Appendix D

NONPOINT SOURCE POLLUTION CONTROL MEASURES

Nonpoint, or diffuse, sources of water pollution include urban sources such as runoff from residential, commercial, industrial, transportation, and recreational land uses; construction activities; and onsite sewage disposal systems and rural sources such as runoff from cropland, pasture, and woodland, atmospheric contributions, and livestock wastes. These sources of pollutants discharge to surface waters by direct overland drainage, by drainage through natural channels, by drainage through engineered stormwater drainage systems, and by deep percolation into the ground and subsequent return flow to the surface waters.

A summary of the methods and estimated effectiveness of nonpoint source water pollution control measures is set forth in Table D-1. These measures have been grouped for planning purposes into two categories: basic practices and additional. Application of the basic practices will have a variable effectiveness in terms of level of pollution control depending upon the subwatershed area characteristics and the pollutant considered. The additional category of nonpoint source control measures has been subdivided into four subcategories based upon the relative effectiveness and costs of the measures. The first subcategory of practices can be expected to generally result in about a 25 percent reduction in pollutant runoff. The second and third subcategory of practices, when applied in combination with the minimum and additional practices, can be expected to generally result in up to a 75 percent reduction in pollutant runoff, respectively. The fourth subcategory would consist of all of the preceding practices, plus those additional practices that would be required to achieve a reduction in ultimate runoff of more than 75 percent.

Table D-1 sets forth the diffuse source control measures applicable to general land uses and diffuse source activities, along with the estimated maximum level of pollution reduction which may be expected upon implementation of the applicable measures. The table also includes information pertaining to the costs of developing the alternatives set forth in this appendix.[1] These various individual nonpoint source control practices are summarized by group in Table D-2.

[1] *Costs are presented in more detail in the following SEWRPC Technical Reports: No. 18,* State of the Art of Water Pollution Control in Southeastern Wisconsin*, Volume Three,* Urban Storm Water Runoff*, July 1977, and Volume Four,* Rural Storm Water Runoff*, December 1976; and No. 31,* Costs of Urban Nonpoint Source Water Pollution Control Measures*, June 1991.*

Table D-1

GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF NONPOINT SOURCE WATER POLLUTION ABATEMENT

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban	Litter and pet waste control ordinance	Prevent the accumulation of litter and pet wastes on streets and residential, commercial, industrial, and recreational areas	2 to 5	Ordinance administration and enforcement costs are expected to be funded by violation penalties and related revenues
	Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning	Improve the scheduling of these public works activities, modify work habits of personnel, and select equipment to maximize the effectiveness of these existing pollution control measures	2 to 5	No significant increase in current expenditures is expected
	Management of onsite sewage treatment systems	Regulate septic system installation, monitoring, location, and performance; replace failing systems with new septic systems or alternative treatment facilities; develop alternatives to septic systems; eliminate direct connections to drain tiles or ditches; dispose of septage at sewage treatment facility	10 to 30	Replace one-half of estimated existing failing septic systems with properly located and installed systems and replace one-half with alternative systems, such as mound systems or holding tanks; all existing and proposed onsite sewage treatment systems are assumed to be properly maintained; assume system life of 25 years. The estimated cost of a septic tank system is $5,000 to $6,000 and the cost of an alternative system is $10,000. The annual maintenance cost of a disposal system is $250. An in-ground pressure system is estimated to cost $6,000 to $10,000 with an annual operation and maintenance cost of $250. A holding tank would cost $5,500 to $6,500, with an annual operation and maintenance cost of $1,800
	Increased street sweeping	On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas	30 to 50	Estimate curb-miles based on land use, estimated street acreage, and Commission transportation planning standards; assume one street sweeper can sweep 2,000 curb-miles per year; assume sweeper life of 10 years; assume residential areas swept once weekly, commercial and industrial areas swept twice weekly. The cost of a vacuum street sweeper is approximately $120,000. The cost of the operation and maintenance of a sweeper is about $25 per curb-mile swept
	Increased leaf and clippings collection and disposal	Increase the frequency and efficiency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings. and other organic debris to be mulched, composted, or bagged for pickup	2 to 5	Assume one equivalent mature tree per residence, plus five trees per acre in recreational areas; 75 pounds of leaves per tree; 20 percent of leaves in urban areas not currently disposed of properly. The cost of the collection of leaves in a vacuum sweeper and disposal is estimated at $180 to $200 per ton of leaves
	Increased catch basin cleaning	Increase frequency and efficiency of catch basin cleaning; clean at least twice per year using vacuum cleaners; catch basin installation in new urban development not recommended as a cost-effective practice for water quality improvement	2 to 5	Determine curb-miles for street sweeping; vary percent of urban areas served by catch basins by watershed from Commission inventory data; assume density of 10 catch basins per curb-mile; clean each basin twice annually by vacuum cleaner. The cost of cleaning a catch basin is approximately $10
	Reduced use of deicing salt	Reduce use of deicing salt on streets; salt only intersections and problem areas; prevent excessive use of sand and other abrasives	Negligible for pollutants addressed in this plan, but helpful for reducing chlorides and associated damage to vegetation	Increased costs, such as for slower transportation movement, are expected to be offset by benefits, such as reduced automobile corrosion and damage to vegetation

Table D-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban (continued)	Improved street maintenance and refuse collection and disposal	Increase street maintenance and repairs; increase provision of trash receptacles in public areas; improve trash collection schedules; increase cleanup of parks and commercial centers	2 to 5	Increase current expenditures by approximately 15 percent
	Parking lot stormwater temporary storage and treatment measures	Construct gravel-filled trenches, sediment basins, or similar measures to store temporarily the runoff from parking lots, rooftops, and other large impervious areas; if treatment is necessary, use a physical-chemical treatment measure, such as screens, dissolved air flotation, or a swirl concentrator	5 to 10	Design gravel-filled trenches for 24-hour, five-year recurrence interval storm; apply to off-street parking acreages. For treatment, assume four-hour detention time. The capital cost of stormwater detention and treatment facilities is estimated at $40,000 to $80,000 per acre of parking lot area, with an annual operation and maintenance cost of about $200 per acre
	Onsite storage—residential	Remove connections to sewer systems; construct onsite stormwater storage measures for subdivisions	5 to 10	Remove roof drains and other connections from sewer system wherever needed; use lawn aeration, if applicable; apply dutch drain storage facilities to 15 percent of residences. The capital cost would approximate $500 per house, with an annual operation and maintenance cost of about $25
	Stormwater Infiltration—urban	Construct gravel-filled trenches for areas of less than 10 acres or basins to collect and store temporarily stormwater runoff to reduce volume, provide groundwater recharge and augment low stream flows	45 to 90	Design gravel-filled trenches or basins to store the first 0.5 inch of runoff; provide at least a 25-foot grass buffer strip to reduce sediment loadings. The capital cost of stormwater infiltration is estimated at $12,000 for a six-foot-deep, 10-foot-wide trench, and at $70,000 for a one-acre basin, with an annual maintenance cost of about $10 to $350 for the trench and about $2,500 for the basin
	Stormwater storage—urban	Store stormwater runoff from urban land in surface storage basins or, where necessary, subsurface storage basins	10 to 35	Design all storage facilities for a 1.5-inch runoff event, which corresponds approximately to a five-year recurrence interval event, with a storm event being defined as a period of precipitation with a minimum antecedent and subsequent dry period of from 12 to 24 hours; apply subsurface storage tanks to intensively developed existing urban areas where suitable open land for surface storage is unavailable; design surface storage basins for proposed new urban land, existing urban land not storm sewered, and existing urban land where adequate open space is available at the storm sewer discharge site. The capital cost for stormwater storage would range from $35,000 to $110,000 per acre of basin, with an annual operation and maintenance cost of about $40 to $60 per acre
	Stormwater treatment	Provide physical-chemical treatment which includes screens, microstrainers, dissolved air flotation, swirl concentrator, or high-rate filtration, and/or disinfection, which may include chlorination, high-rate disinfection, or ozonation to stormwater following storage	10 to 50	To be applied only in combination with stormwater storage facilities above; general cost estimates for microstrainer treatment and ozonation were used; some costs were applied to existing urban land and proposed new urban development. Stormwater treatment has an estimated capital cost of from $900 to $7,000 per acre of tributary drainage area, with an average annual operation and maintenance cost of about $35 to $100 per acre

Table D-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Rural	Conservation practices	Includes such practices as strip cropping, contour plowing, crop rotation, pasture management, critical area protection, grading and terracing, grassed waterways, diversions, woodlot management, fertilization and pesticide management, and chisel tillage	Up to 50	Cost for Natural Resources Conservation Service (NRCS) recommended practices are applied to agricultural and related rural land; the distribution and extent of the various practices were determined from an examination of 56 existing farm plan designs within the Region. The capital cost of conservation practices ranges from $3,000 to $5,000 per acre of rural land, with an average annual operation and maintenance cost of from $5.00 to $10 per rural acre
	Animal waste control system	Construct streambank fencing and crossovers to prevent access of all livestock to waterways; construct a runoff control system or a manure storage facility, as needed, for major livestock operations; prevent improper applications of manure on frozen ground, near surface drainageways, and on steep slopes; incorporate manure into soil	50 to 75	Cost estimated per animal unit; animal waste storage (liquid and slurry tank for costing purposes) facilities are recommended for all major animal operations within 500 feet of surface water and located in areas identified as having relatively high potential for severe pollution problems. Runoff control systems recommended for all other major animal operations. It is recognized that dry manure stacking facilities are significantly less expensive than liquid and slurry storage tanks and may be adequate waste storage systems in many instances. The estimated capital cost and average operation and maintenance cost of a runoff control system is $100 per animal unit and $25 per animal unit, respectively. The capital cost of a liquid and slurry storage facility is about $1,000 per animal unit, with an annual operation and maintenance cost of about $75 per unit. An animal unit is the weight equivalent of a 1,000-pound cow
	Base-of-slope detention storage	Store runoff from agricultural land to allow solids to settle out and reduce peak runoff rates. Berms could be constructed parallel to streams	50 to 75	Construct a low earthen berm at the base of agricultural fields, along the edge of a floodplain, wetland, or other sensitive area, design for 24-hour, 10-year recurrence interval storm; berm height about four feet. Apply where needed in addition to basic conservation practices; repair berm every 10 years and remove sediment and spread on land. The estimated capital cost of base-of-slope detention storage would be $500 per tributary acre, with an annual operation and maintenance cost of $25 per acre
	Bench terraces	Construct bench terraces, thereby reducing the need for many other conservation practices on sloping agricultural land	75 to 90	Apply to all appropriate agricultural lands for a maximum level of pollution control. Utilization of this practice would exclude installation of many basic conservation practices and base-of-slope detention storage. The capital cost of bench terraces is estimated at $1,500 per acre, with an annual operation and maintenance cost of $100 per acre
Urban and Rural	Public education programs	Conduct regional and county-level public education programs to inform the public and provide technical information on the need for proper land management practices on private land, the recommendations for management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contract and education efforts	Indeterminate	For first 10 years, includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied for every 50,000 population. The cost of one person, materials, and support is estimated at $55,000 per year

Table D-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban and Rural (continued)	Construction erosion control practices	Construct temporary sediment basins; install straw bale dikes; use fiber mats, mulching, and seeding; install slope drains to stabilize steep slopes; construct temporary diversion swales or berms upslope from the project	20 to 40	Assume acreage under construction is the average annual incremental increase in urban acreage; apply costs for a typical erosion control program for a construction site. The estimated capital cost and operation and maintenance cost for construction erosion control is $250 to $5,500 and $250 to $1,500 per acre under construction, respectively
	Materials storage and runoff control facilities	Enclose industrial storage sites with diversion; divert runoff to acceptable outlet or storage facility; enclose salt piles and other large storage sites in crib and dome structures	5 to 10	Assume 40 percent of industrial areas are used for storage and to be enclosed by diversions; assume existing salt storage piles enclosed by cribs and dome structures. The estimated capital cost of industrial runoff control is $2,500 per acre of industrial land. Material storage control costs are estimated at $75 per ton of material
	Stream protection measures	Provide vegetative buffer zones along streams to filter direct pollutant runoff to the stream; construct streambank protection measures, such as rock riprap, brush mats, tree revetment, jacks, and jetted willow poles, where needed	5 to 10	Apply a 50-foot-wide vegetative buffer zone on each side of 15 percent of the stream length; apply streambank protection measures to 5 percent of the stream length. Vegetative buffer zones are estimated to cost $21,200 per mile of stream and streambank protection measures cost about $37,000 per stream mile
	Pesticide and fertilizer application restrictions	Match application rate to need; eliminate excessive applications and applications near or into surface water drainageways	0 to 3	Cost included in public education program
	Critical area protection	Emphasize control of areas bordering lakes and streams; correct obvious erosion and other pollution source problems	Indeterminate	Indeterminate

[a]Not all control measures are required for each subwatershed. The characteristics of the watershed, the estimated required level of pollution reduction needed to meet the applicable water quality standards, and other factors will influence the selection and estimation of costs of specific practices for any one subwatershed. Although the control measures costed represent the recommended practices developed at the regional level on the basis of the best available information, the local implementation process should provide more detailed data and identify more efficient and effective sets of practices to apply to local conditions.

[b]The approximate effectiveness refers to the estimated amount of pollution produced by the contributing category (urban or rural) that could be expected to be reduced by the implementation of the practice. The effectiveness rates would vary greatly depending on the characteristics of the watershed and individual diffuse sources. It should be further noted that practices can have only a "sequential" effect, since the percent pollution reduction of a second practice can only be applied against the residual pollutant load which is not controlled by the first practice. For example. two practices of 50 percent effectiveness in series would achieve a theoretical total effectiveness of only 75 percent control of the initial load. Further, the general levels of effectiveness reported in the table are not necessarily the same for all pollutants associated with each source. Some pollutants are transported by dissolving in water and others by attaching to solids in the water; the methods summarized here reflect typical pollutant removal levels.

[c]For highly urbanized areas which require retrofitting of facilities into developed areas, the costs can range from $400,000 to $1,000,000 per acre of storage.

Source: SEWRPC.

Of the sets of practices recommended for various levels of diffuse source pollution control presented in Table D-2, not all practices are needed, applicable, or cost-effective for all watersheds, due to variations in pollutant loadings and land use and natural conditions among the watersheds. Therefore, it is recommended that the practices indicated as needed for nonpoint source pollutant control be refined by local level nonpoint source control practices planning, which would be analogous to sewerage facilities planning for point source pollution abatement. A locally prepared plan for nonpoint abatement measures should be better able to blend knowledge of current problems and practices with a quickly evolving technology to achieve a suitable, site-specific approach to pollution abatement.

Table D-2

ALTERNATIVE GROUPS OF DIFFUSE SOURCE WATER POLLUTION CONTROL MEASURES PROPOSED FOR STREAMS AND LAKE WATER QUALITY MANAGEMENT

Pollution Control Category	Level of Pollution[a] Control	Practices to Control Diffuse Source Pollution from Urban Areas[b]	Practices to Control Diffuse Source Pollution from Rural Areas[a]
Basic Practices	Variable	Construction erosion control; onsite sewage disposal system management; streambank erosion control	Streambank erosion control
	25 percent	Public education programs; litter and pet waste control; restricted use of fertilizers and pesticides; construction erosion control; critical areas protection; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; material storage facilities and runoff control	Public education programs; fertilizer and pesticide management; critical area protection; crop residue management; chisel tillage; pasture management; contour plowing; livestock waste control
Additional Diffuse Source Control Practices[c]	50 percent	Above, plus: Increased street sweeping; improved street maintenance and refuse collection and disposal; increased catch basin cleaning; stream protection; increased leaf and vegetation debris collection and disposal; stormwater storage; stormwater infiltration	Above, plus: crop rotation; contour strip-cropping; grass waterways; diversions; wind erosion controls; terraces; stream protection
	75 percent	Above, plus: An additional increase in street sweeping, stormwater storage and infiltration; additional parking lot stormwater runoff storage and treatment	Above, plus: Base-of-slope detention storage
	More than 75 percent	Above, plus: Urban stormwater treatment with physical-chemical and/or disinfection treatment measures	Bench terraces[b]

[a]Groups of practices are presented here for general analysis purposes only. Not all practices are applicable to, or recommended for, all lake and stream tributary watersheds. For costing purposes, construction erosion control practices, public education programs, and material storage facilities and runoff controls are considered urban control measures and stream protection is considered a rural control measure.

[b]The provision of bench terraces would exclude most basic conservation practices and base-of-slope detention storage facilities.

[c]In addition to diffuse source control measures, lake rehabilitation techniques may be required to satisfy lake water quality standards.

Source: SEWRPC.